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# Coordinates

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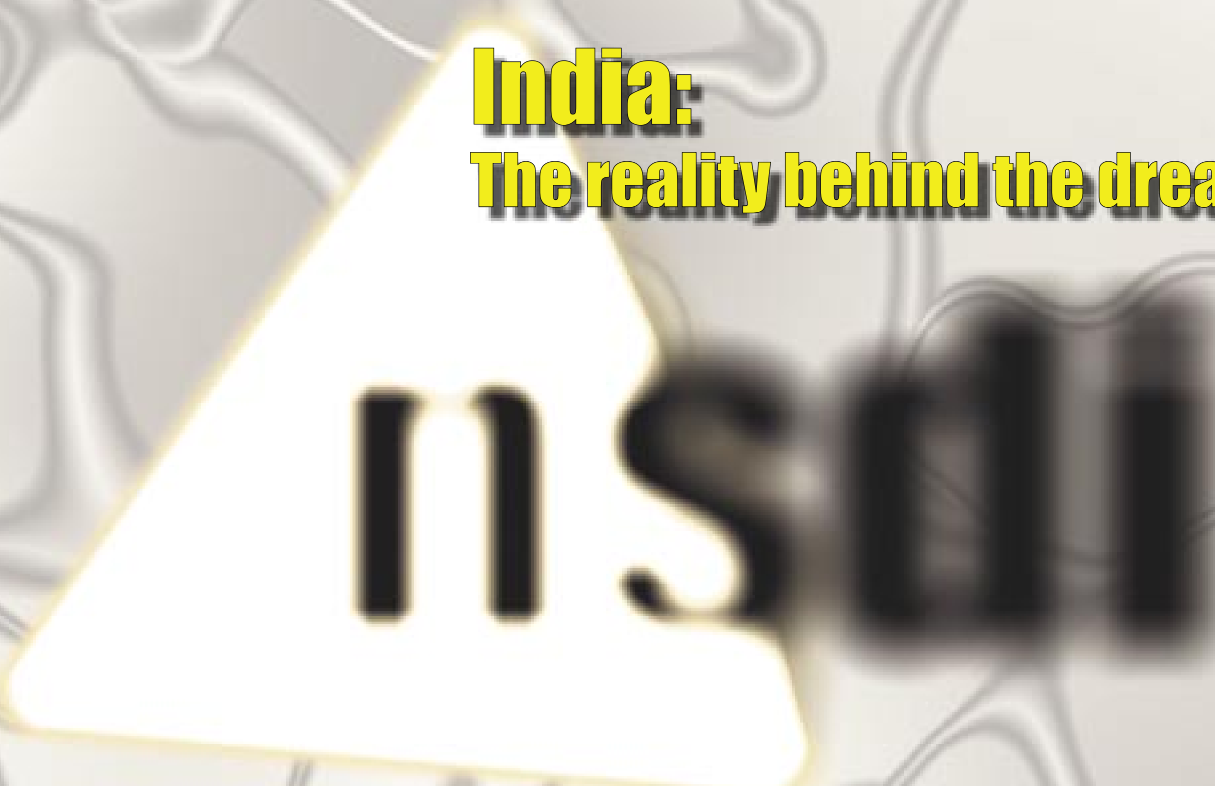
**POSITIONING, NAVIGATION AND BEYOND**

## GPS research trends in Hong Kong

## India: The reality behind the dream



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## Articles



## Columns



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## NSDI in India: A dream being pursued

National Spatial Data Infrastructure (NSDI) in India happens to be a long journey.

For many it is a time consuming process to be dealt with patience and perseverance. Some perceive it as an endless journey.

It started in 2001.

There were moments of euphoria and hype. There were promises made, that remain unfulfilled. There were moments of desperation and despair too.

There were debates on 'spatial' or 'geo-spatial'. There were issues about leadership and ownership. At times it appeared as an agenda driven by a few enthusiasts. At times it seemed as a policy being sincerely pursued.

At times I wonder what drives it and what stops it.

However, I know what encourages it are the visible changes in attitude, temperament and mindsets.

The National Informatics Centre, Government of India is organizing NSDI-V during December 18-21, 2005 at Hyderabad, India. On the occasion, Coordinates narrates the story of NSDI in India. (See page 34)

There are assurances again.

It is yet to be seen whether it is a dream envisioned by a few or a reality to benefit many.

What is important that the journey continues…

It may be slow but must be firm and positive.

**Bal Krishna, Editor**
**bal@mycoordinates.org**

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# Measuring geopotential difference between two points

By receiving the light signals emitted by a light source simultaneously at two points P and Q located on the Earth's surface, it is possible to directly measure the geopotential difference between P and Q, based on the gravity frequency shift equation

**W B Shen**

Conventionally, the potential difference between two points P and Q located on the Earth's surface are determined by gravimetry and levelling (Heiskanen and Moritz 1967), the drawback of which is that it is almost impossible to connect these two points in the case that they are located on two continents, because it is well known that the potential surface of the mean sea level (MSL) is not an equi-potential surface. In another aspect, if given the gravity data on the Earth's surface, one might determine the potential difference between two points by using the Stokes method or Molodensky method (ibid). In this case the potential field is determined and consequently the potential difference between two arbitrary points could be determined. However, Stokes method is approximate due to the requirement that the measured gravity data should be deduced on the geoid, which gives rise to obvious errors; Molodensky method is complicated, and the determined is the quasi-geoid. The transformation from quasi-geoid to geoid needs again levelling, which encounter difficulties in connecting two points located on different continents. Hence, applying the conventional approach, it is very difficult to establish a unified global datum system (with adequate precision). To avoid this difficulty, Bjerhammar (1985) suggested that the geopotential difference between two arbitrary points P and Q might be determined by using two precise clocks put at P and Q respectively, based on the theory of general relativity (e.g. Weinberg 1972). The basic principle is stated as follows. According to Einstein's general relativity theory, the running rate of a clock is closely related with the geopotential at the point where the clock is located: the clock located at the position with higher geopotential runs faster than the clock located at the position with lower geopotential. Based on the above considerations, Bjerhammar defined a relativistic geoid as follows: the relativistic geoid is the equi-potential surface nearest to MSL on which a precise clock runs with the same rate. This is referred to as the equi-time-rate geoid (Shen 1998).

Different from Bjerhammar, Shen et al (1993) argued that it is better to determine the geopotential difference by receiving the light signals emitted by an emitter (which could be located on the Earth's surface or in space), based on the gravity frequency shift equation, which is not only the result derived from the general relativity but also the quantum mechanics and energy conservation law (Shen 1998). Further, it was shortly proposed that (Shen et al 1993; Shen 1998), it might be possible to directly determine the potential difference between two points P and Q on the surface of the Earth (even these two points are located on different continents) by receiving the light signals emitted by a satellite or a distant star.

Suppose an emitter is equipped with a flying satellite, which can emit light signals with regular intervals. Then, by receiving the light signals emitted by the emitter simultaneously at two points P and Q, one could determine the geopotential difference between P and Q, based on the gravity frequency shift principle. Then, one

can determine the potential field based on the truncated spherical harmonic expansion combining with the least squares adjustment (e.g., Rummel et al 1993) or the fictitious compress recovery approach (Shen 2004), the main idea of the latter is stated as follows. Compress the boundary value, given on the Earth's surface, on the surface of an inner sphere located inside the Earth, and using Poisson integral one gets a harmonic field in the domain outside the inner sphere; compress again the residuals between the initial boundary value and the calculated one, provided on the Earth's surface, on the surface of the inner sphere, and using Poisson integral one gets again a harmonic field in the domain outside the inner sphere; this procedure is repeated and a series result is obtained, which coincides with the real field in the domain outside the Earth.

The gravity frequency shift principle is stated as follows (Shen et al. 1993; Shen 1998).

Suppose a light signal with frequency f is emitted from point P by an emitter that is not necessarily located on a satellite, and the signal is received at point Q by a receiver (Cf. Fig.1). Because of the geopotential difference between these two points, the frequency of the received light signal is not f but f'. Using $f_P$ and $f_Q$ to denote f and f' respectively, the following equation holds (Pound and Snider 1965; Shen et al. 1993):

$$\Delta f = f' - f = -f\,(W_Q - W_P) / c^2 \qquad (1)$$

where c is the velocity of light in vacuum, $W_P$ and $W_Q$ are the geopotentials at points P and Q respectively. Expression (1) is referred to as the gravity frequency shift equation (Pound and Snider 1965), or properly called the geopotential frequency shift equation due to the fact that the frequency shift is caused by the geopotential difference. Katila and Riski (1981) confirmed Eq. (1) with accuracy $10^{-2}$. Vessot et al. (1980) proved that Eq. (1) is correct to the accuracy of $10^{-4}$. Scientists believe that Eq. (1) is correct, because it is a result derived from the theory of general relativity. As mentioned previously, Eq. (1) can be also derived out based on quantum theory and energy conservation law (Shen, 1998). Hence, suppose the geopotential at point P is given, then, from Eq. (1) the geopotential at an arbitrary point Q can be determined by measuring the geopotential frequency shift between P and Q.

Set at point P an emitter which emits a light signal with frequency f and a receiver at point Q receives the light signal emitted by the emitter at point P. Suppose the received signal's frequency is f'. Then, it could be compared the frequency f' of the received light signal with it self's standard frequency f (this is not only the emitting frequency at point P but also the standard innate frequency of the receiver at point Q), and the frequency shift $\Delta f = f' - f$ can be determined. Consequently, according to Eq. (1) the geopotential difference $\Delta W_{PQ}$ between P and Q can be determined. Applying the same principle it will be found the geopotential difference $\Delta W_{OP} = W_P - W_O$ between the point O on the geoid and an arbitrarily point P, where $W_O = C_0$ is the geoid geopotential constant. If $C_0$ is a known constant, $W_P$ as well as $W_Q$ can be determined. Hence, based on the geopotential frequency shift equation (1), the relativistic geoid could be defined as follows (Shen et al 1993): the relativistic geoid is the equi-potential surface nearest to MSL on which there does not exist light signal's frequency shift. This is referred to as the equi-frequency geoid (Shen 1998).

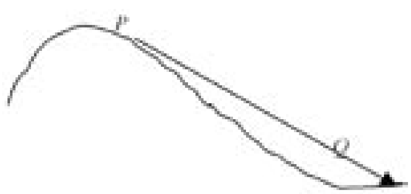


**Fig. 1 A receiver at point Q receives the light signal with frequency f emitted by an emitter at P, where P and Q are located on the Earth's surface**

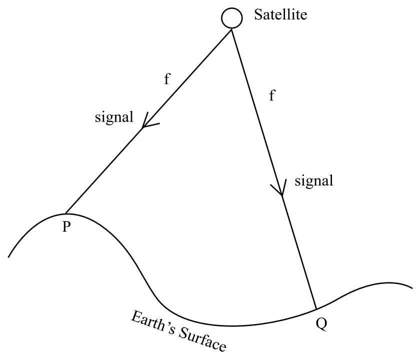


**Fig. 2 Two light signal receivers at points P and Q receive simultaneously the emitted light signals with frequency f by an emitter equipped in a satellite**

Now, suppose the light signal emitter E is located in a satellite, and two light signal receivers at P and Q receive the light signals coming from E corresponding to an emitting time t (Cf. Fig.2). Further suppose the received signals' frequencies corresponding to time t are recorded by receivers at P and Q in some way, respectively, i.e., $f_P$ and $f_Q$ corresponding to time t are recorded by receivers at P and Q, respectively. Note that the time at which the signal is received by P is generally different from that by Q. By comparing the received frequencies $f_P$ and $f_Q$ it could be determined the geopotential difference $\Delta W_{PQ} = W_Q - W_P$ (Shen et al., 1993), which is just given by Eq. (1).

By the above mentioned way, the geopotential on the Earth's whole surface could be determined based on the geopotential frequency shift approach by receiving the light signals emitted by satellites. Once the geopotential W on the Earth's surface is determined, the potential field V outside the Earth could be determined, and as a result, the geoid could be more precisely determined.

The emitter could be a distant stable star. The receivers at P and Q could be designed in such a way that the received light signals might be recorded on diskettes at P and Q in details. Then, comparing the recorded diskettes at a centre process system. In this way, the frequency shift information between P and Q might be drawn out.

In the case that the emitter is located on the Earth's surface, the potential difference between the two points P and Q could be also directly determined based on the same principle, as long as the the receivers at these two points could simultaneously receive the light signals emitted by the emitter.

It is noted that the accuracy for determining the potential difference by using the geopotential frequency shift approach is becoming more and more prospective for the goal of determining the centimeter-geoid, which is mainly depending on the frequency stability of the receiver. More than 10 years ago, the frequency stability was around $10^{-14}$, which is very poor for determining the geoid with an adequate accuracy. At present however, the frequency stability is around $10^{-15}$ - $10^{-16}$ (HMC Project 2005), which corresponds to the height variation about 1 m. In the next ten years, it is prospective that the frequency stability $10^{-17}$ - $10^{-18}$ could be achieved, which corresponds to the height variation 1cm.

The great advantage by using the geopotential frequency shift approach lies in that a unified global datum system could be established: two receivers located at two datum points A and B which belong to two separated continents could simultaneously receive the signals emitted by a satellite source emitter, and consequently the frequency shift between A and B is determined; then, based on the geopotential frequency shift equation the geopotential difference between A and B is determined.

With satellite technique (e.g. CHAMP mission, Cf. Gerlach 2003), the potential on the satellite surface could be determined, and consequently it could be determined the Earth's external potential field, which is quite accurate for the long and middle wave-length of the field, but not for the short wave-length of the field.

The will-be launched GOCE system could provide a $1^0$ x $1^0$ global gravity model with accuracy level around 1cm. However, concerning a single datum point A, the accuracy of the potential at A determined based on the global gravity model is far from centimeter level. To get more precise result, local measurements (gravimetry and leveling) are needed. Hence, with the goal of determining the global centimeter-geoid, the connections between different datum points located on different continents should be precisely established, which might be completed by geopotential frequency shift approach.

## Acknowledgements

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# Geodetic infrastructure in India

Geodetic Infrastructure in India is inadequate. It needs a fresh look and complete revision

N K Agrawal

The Great Trigonometrical Survey of India was completed in 19th century under leadership of the great surveyors- Lambton and Sir George Everest. It is inconsistent and inadequate. Accuracy of the network is only of the 1st order or less. First order was defined as better than only 1 in 50,000 only. Reference surface and Datum- The Everest Spheroid was given by Sir George Everest in 1830. Center of Everest Spheroid is about a km away from the center of gravity of the Earth; hence it is non-geocentric. Thus it is inaccurate and unsuitable under present circumstances. Leveling network of India has inconsistencies. Gravity observations were not carried out and not taken in to consideration. It was not appropriately adjusted. Indian Absolute Gravity Datum does not exist. Absolute gravimeters have not yet been used to define Gravity Datum in India. Topographical maps are on Polyconic projection. Assumptions and approximations accepted make it a non-projection. The earth is assumed to be flat and there are no distortions of any kind. The projection has created problems in digitization, compilation and integration of maps. Design of the Grid adopted in India is not satisfactory. Distortion at central parallel is 1 in 824, which is quite high. There is archaic Restriction policy, which is not transparent and hinders research and development India has to make a choice between chaos and development. These problems have been discussed in detail in this paper. How India should go about to establish new geodetic infrastructure for systematic development and research, has been described in this paper.

Geodetic Infrastructure in India is inadequate. It needs a fresh look and complete revision. Indian Geodetic Datum, The Reference Surface, Horizontal Control, The Vertical Datum, Height Control, Indian Geoid and Mean sea level, The Gravity datum, Projection System for Maps, and Indian Grid, are all inadequate or inappropriate.

Indian Geodetic Datum is based on Everest Spheroid as Reference Surface and Kalyanpur in Central India as initial point. Center of this reference surface is estimated to be about 1 km away from the center of gravity of the Earth. The datum is thus a local datum and in error. Scientific and Defense studies of vital National importance cannot be based on such a system. It is therefore extremely necessary that the Indian Geodetic Datum should be redefined at the earliest. The project on Redefinition of Indian Geodetic Datum should be taken up in right earnest and completed within one year. Horizontal Control in India resulted from The Great Trigonometrical Survey. The different triangulation series are inconsistent between each other. It has not been properly adjusted. Stations are burdened with varying degrees of error and many points are either destroyed or in need of repair. It is therefore urgently necessary that fresh observations be carried out to get a set of vectors by GPS and other means and least square adjustment be carried for the whole country at one go to get control points of zero, 1st, and 2nd order in 2 to 3 years. Vertical Datum for Heights in India was chosen as the Mean Sea Level at a group of nine tidal observatories situated at Indian ports. Level network in India is of moderate to high precision at different places. No gravity observations were carried out at that time. Network has not been properly adjusted. It is required that a fresh datum for heights based on Mean Sea level at one tidal observatory say Mumbai. High Precision Leveling should be carried out afresh throughout India to get a network along with gravity observations and adjusted so as to have 1st order vertical control. It is necessary to have a Gravity Datum in India. Presently there is no absolute gravity station in India. Gravity values in India are based on relative gravity observations based on gravity datum/s in other countries. It is therefore necessary to establish some absolute gravity stations, adopt a gravity datum and carry out relative gravity observations in order to get a 1st order gravity network. No satisfactory Indian Geoid is available. To get heights above Mean sea level by GPS observations we need a geoid that can give geoidal undulation of accuracy of 25 cm or better. A project should be taken up immediately to obtain geoid by gravimetric as well as astro-geodetic methods. Projection for topographical maps in India is Polyconic. Each individual sheet is projected individually assuming no distortion along parallels and neglecting distortion along meridians. Meridians and parallels are assumed as straight lines. These assumptions make it a perfect projection, which is not possible. We can say that The Earth/Ellipsoid has been assumed to be flat for individual sheets. This creates problems in digitization, integration and compilation of maps. It is therefore necessary to abandon so called polyconic projection and adopt either Lambert Conformal Conic or Transverse Mercator Projection designing suitable zones. Indian Grid on Lambert Conformal Conic Projection for superimposition on topographical maps was designed during British days. It has 9 zones with scale factors at central parallel as 649/650 and 823/824. The design

***Presently no satisfactory Indian geoid is available. To obtain heights above MSL with GPS we need a geoid, which can give geoidal undulation accuracy of about 25 to 50 cm or better***

is unsatisfactory as scale error at central parallel should be 1 in 2000 or better. The grid has been restricted which is irrational as the grid parameters are available to everyone outside India including Pakistan. It is therefore necessary to design grids on Transverse Mercator or Lambert Conformal conic Projection with suitable zones similar to State Plane Coordinate systems in USA. It is suggested that each Indian state should have a grid for that state and all mapping is carried out on such grid for civil use. Structure of Monuments (geodetic stations, bench marks etc.) is not of permanent nature in many cases and many have been destroyed. Monuments that are not fixed to bedrock are not suitable for geodetic monitoring of crustal movements. New and suitable permanent monuments need to be constructed before any new project regarding geodetic infrastructure is taken up.

## Indian Geodetic Datum

Indian Geodetic Datum is based on Everest Spheroid as reference surface given by Sir George Everest, then Surveyor General of India in 1830. Kalyanpur in central India was chosen as initial point or origin. Coordinates of initial point and azimuth of a line were obtained by astronomical observations and leveling. The reference surface was however defined peace-meal at various times. Astronomical observations were carried out at least twice. More precise observations carried out later were accepted. Hence meridional and prime vertical deflection of vertical, were defined at Kalyanpur. Parameters of the datum are given in table1.

**Table 1**

| **Initial Point (Origin)** | **Kalyanpur** |
|---|---|
| Longitude of origin | $24^0$ 07' 11".26 |
| Latitude of origin | 77 39 17.57 |
| Meridional deflection of vertical | - 0".29 |
| Prime vertical deflection of vertical | + 2".89 |
| Geoidal undulation | 0 metres |
| Semi major axis | 6,377,301.243 metres |
| Flattening f | 1/300.8017 |
| Azimuth to Surantal | $190^0$ 27' 06".39 |

Value of Semi major axis and semi minor axis were given in feet as 20,922,931.80 feet and 20,853,374.58 feet respectively. These values were converted into metres using different conversion factors resulting in many values of a and b of Everest spheroid. The official conversion factor for India is 0.3047996 and should be accepted.

It is estimated that the center of Everest spheroid is about 1 km away from the center of gravity of the earth; hence it is not a geocentric datum. We therefore conclude that it is inaccurate system and needs redefinition. The present datum is especially not suited for many geodetic, geodynamic, geophysical and defence applications. One has either to use WGS84 for Geodetic monitoring of crustal movements, plate tectonic movements, development and deployment of missiles and many other scientific applications or redefine Indian Geodetic System/Datum. A project to redefine Indian Geodetic Datum was taken up in 1989 but nothing much appears to have been done so far. Redefinition project should be taken up and given highest priority. It should be time bound and completed in 2 to 3 years. In USA a similar project was taken up in 1974 by National Geodetic Survey and completed in 1983. It is known as NAD 83 and is used for all applications including Geodynamic and defense.

## Horizontal Control

Horizontal datum in India is Indian Geodetic Datum based on Everest Spheroid. Existing horizontal control in India is the result of Great Trigonometrical Survey of India consisting of 5 blocks with 2700 stations and 10 bases. Triangulation series were started from Kalyanpur. The Indian subcontinent was divided into five parts region-wise, four quadrilaterals (NW, NE, SW, SE) and the Southern Trigon. The quadrilaterals could not be adjusted together due to computational limitations at that time. Several corrections viz. for deflection of vertical, skew normal and geodesic also could not be applied. In 1937-38 an attempt was made to readjust the triangulation network but this also suffered from the same limitations. Though densification of control and filling of gaps has been done in addition to observation of more bases and Laplace stations, no fresh adjustment has been carried out. This has resulted in the various series being inconsistent with each other. The horizontal control is therefore burdened with varying degrees of errors; say from a few metres to as much as 100 metres at places. Many stations are however supposed to of 1st order that is 1 in 50,000. Most of the stations of this control are on hills covered by jungles. Many stations have been destroyed and many others in poor condition, hence not suitable for geodynamic studies and zero/1st order geodetic horizontal control.

The need therefore is to provide complete horizontal control of zero and 1st order afresh and adjust it by least squares for the whole country at one go using available scientific adjustment software. BIGADJUST, the software used by National Geodetic Survey of USA has been obtained by Survey of India to adjust the present control but the same has not been completed and it is not known as to what are there plans regarding this.

It is suggested that in addition to redefinition of Indian Geodetic Datum a project should be planned to provide horizontal control of zero, 1st and 2nd order throughout India. The following steps are suggested: -

1) Identify places for monuments. Care should be taken to choose places suitable for geodynamic studies also. Rooftops of permanent public buildings can also be chosen in preference to hilltops in many cases, as the control will now be provided using GPS.
2) Design suitable monuments and carry out construction of monument pillars. It should be seen that pillars are fixed to bedrocks to be suitable for future geodynamic studies.
3) Design network and observe all vectors using dual frequency geodetic GPS receivers in relative positioning mode.
4) Process the data using a scientific software such as Bernese.
5) Adjust the data by least squares using a network adjustment software such as BIGADJUST.
6) Compile the data in a suitable format for use for various purposes and for dissemination to public.

## Vertical Datum and Height Control

In India, the vertical datum for heights has been chosen as the mean sea level at a group of nine tidal observatories situated at various Indian ports. Hourly tidal observations were carried out at these ports for a number of years and averages obtained.

It was assumed that the mean sea level at these ports, belong to the same sea level surface. All these ports served as issue points for the first level net of India. Leveling net in India consists of first level net of moderate precision covering 18,000 miles started in 1858, and second level net of 16,000 miles based on first level net. Second level net was adjusted on to first level net wherever necessary. We can see clearly from the above that assumptions were incorrect. Precision was moderate and adjustment was not carried out properly. Choice of vertical datum was not unique and creates confusion. Gravity observations were not carried out which is necessary for National Level Nets of high precision and 1st order accuracy. The present heights are thus in varying degrees of error and are not of present day standards. These cannot be used as basis for geodynamic studies and many geodetic and geophysical studies where 1st order vertical control is required. It is therefore suggested that a fresh vertical datum be adopted and vertical control of 1st and 2nd order be provided by spirit leveling along with gravity observations. The following steps are suggested:

1) Select a tidal observatory where hourly tidal observations of 18.6 years cycle of successive nodes of the moon are available. Construct a few permanent benchmarks near the observatory in stable and protected area. Provide heights of these benchmarks by 1st order spirit leveling from the chart datum to the benchmarks. These benchmarks should be taken as issue points for the fresh leveling network of India. The mean sea level obtained here should be the National Mean Sea Level for India at this observatory. Tidal observatory at Mumbai port may be chosen for obtaining the mean sea level. Design the network and construct the benchmarks along the routes selected for leveling in phases. Leveling of 1st order should be carried out along-with gravity observations using relative gravimeters throughout India.
2) Carry out adjustment of the network by least squares at one go and document the heights along with description of benchmarks.
3) Construct a few permanent benchmarks near other tidal observatories also. Find mean sea level at these observatories also and provide heights of the benchmarks constructed near the observatories from the chart datums of such observatories by 1st order leveling. These will represent the local mean sea level in those areas. There will be some difference between the national mean sea level heights and local mean sea level heights. The difference can be applied to heights in that area wherever needed based on sound statistical analysis. Scientific analysis of various mean sea levels and heights may be carried out for geoidal, geodynamic and geophysical studies.
4) All the monuments constructed for zero and 1st order horizontal control, should also be connected by 1st order spirit leveling. Monuments constructed for geodynamic studies should also be similarly connected.

## Gravity Datum

Presently we do not have a gravity datum in India. A 1st order gravity station exists at Palam airport Delhi, which was provided by relative gravity observations from other countries. A precise gravity network of 42 stations was established in 1971 by Survey of India covering airports of the country with an uncertainty of + or – 0.05 mgal. These stations served as reference for future gravity surveys in India. This gravity network was adjusted within the framework of International Gravity Standardization Net 1971 (IGSN 71). La-Coste and Romberg model G gravimeters were used for observations.

Until recently we did not have any absolute gravimeter. Recently NGRI has acquired one absolute gravimeter, which is being used by them for scientific research. We have to plan establishment of absolute gravity datum in India and connect existing gravity stations to the absolute gravity station/stations. It is hoped that NGRI will take leading part in this project. All first order horizontal control monuments and 1st order leveling bench marks should be connected to gravity network so as to have 1st order gravity values. This will facilitate precise repeat gravity observations for geodynamic applications such as 1) Detection and interpretation of vertical ground motion in earthquake prediction. 2) Monitoring and interpretation of post earthquake motion. 3) Postglacial rebound studies. 4) Monitoring of movement of magma in volcanic areas along with leveling. 5) Reservoir depletion studies of all kinds. 6) Tectonic motions and crustal warping studies.

## Indian Geoid

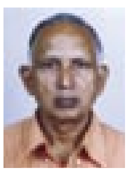
Presently no satisfactory Indian geoid is available. To obtain heights above MSL with GPS we need a geoid, which can give geoidal undulation accuracy of about 25 to 50 cm or better. It is therefore necessary that a project should be taken up to determine Indian geoid by gravimetric as well as by astro-geodetic methods.

## Projection for Maps

All topographical maps in India are on polyconic projection. Assumptions and approximations applied to it make it a mockery if we say that a projection has been adopted. The sheets on 1:25,000; 1:50,000; and 1:250,000 topographical sheets are individually projected assuming that distortion along meridians can be neglected. There is no distortion along parallels. Besides these the meridians and parallels are joined by straight lines. This means that it is not a projection. It amounts to assuming that the earth is flat in respect of individual sheets. It has created a lot of problems in integration of different maps, compilation of maps, digitization and hence in GIS. We should change over to Lambert Conformal Conic or Transverse Mercator/UTM for our topographical maps after forming suitable zones. Individual states of India should adopt one of the two projections for all mapping in their states similar to State Plane Coordinate System in various states of USA.

## Indian Grid

Indian grid was designed during British days dividing India into 9 zones in Lambert Conformal Projection. The grid is not satisfactory as scale error at central parallels is 1in 850 and 1 in 650. Distortion is considered high. We should aim for 1 in 2500 but should not be more than 1 in 1000. Restriction of the grid is also irrational as parameters and all information about it is available to everyone anywhere in the world except in India. There is therefore an urgent need to design grids afresh. We should adopt either Lambert Conformal Conic or Transverse Mercator depending upon whether the area to be projected is greater in E-W extent or N-S extent.



**NK Agrawal**
Former Director, Survey Training Institute, Survey of India Hyderabad, India **nande@rediffmail.com**

## Geodetic Misunderstandings

(Still prevailing Around the World)

1. Spheroid is considered equivalent to an ellipsoid.
2. The longitude at the North or South Pole is zero degree.
3. The Mean Sea Level (MSL), a time-variant "average", is considered as time-invariant and time-independent.
4. The measured "dn" along a spirit level loop sum up to zero.
5. Imagine a freely flowing ocean or sea channel under a continent and it represents the Geoid.
6. The geoidal undulation or height (N) is equivalent to orthometric height (H).
7. There are "yours" and "mine" geoids. In other words every country has its own geoid, creating a "political" boundary value problem for gravity.
8. When one has to re-observe at any station, it does not make any difference so long one is observing within "few" meters.
9. If one asks for and gets a height as "123.4 m". It is OK to add zeros at the end, e.g., 123.4000, to make it more accurate.
10. A sea can be below the sea level.
11. The origin of WGS 84 is at the center of gravity of the Earth.
12. A map or chart can be plotted on any projection and a "different" grid can be super imposed. The extreme example here is the use of UTM grid over a stereographic projection in the polar region.
13. A map or chart can have TWO grids without TWO datums or ellipsoids and be printed in the SAME color.
14. The standard deviation (or sigma) can be computed with "n = 1".
15. The ellipsoid is used as zero reference for orthometric heights (H).
16. In a 70 GPS station network adjustment, 40+ or even more stations can be held "fixed".
17. Two points on a "level" surface will have the SAME heights.
18. At any point on the Earth, the latitudinal arc depicts E-W direction.
19. Zero longitude still passes through Greenwich.
20. Everyone can teach geodesy.

Last but not the least:

If you have GPS, who needs a GEODESIST?

If anyone wants to know "why" about any misunderstanding, I will be very willing to provide the geodetic reason(s) or "why" it is still lingering.

## Innovative excellence

**21st Century Indian Geodetic System, Distortion-Free Maps, Charts, and GIS**

As India launches the DSMs and OSMs under its new map policy, it should not let the opportunity to slip by. The Timing could not be better to start producing the most accurate geospatial intelligence. The most accurate geodetic system with IAG recommended modeling is realizable in the very near future (Note: The GPS data collection over six Million square miles for the South American Geodetic System took a week to establish the fundamental framework).

New technique(s) are available to produce distortion-free maps, charts, and GIS. GPS surveyed ellipsoid heights are the most efficient and cost effective vertical control and contours drawn with them on topographic maps and aeronautical charts will depict the real relief. For nautical charts, time-invariant ellipsoidal depths will provide the real bathymetry for safe navigation. All that is needed is to make a start and be ahead of everyone!

## Geodetic commentary

The Mix up of "X, Y, Z" Coordinates Between Photogrammetry and Geodesy

**In Spatial considerations –**

**In geodesy**, the "ZXY" coordinate system is "right-handed", where the right thumb points towards the Z-axis, index finger towards the intersection of the Reference Meridian and Equatorial planes, and middle finger or the positive Y-axes, which is at right angle to the Z- and X- axes and in the Equatorial plane, towards East. The axes are defined in the order "Z", "X", and "Y".

### Clarifications

a. The origin is at the Earth's center of mass.
b. The reference meridian is as realized by the ITRFyy (nn.0), not by the "Greenwich".
c. The origin of the reference ellipsoid is coincident with the origin of the 3-D "XYZ" Coordinate System

**In photogrammetry**, the "ZXY" coordinate system is "left-handed". Here, the main difference (from the geodetic system) is that the left middle finger or the "positive" Y-axes points towards West.

**On the Photo Platform –**

Here, the "X and Y" relate to the horizontal and "Z" relates to the elevation.

NOTE: The "Z" of the photo platform should NOT be mixed up with the "Z" of the 3-D rectangular coordinates of a geodetic system, e.g., WGS 84.

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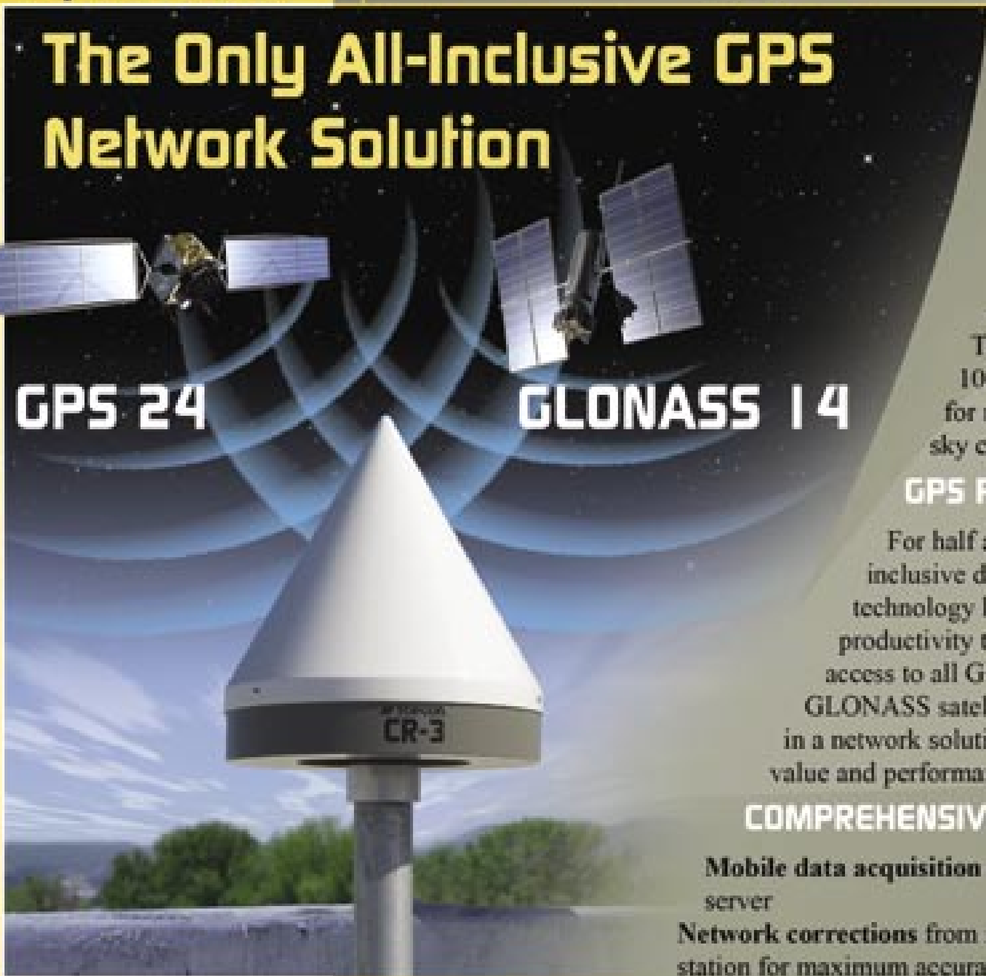
## TopNET RTK

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- **Mobile data acquisition** through a centralized server
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# Products

## NovAtel's latest version of ProPak-LBplus

NovAtel Inc. has announced that its ProPak-LBplus GPS receiver now supports OmniSTAR's new XP L-band satellite service. XP is the latest in a range of satellite correction services offered by subscription from OmniSTAR. With the latest version 2.31 release, all ProPak-LBplus products will have the combined capability to receive the Omnistar XP and Omnistar HP services.

## Intermap remaps State of Hawaii in 3D

Intermap Technologies Corporation has announced that it has completed the data acquisition of the state of Hawaii under its NEXTMap USA program. The completion of Hawaii progresses Intermap's plan to digitally map the entire continental United States and Hawaii in three dimensions. Acquisition of the entire states of California, Florida and Mississippi has also been completed. *www.intermap.com*

## Advance stereoscopic technology by NuVision

MacNaughton's NuVision solutions deliver the highest quality in stereoscopic visualization like flicker – free 3D realism. The product line supports stereo ready software used in GIS, Computational Chemistry, Mechanical / Architectural CAD, Robotics, Resource Management, Oil & Gas Exploration, Scientific Visualization, Site-Base entertainment and 3D Animation. *www.nuvision3d.com*

## PCI Geomatics releases Geomatica 10

PCI Geomatics has announced the release of Geomatica 10. The latest version emphasizes automation, productivity, and support for more than 100 geospatial data formats. It offers solutions for various geomatics processing requirements, while maintaining interoperability with outside software packages. It has Smart Digitizer technology for semi-automated feature extraction, enhanced charting, complete Oracle 10g support, and new atmospheric correction algorithms for hyperspectral data. *www.pcigeomatics.com*

## Geodetic Systems announces new photogrammetry software

Geodetic Systems, Inc. (GSI), a provider of portable 3D coordinate measurement systems for diverse industrial applications, recently announced it is shipping a new version of its metrology software -- V-STARS 4.4 SR2. This updated release stacks up the enhancements in the industry-leading photogrammetry product line for high precision data acquisition. *www.theautochannel.com*

## New Mapping Tools from Intergraph and TerraGo Tech

Intergraph Corporation and TerraGo Technologies have announced that versions of MAP2PDF have been jointly developed for Intergraph product lines, GeoMedia and Digital Cartographic Studio (DCS). It has also acquired POPPENHÄGER GRIPS GMBH, a software company based in Neunkirchen/Saarland, Germany which provides geospatial analysis software and services to municipalities and utility companies.

## Portable golfing GPS tees off

The sureshotgps system was launched in Australia recently. Using Australian technology, the sureshotgps system provides golfers with all the benefits of traditional golfing GPS systems, in an easy-to-use, portable format.

Similar in size to a mobile phone, the sureshotgps unit allows data for 10 courses to be stored in the hand-held unit at any one time. Golfers can also download course data from an extensive list via the Internet. *www.pga.org.au*

## Feature Analyst for SOCET SET now available

Visual Learning Systems, Inc. (VLS), providing automated feature extraction (AFE) technology, has announced the immediate availability of Feature Analyst 4.0 for SOCET SET. Earlier this year the National Geospatial-Intelligence Agency (NGA) selected Feature Analyst for SOCET SET for early technology insertion into the NGA production environment. NGA intends to deploy it across their Integrated Exploitation Capability (IEC) workstations. BAE Systems has also released an upgraded version of its SOCET GXP software application that supports image analysis, geospatial analysis, photogrammetry, and targeting—all from a single user interface. *www.na.baesystems.com, www.featureanalyst.com*

## Leica Geosystems releases new GPS RTK Processing option

Leica Geosystems releases new GPS RTK Processing option for Leica MobileMatriX and new Edition of Leica MobileMatriX Edition as extension to existing ArcGIS 9 Desktop installations. Leica MobileMatriX, the link between GIS technology from the world's leading supplier, ESRI® and surveying equipment from the world's leading manufacturer of spatial data capture equipment, Leica Geosystems represents a new era in mobile data collection. *http://www.leica-geosystems.com*

## Kinematic Navigation launches PPro2 software

Kinematic Navigation has announced the release of PPro2 Static software. It processes raw GPS observational data to improve positioning accuracy. One can achieve decimeter, centimeter or even millimeter level positioning with PPro2. Such processing requires data to be collected from two static GPS receivers, one of which be at a known position. It supports both single or dual frequency receiver equipment.

### 2005 Europe Postal digital maps

GfK MACON is now supplying the new 2005 version of the digital map edition "Europe Postal and Administrative". The Europe Edition comprises the postal and administrative territories of all European countries including Turkey. *www.gisuser.com*

## Business

### Hemisphere GPS for Volvo Ocean Race

Hemisphere GPS is supplying Vector heading systems to three of the seven sailboats competing in the Volvo Ocean Race - a seven-month, 31,000-mile, globe-circling odyssey involving some of the world's best sailors. All three boats will be using state-of-the-art Vector products for heading accuracy when the Volvo Ocean Race - widely known as the Mount Everest of ocean racing. *www.hemispheregps.com*

### Bentley completes acquisition of STAAD product lines

Bentley Systemshas announced the acquisition of the Research Engineers International (REI) business from netGuru, Inc. The business features the STAAD.Pro line of leading structural engineering analysis software, which is now offered by Bentley worldwide. It facilitates the design of steel, concrete, timber, and aluminum structures for buildings, plants, tunnels, bridges, and more. *www.bentley.com*

### MapInfo Corporation reports earnings for fourth quarter

MapInfo Corporation has reported earnings per share of $0.18 for the fourth fiscal quarter ended September 30, 2005, representing the tenth consecutive quarter of year-over-year earnings per share growth for the company. Included in the results is an approximate $0.03 per share benefit due to a decrease in the effective tax rate. For the same period last year the company reported earnings per share of $0.09. Revenues for the fourth quarter grew 24 percent to $40.3 million versus $32.5 million for the same quarter last year. *www.mapinfo.com*

### Leica Geosystems wins order from Seismic Survey Company

Leica Geosystems announces that it has won an order for 30 GPS1230 surveying systems from Wolf Survey and Mapping, a division of Destiny Resources Services Partnership in Western Canada.

### Leica and Acquis becomes strategic partners

Leica Geosystems Geospatial Imaging has entered into a strategic partnership with Acquis to facilitate the processing and delivery of geospatial data within the Oracle® Spatial 10g environment.

### Brandmotion selects Magellan for OEM navigation

Thales Navigation has announced a partnership with Brandmotion, LLC to deliver the first integrated aftermarket Magellan navigation system, based on the best-selling Magellan RoadMate™. It partners with leading companies to develop, market and distribute integrated entertainment, safety and convenience products for automobiles. It will provide integrated navigation devices for select high volume vehicle lines, beginning with an integrated vehicle navigation system for Ford F-150 trucks. The Magellan integrated navigation system delivers a full-color touchscreen with visual, voice and text-prompted turn-by-turn guidance for door-to-door routing anywhere in the United States and Canada.

## LBS

### Ti Single Chip drives LBS in mobile phones

Texas Instruments (TI) introduced single-chip assisted A-GPS solution in 90 nanometer process technology for mobile phones. Its DRPTM technology, the GPS5300 NaviLinkTM 4.0 single chip offers the smallest system area for a discrete GPS solution, lowest total system cost, low power consumption and high performance A-GPS functionality. To speed the development of A-GPS enabled handsets, it is optimized to interface with TI's 3G technology and OMAPTM processors to deliver a complete solution for handset OEMs.

### Marubeni Solutions in Japan ties up with Ekahau

Marubeni Solutions has signed a distribution agreement with Ekahau, Inc., and starts reselling its wireless LAN-based Real-Time Location System (RTLS) and site survey tools. RTLS provides ubiquitous positioning indoors and outdoors with accuracy of 5m maximum error, whereas GPS and PHS can basically be used only outdoors with less precision. It tracks and pinpoints laptops with wireless LAN adapter, PDAs and Wi-Fi tags. RTLS creates a signal strength map of the wireless LAN access points, by using received signal strength indicator (RSSI), it tracks Wi-Fi enabled terminals, and graphically displays the location of the terminals on a personal computer screen.

### Vodafone offer A-GPS Handset in Japan

Japan's Vodafone K.K.commences sales of the Vodafone 903T 3G handset by Toshiba, the world's first mobile handset capable of network-assisted GPS navigation both in Japan and abroad. It will also launch the 'Vodafone live! NAVI' GPS navigation service enables customers to check their current location, search for surrounding area information and find the best routes to destinations.

## India to Use Russian GLONASS Navigation System

Russia and India are planning to cooperate in the sphere of satellite navigation, Indian Defense Minister Pranab Mukherjee announced at a Moscow recently. He said this was a momentous decision for India, but that the specifics of cooperation in the area had yet to be discussed. Russia's satellite navigation system, called GLONASS, is operated for the government by the its Space Forces. An improved GLONASS-K satellite, with a reduced weight and an increased operational lifetime of 10-12 years, is due to enter service in 2008. Following a joint venture deal with the Indian government, which will launch two GLONASS-M satellites on its PSLV rockets, it is proposed to have the system fully operational again by 2008 with 18 satellites and by 2010 with all 24 satellites.

## Russia's Satellite System operational in 2007

The Global Orbiting Navigation Satellite System (GLONASS) will be fully operational in 2007, the head of the Russian Space Agency, Mr. Anatoly Perminov said recently. He said the president had given orders to restore GLONASS by 2007 while visiting the Baikonur Space Center in Kazakhstan last summer. Under the federal space program approved by the government, the GLONASS grouping will be increased to the minimal level of 18 satellites by 2007. Currently, the system includes 14 satellites in orbit.

## China builds five high-precision GPS infrastructure networks

Trimble recently announced it has supplied GPS reference stations and Trimble VRSTM (Virtual Reference Station) software to establish five new infrastructure networks throughout China. Located in Shanghai, Wuhan, DongGuan, Tianjin and Beijing, the multi-purpose networks will provide a geo-spatial infrastructure in each area. The networks will supply fast and accurate GPS positioning for a variety of applications including surveying, urban planning, urban and rural construction, environmental monitoring, resource and territory management, disaster prevention and relief, precision agriculture, scientific research and transportation management. The new Trimble VRS installations follow the Shenzhen and Chengdu networks already implemented in China. *www.trimble.com*

## Lockheed modernizes GPS satellite

Lockheed Martin Space Systems has announced this week that it has delivered the second of eight GPS IIR satellites it is modernizing. The unit of Bethesda, Md., defense contractor Lockheed Martin Corp. delivered the satellite to Cape Canaveral Air Force Station in US where it will be readied for a January launch. The first modernized GPS-IIR satellite was launched on September 25. It is expected to be declared fully operational in January following a four-month test period. *http://philadelphia.bizjournals.com*

## New vehicle tracking solution to hit the roads

Citadel Research and Solutions, has announced the launch of its advanced Vehicle Tracking Solutions (VTS). The Solutions extend features that can help in locating and planning the routes to locations in the city, measure distances, find the shortest routes and GPS tracking. *http://news.webindia123.com*

## @Road to launch tracking solutions in India

@Road plans to launch its tracking solutions in India. Using solutions that employ GPS and internet, clients can view schedules of their workforce, balance workloads across available field resources by shifting assignments and modifying dates and time for service. Companies can track service calls on real-time. The Hindu Business Line

## Study to monitor bears and hunters

West Virginia University and the Maryland Department of Natural Resources in US are using GPS to study black bears. The project will monitor the movement of Maryland's black bears by using radio collars and determining hunter movements through the use of GPS armband units. Use of GPS help to determine spatial patterns and habitat use of black bears throughout the year, while at the same time allowing them to assess the vulnerability of bears to hunting mortality by providing real-time information of bear and hunter movements during the black bear season. *www.upi.com*

## GPS to reel in illegal fishers in Philippines

Cracking down on illegal fishers will take a new face after the provincial government of Bohol, Philippines donated to the provincial police command a GPS device that could track the exact location of the encroachers. Also donated were a night vision monocular and two hand-held radio sets, to back the GPS tool. *www.theboholchronicle.com*

## Applanix POS LV wins at DARPA Unmanned Vehicle Race

After a close race to the finish line, Applanix joins Carnegie Mellon University in celebrating an impressive second and third place finish of the 2005 DARPA Grand Challenge. Using Applanix POS LV (Position and Orientation System, Land Vehicles) integrated Inertial/GPS technology as part of their on-board navigation systems, the Carnegie Melon University (CMU) Red Teams "Sandstorm" and Red Too Teams "H1ghlander" vehicles both successfully completed the 132.2 mile on-road/off-road course.

## World digital library plans by US Library of Congress

The Library of Congress in US has announced plans to establish a World Digital Library allowing online access to manuscripts, maps and other materials held in library collections around the globe. The project will be funded by nonexclusive partnerships with public and private organizations and has been kick-started by a $3 million donation by search engine company Google. *www.researchresearch.com*

## Yahoo redesigns its online mapping service

Yahoo has redesigned its online maps to make it easier to get driving directions to multiple destinations and find local merchants. Yahoo is introducing some features such as the ability to scroll across a map without reloading a Web page. There are four or five 'only at Yahoo' features" included in the upgrade. The innovations include the ability to obtain driving directions to several different city locations. *http://sify.com*

## ITC produce Maps for Pakistan Earthquake area

ITC has produced 49 maps at scale 1:50,000 of the complete Pakistan earthquake area to aid relief workers and agencies in the field. After registration, these maps can be freely downloaded. The maps are based on satellite imagery with a resolution of 15 meters and show land cover, relief (mountains/hill shading), main roads, rivers, 200-meter contour lines, and village names.

## Web portal to assist earthquake relief

An information-sharing web portal called Pakistan Relief and Information Systems for Earthquakes has been launched to provide information about the 4,000 villages in the largely rural earthquake-affected areas of Pakistan. The portal was developed and is maintained by a consortium of experts drawn from the World Bank, American and Pakistani universities and the private sector, with support from the government of Pakistan. *www.risepak.com*

## Ordnance Survey reveals boost for Britain's spatial address data

Ordnance Survey has announced a radical series of improvements to its most highly detailed address data pinpointing the locations of more than 27 million properties across Great Britain. The enhancements to the OS MasterMap Address Layer are designed to help customers in both government and business.

## Jharkhand maps natural resources

The Jharkhand government in India has taken up an important scheme -- state natural resources management system -- which is aimed at developing statewide mapping and monitoring of natural resources in the mineral-rich state. Under the statewide area network (SWAN) project the plan is to extend Internet and e-governance facilities to the people. And in the first phase, all the 212 blocks will be brought under SWAN, a centrally funded programme. *www.hindustantimes.com*

## Bhutan - Land Management Project

The project will support a GIS-based biophysical and socio-economic mapping exercise to identify the causes and incidence of land degradation.

The information generated through the mapping exercise will be used to identify "hot-spots" and to assess the presence or absence of incentives that currently guide farming practices and inform community decisions. It will support community decision making and prioritization of potential sustainable land management (SLM) investments at the chiog level. Implementing Agency: Ministry of Agriculture. *www.worldbank.org*

## Agriculture markets digitally connected

The agriculture ministry in India will provide electronic connectivity to important wholesale markets throughout the country to ultimately put in place a national atlas of agriculture markets on the telecom-based GIS platform. The atlas will contain information on the entire agricultural marketing infrastructure, including warehouses, cold storages, markets and other related infrastructure. *www.business-standard.com*

## Land use maps in West Bengal

The government of West Bengal in India has started preparing land-use maps for all 18 districts. The science and technology department, under charge of chief minister Buddhadeb Bhattacharjee himself, is preparing the maps with the help of remote sensing, satellite imaging and physical verification. Separate maps are being prepared for each district. *www.telegraphindia.com*

## Wastewater management in Oman

OWSC is implementing GIS to manage the wastewater assets in Muscat. This implementation will be one of the major milestones of OWSC's overall information system framework. GIS will assist OWSC to address the requirement of integrated approach to manage wastewater assets more efficiently and effectively and thus in turn serve the needs to Muscat community. *www.menafn.com*

## Digital land registration system in Iraq

The USAID is working with the State Board for Agricultural Lands in Iraq to create and implement an updated and secure digital system of land registration. Such a system is critical to the success of an emerging private agriculture sector in Iraq. *www.portaliraq.com*

## China launches satellite to observe Beijing

A high-performance earth observation satellite used to “observe” Beijing, host of the 2008 Olympics, was successfully sent into its preset orbit. The ‘Beijing-1’ satellite blasted off at the Plesetsk satellite launching centre of Russia on Friday, 28th October evening. The satellite is expected to send back remote sensing pictures of Beijing about 20 days later. The pictures of the Chinese capital will serve its urban planning, ecological environment monitoring, key projects monitoring and land utilisation purposes. *www.hindu.com*

## China to measure Great Wall’s length

China would measure the length of the over 7,000-km-long Great Wall once again with the help of the latest remote sensing technology. Deputy secretary-general of China Great Wall Institute Zhang Ji said recently a plan on comprehensively surveying the Great Wall with remote sensing technology was made and approved as feasible by experts. The plan will provide an accurate length of the Great Wall, which was built by first Chinese emperor Qinshihuang, and rebuilt and renovated by the Ming Dynasty (1368-1644) rulers. The current measure of the Great Wall, which is 7,300 kilometres, is likely not very accurate due to the relatively backward measuring equipment and methods in the past. *www.ptinews.com*

## Iran to build satellite with China

Iran, in cooperation with China will build and launch its national satellite according to recent reports. Technical specifications of the proposed satellite have already been identified. Iran is preparing to launch five satellites including Mesbah, Zohreh and Sina. In addition to the five satellites, three micro-satellites are also planned to be launched. Following its establishment in 2000, Iran’s Aerospace Organization has also been engaged in designing and manufacturing a small multi-mission satellite (SMMS) in the framework of a pact signed with China and Thailand. It is planned to be launched by 2006. *www.iranmania.com*

## EADS Fleximage study on Google Earth

EADS Fleximage is issuing a study covering the changes, the outlets or threats Google Earth product generates in the geographical information and Defence & Security world. What are the technical features, the reliability and limits of Google Earth data and software, face to the international security regulations? What are the new applications stemming from the Google Earth offering, the services, which can be derived from, or the ways to integrate Google Earth into an information system? This analysis performed with the contribution of representative experts and organisations is detailed in the 150 pages. *www.fleximage.fr*

## India’s NRSA to introduce ‘image atlas’

The National Remote Sensing Agency (NRSA)in India is bringing out an atlas. NRSA’s bouquet of high-resolution images will not carry features of defence installations. Unlike the outline maps produced by the Survey of India, NRSA’s ‘image atlas’ will comprise high-resolution pictures showing the physiographic features of the globe. A first in the country, the ‘image atlas’ should be of help to scientists, cartographers and land-use planners, apart from students. The 212-page book will contain nearly 250 images taken by Indian satellites such as Cartosat-I. *http://timesofindia.indiatimes.com*

## Vietnam to launch remote sensing satellite

Vietnam could have its first remote sensing satellite in late 2007 or early 2008, if the government approved the space industry development strategy and a project on launching it in the next few months. Vietnam plans to launch a small remote sensing satellite to provide aerial images mainly used to better manage natural resources and transport systems, prevent natural disasters and forest fires, put forth weather forecasts, and draw maps. *http://english.people.com.cn*

## Cartosat-1 data products now available

National Remote Sensing Agency in India has announced the availability of first phase Cartosat-1 data products to the user community. All the acquired Cartosat-1 data from May 08, 2005 onwards can be supplied as Monodata and/or Stereo Data. The Prices for the products are finalized and made competitive and affordable. Users can place orders with NDC for the archived data. *www.nrsa.gov.in*

## Radhakrishnan is new Director of NRSA

Dr K Radhakrishnan has taken over as Director of the National Remote Sensing Agency of the Dept of Space in India. He replaces Dr R R Navalgund, now the Director of Space Applications Centre, Ahmedabad. Dr Radhakrishnan, had served as Director of the Indian National Centre for Ocean Information Services, Hyderabad, the Vice-Chairman of Inter-Governmental Oceanographic Commission of UNESCO and the Founder-Chairman of Indian Ocean Global Ocean Observing System.

# "A web-based transport system is well developed in Hong Kong"

says Prof. YQ Chen, Department of Land Surveying and Geo-informatics, The Hong Kong Polytechnic University, Hong Kong, while discussing the current trends in GPS research and its applications

## Tell us about your department

The Department of Land Surveying and Geo-informatics is the only academic unit in Hong Kong that provides a broad education in Geomatics. In addition to full-time degree and Higher Diploma programmes, the Department offer part-time degree and postgraduate programmes for technicians and professionals to upgrade their academic qualifications. The Department also provides research programmes leading to MPhil and PhD awards. All of our programmes are carefully designed to meet the needs of the local professional community and to meet international standards.

## What are the objectives of research activities?

Research activities are mainly conducted under the Research Centre for Geo-Information Science and Technology with the following aims:

- To conduct specialised research in geo-information science and technology;
- To promote external research collaborations; and
- To promote applications of latest research outputs and to provide services to the local and international communities.

There are three main research laboratories under the umbella of this Centre:

- Laboratory for Environmental Change (LEC) which is concerned with monitoring of environmental changes and natural hazards
- Laboratory for Integrated Navigation Technologies (LINT), focusing on integrated navigation technologies and information systems
- Cyber City Laboratory (CCL), which conducts research on technologies for the development of cyber city

## What research is being done in natural hazards?

Some of our research activities focus on detection and interpretation of landslides using satellite sensor image. Landslide monitoring which requires large areas to be surveyed at a detailed level has previously been unsatisfactory due to its reliance on air photo interpretation. One of our studies demonstrates the synergistic use of medium resolution, multitemporal SPOT XS, and fine resolution IKONOS images for landslide inventories using change detection and image fusion. The visual quality of images obtained from Pan-sharpening of IKONOS images is comparable to that obtainable from 1:10,000 scale air photos. Another study in our department demonstrates that old landslide trails over 50 years old can be interpreted using a DEM from IKONOS stereo images. We have also used GPS to monitor crustal deformation. In north China, the velocity field obtained by GPS surveying during 1995 to 2001 is used for calculation of crustal deformation rates. The number of total GPS stations is about 450 in this area.

## Do you conduct research in the field of engineering?

Research is being conducted to develop specialized technologies to apply GPS to monitoring the health conditions of structures such as bridges, tall buildings, slopes and dams. We have developed a patented multi-antenna GPS technology that allows one GPS receiver to be used to monitor the motion of a series of points to substantially reduce the cost of GPS hardware. We have also been developing special data processing algorithms to enhance the accuracy and reliability of GPS.

## And what about meteorological research?

Recently, a technique of remote sensing water vapour in the atmosphere using GPS has been rapidly developed. The estimation accuracy of 1-2 kg/m2 has been routinely available from ground based GPS networks. Extending this technique into the sea on a moving platform would be greatly beneficial for the meteorological research, such as calibration of satellite data and investigation of sea/air interface. A new method based on Kalman filter technique has been developed to estimate water vapour under a kinematic environment. In addition, we have also concentrated on the study of ionospheric disturbances in Hong Kong and their effects on GPS. Also, a new method is proposed to establish a precise local ionospheric delay model based GPS reference network.

## What issues in navigation are faced by Hong Kong?

Locating a car on a road map is an important function of a car navigation system. GPS is widely used for vehicle navigation due to its high accuracy and low cost but in an urban environment, GPS satellite signals are blocked by buildings and other obstructions. In urban Hong Kong, GPS availability is less than 30%. A navigation system that integrates GPS, Dead Reckoning (DR), radio beacons, and digital map and navigation databases, has been developed. It includes several new techniques developed by the research team in the department, including adaptive Kalman filter for sensor integration, tight integration of map and positioning sensors, and Bluetooth-based radio beacon. With the integrated system, positioning availability increases to over 96%. Another research related to map matching for vehicle navigation is supported by a number of projects from government, industry, research council, and the university. A new map-matching method is developed that can be implemented in different platforms. It consists of a number of basic functions, such as road identification, road following, road feature extraction, and reliability assessment. The precise map information has also been integrated with the navigation units to provide calibration for DR errors.

## Do you think we need more user-friendly maps?

Yes, the main requirement of maps for navigation purpose is effectiveness. Experimental results in psychology indicate that it is dangerous for the driver to leave his/her attention away from the road for more than a few seconds. To make maps effective, general-purpose maps should be greatly simplified because too much information on the map would confuse the driver. Furthermore, map symbols critical for navigation should be more attractive than symbols for the surrounding environment. The aim is to achieve optimum design of effective maps for land vehicle navigation. In one of our studies, effective use of visual variables (shape, size, orientation and color), dynamic variables (duration, change of rate and order), and exploration acts (blink, highlight, zooming, pan, drag and click) in dynamic visualization are explored, and maps with different complexity and perspective points are designed and experimentally tested in Hong Kong.

## What is the status of public transport system?

Hong Kong's public transport system is complicated. Residents and tourists rely on public transport for everyday travel. To assist people, a web-based multi-modal public transport query and guiding system, EASYGO, has been developed. This is a collaborative venture between the Department of Land Surveying and Geo-Informatics of the Hong Kong Polytechnic University and the Brilliant Technology Development Limited. The system finds optimal travelling routes for users in terms of fewer mode transfers, shortest travelling time and lowest fare. It is designed for mobile phone and internet connection so that transport users may plan their travels in advance. EASYGO is multi-modal, in that it includes all legally run public transport modes throughout the whole territory of Hong Kong and those linking to the neighbouring Guangdong townships and cities. These cover all kinds of mass transits, buses, minibuses, ferries and trams. The project started in early 2002 and is now commercialized with the collaboration of several telecom companies. The system has also widely been used among visitors, students and staff via the University campus kiosks and portal system.

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## What about LBS in Hong Kong?

Although mobile positioning technology has many potential applications in Hong Kong, the use of LBS is still at an early stage. Major concerns are related to its accuracy and reliability. It is believed that LBS platforms now available in Hong Kong can generally provide positional information better than 500m accuracy in the urban area which would be sufficient for various applications such as manpower and fleet management, transportation query and guidance system. This research investigates the accuracy achievement of current LBS in Hong Kong.

It was found that the current LBS can generally provide better than 200m accuracy in urban areas, but the positioning error in rural areas can be as high as 1km. The trend for LBS in Hong Kong will gradually move to the hybrid positioning technique, which is the combination of AGPS and cellular network positioning, to provide high accuracy indoor and outdoor location based services. Future application of LBS technology are only limited by our imagination, and include manpower and fleet management, travel aids, location identification in case of emergency, and the provision of guidance for visually impaired persons.

## Any interesting application of geospatial technology?

Terrestrial laser scanners provide high density, accurate spatial data, but do not (typically) provide high quality spectral information and are earth-bound. Cameras produce high quality spectral information and can be moved freely about an object, but photogrammetrically extracting 3D data can be cumbersome and time consuming. Methodologies to exploit the positive characteristics of these two technologies to automatically produce representations that contain high quality spatial and spectral information have been developed.



# ACRS: The journey continues…

26th ACRS 2005, 7-11, November, 2005 Hanoi, Vietnam

The 26th Asian Conference on Remote Sensing (ACRS) and 2nd Asian Space Conference was held at Hanoi, Vietnam from 7th November 2005 to 11th November 2005. First time in Vietnam, the ACRS was organized jointly by the Asian Association on Remote Sensing, The Vietnam Association on Geodesy, Cartography and Remote Sensing and The Association of Vietnamese Geographers.

The Conference was inaugurated by Professor DrSc Dang Hung Vo, Deputy Minister, Ministry of Natural Resources, Vietnam who was also the Honorary Chairman of the 26th ACRS. The Welcome Address was given by Professor Emeritus Dr. Shunji Murai, General Secretary, AARS and Professor Ian Dowman, President ISPRS. One of the highlights of the conference was that The Vietnam Union of Science and Technology Associations (VUSTA) conferred a Medal to Professor Emeritus Shunji Murai in recognition of his invaluable contribution to Science and technology.

There were five Keynote addresses given by – Dr Kaoru Mamiya, Vice President, JAXA, Japan, Mr Jorg Hermannn, Managing Director INFOTERA GmbH, Germany and Dr Suvit Vibulsresth, GISTDA, Thailand and Professor DrSc Dang Hung Vo, MONRE, Vietnam.

The conference was attended by 628 delegates from 37 countries around the world. There was an active interaction, exchange of ideas, experiences and information among the world-renowned scientists on the various issues through 59 absorbing technical oral sessions and 3 poster sessions. In all 628 presentations were made; 380 from foreign countries and 143 from Vietnam. There were 105 observers. There was a separate student session in which students got an opportunity to share information about their individual Universities and their academic pursuits. They also got an opportunity to share information on career prospects with the renowned scientists. A workshop on Capacity Building in Asia was also one of the highlights of the conference. This workshop was organized by JAXA, Japan and Geomatics Centre of AIT.

Professor DrSc. Dang Hung Vo, Deputy Minister, Ministry of Natural Resources, Vietnam was the chief Guest at the Closing Ceremony, Five Best Speaker and one Best Poster Award were conferred on the Young Scientists by JSPRS, Japan. The 26th ACRS was marked by an exceptionally god cultural programme.

Along with ACRS, 2nd Asian Space Conference was also organized.

**Dr NS Rathore** Associate Professor, M L Sukhadia University, Udaipur, **Indiarathorens@yahoo.com**

### JSPRS Award

**Best Speaker 2005**

- Mr. Narong Pleerux, Thailand
  Flood hazard estimate
- Mr. Nguyen Lam Dao, Vietnam
  Rice crop monitoring by SAR
- Dr. Jiakui Tang, China
  Aerosol remote sensing
- Mr. Liang-Chien Chen, China Taipei
  Fusion of LIDAR and vector maps
- Ms. Yindi Zhao, China
  Rotation invariant texture

**Best Poster 2005**

- Mr. Nguyen Tho, Vietnam
  Shrimp Farming

# Multiple reference station GPS networks for airborne navigation

The use of RTK multi-station reference networks in precise aircraft navigation is feasible, particularly for the airport area. A real-time testing of this approach was carried out in Dubai

Ahmed El-Mowafy

Interest in the use of Global Navigation Satellite Systems (GNSS) as a main source of navigation reference is increasing. The system employed for such a purpose should be capable of meeting the requirements of air navigation in terms of accuracy, availability, integrity, and reliability. At present, the accuracy requirements for all flight categories up to precision approach are summarized in Table 1. The accuracy requirement for Category I can be achieved most of the time using wide area differential systems such as the American "WAAS", the European "EGNOS", and the Japanese "MSAS". The American Federal Aviation Authority (FAA) is developing a Local Area Augmentation System (LAAS) for categories II and III, involving the final and precision approach phases of flight. The system includes at least four reference GPS receivers located at each airport, whereby GPS measurements are collected and processed in real time. The computed GPS differential corrections are sent to aircraft via a (VHF) radio link to calculate its location. LAAS preliminary test results have generally demonstrated accuracy of less than 1 meter. However, the percentage of system availability is still under evaluation. The cost of establishing LAAS for major airports is expected to be significant.

## Multi-station RTK networks in airborne navigation

Existing Real-Time Kinematic (RTK) multi-station reference networks can be used as an alternative to the airport LAAS to aid accurate positioning of aircraft during precision approach, takeoff and airport surface navigation. These systems were originally developed for surveying applications. In principle, observations from multiple reference stations covering a large area are gathered and processed in a common network adjustment at a central processing facility and measurement corrections are computed. The corrections are optimized for the coverage area to account for distance dependent errors. A single rover GPS receiver receives these measurement corrections from the control centre of the network and uses the corrections to estimate its position in real-time accurate to the cm-level with fixed integer carrier-phase ambiguity resolution, or to the sub-meter level with a float solution. The use of these networks in airborne navigation can be done by mounting the rover receiving the network corrections on the aircraft to determine its positions during flight. The feasibility of this approach is discussed in this article.

## Advantages

The advantages of using multi-station reference RTK networks for precise airborne navigation are:

- The multi-station reference networks service can extend to several tens or hundreds of kilometres, thus, each network can cover more than one airport, including small airports, unlike the airport LAAS. In addition to airport navigation, the system can be used in search and rescue operations, emergency landing, road traffic control from the air, as well as emergency response.
- RTK networks provide cm to decimetre positioning accuracy even in the case of malfunctioning of some stations. This situation is however more critical in airport LAAS due to the low number of stations used.
- Compared to LAAS, no significant additional infrastructure cost is involved as the hardware and software of the GPS-RTK networks are available in most developed countries and the establishment of new networks is currently underway (or planned) in different regions worldwide.
- RTK networks can give better runway utilization by improving airport surface navigation.

## The DVRS network as an example

The feasibility of using real-time reference networks for precise positioning in navigation is investigated using a network known as the Dubai Virtual Reference System (DVRS), located in Duabi, UAE. The DVRS network consists of five active reference stations (Figure 1), with baseline lengths varying between 23.4 km and 90.8 km. To compute its position, the rover receiver sends its approximate position via a cellular message to the network control centre where computations

| | horizontal | vertical |
|---|---|---|
| Category I | 17.1 m | 4.1 m |
| Category II | 5.2 m | 1.7 m |
| Category III (precision approach) | 4.1 m | 0.6 m |

**Table 1. Positioning accuracy requirements for all flight categories**

are carried out for each user. The estimated network measurement corrections are interpolated for a virtual reference station (VRS) close to the rover position and instantly sent to it. Previous testing of the DVRS system for kinematic ground surveying showed that system positioning accuracy was typically 1-2 cm in planimetry and 3-5 cm in altimetry. For accurate determination of aircraft heights from the ground using GPS-derived ellipsoidal heights, a recently established accurate geoid model for Dubai was utilized.

## Concerns / recommendations

The duplex communication approach used for the DVRS network puts a restriction on the number of users, as this number is limited by the ability of the control centre to simultaneously perform calculations for different users. The problem can however be alleviated by using a one-directional communication method. In this case, one or two ground transmitters (repeaters) at the airport will be established; they will receive the reference-station measurement corrections from the control centre on-line and send them to the aircraft via VHF modems. The receiver on board the aircraft will then interpolate the corrections at its location. Thus, no restrictions exist on the number of users. The establishment of ground transmitters at the airport can also improve the current availability of the corrections.

Concerns related to the use of RTK networks in airborne navigation include:

- Due to the high dynamics involved in airborne navigation, a high update rate of sending the corrections is needed compared with that implemented for land applications, which currently range between 5 and 70 seconds.
- The format of GPS measurement corrections should be standardized to ensure that the system is independent of any single receiver manufacturer. This can be solved by adopting the RTCM standard for RTK multiple reference stations v3.0.
- The integrity of the system should be continuously monitored, and methods should be implemented to warn the pilot against any deficiency in the system.

## Testing the DVRS system

Several flight tests were conducted to study the use of the DVRS network for aircraft navigation. Two types of aircraft were used, a helicopter and a small fixed-wing airplane. A dual-frequency GPS rover receiver (Leica SR530) equipped with a DVRS GSM modem to receive the DVRS corrections was used. The test included the aircraft takeoff, enroute flying, landing and airport surface navigation. The data were processed at one-second intervals.

In the helicopter test, the GPS and GSM antennae were rigidly mounted on an arm approximately 0.9 m long extending outside the helicopter. The arm was attached to a frame rigidly fixed inside the helicopter. No arm vibration was experienced during flight. For better GPS as well as GSM signal reception during testing, the GPS antenna was mounted high on the arm for better visibility of the sky, while the GSM antenna faced down. Figures 2 and 3 show the system installation on the aircrafts. For the fixed-wing aircraft test, the GSM antenna was installed inside the aircraft, which is acceptable for GSM communication. Both tests were carried out over the city of Dubai.

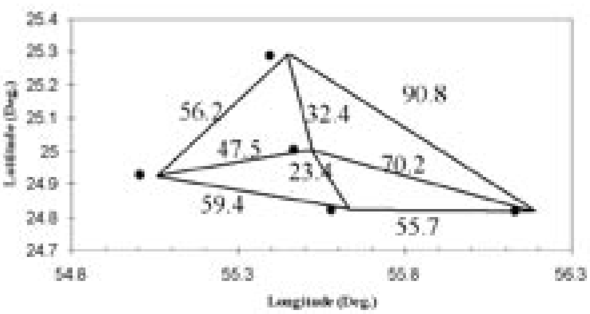


Fig.1 The DVRS Network

Figure 4 and 5 show the helicopter and the fixed-wing aircraft flying height and the 2-D and height positioning accuracies achieved during testing. The DVRS corrections were continuously received (dashed region in the Figures) during major parts of airport surface navigation, takeoff, enroute flying, landing and parking. During some periods, temporary loss of the signals took place. This can be mainly attributed to the use of GSM signals in sending the DVRS data, and partially to changes in the aircraft dynamics. In general, the carrier phase measurement ambiguities were resolved as integers and the average positioning accuracy, represented by coordinate standard deviations, were on the cm-level as shown in Table 2. During the periods where the DVRS corrections were received but the ambiguities were resolved in a float solution, the positioning accuracy was at the sub-meter level. However, when the DVRS signals were not received, errors grew to more than 3.5 m, which are only suitable for category I navigation (enroute flying).


**Figure 2. System instillation for the helicopter test**

**Figure 3. Testing using the fixed-wing aircraft**

| | Helicopter test | | Fixed-wing aircraft test | |
|---|---|---|---|---|
| | 2D (E&N) | Height | 2D (E&N) | Height |
| fixed solution | 0.022 | 0.034 | 0.016 | 0.028 |
| float solution | 0.322 | 0.539 | 0.263 | 0.525 |
| all test periods | 0.484 | 0.642 | 1.107 | 0.831 |

Table 2. Average positioning accuracies

## Solutions to the problem of breaks in reception of network corrections

### Integration with the Inertial system

One method to increase the availability of the positioning accuracy at the required level is to integrate GPS with an Inertial Measuring Unit (IMU). For testing purposes and due to hardware availability, a Honeywell tactical-grade (medium accuracy) IMU system of approximately 1-10 degrees/hour gyro drift was used. For simplicity, the GPS/INS integration was carried out in a decentralized loose coupling scheme. In this approach, the GPS and IMU (INS) filters ran independently in parallel. An adaptive Kalman filtering approach was employed in the processing of the test data. An integrated GPS/INS system is also beneficial in the sense that it gives high frequency output.

In addition, the INS is useful for determination of the attitude information of the aircraft, as well as cycle slip detection and repair, and ambiguity resolution, if a centralized filtering scheme is used. The test results showed that the accuracy requirements for precision approach (category III) were generally achieved up to 25-31 seconds of the GPS data outages. This was dependent to some extent on the aircraft dynamics.

### Prediction of the measurement corrections as a time series

Integration of GPS with an Inertial Measuring Unit (IMU) to bridge positioning during short breaks in reception of corrections is only a valid solution for a short period. This is due to the rapid deterioration of the IMU positioning accuracy in the standalone mode, as well as the increased cost and complexity of the hardware and software involved. Another approach is proposed for this task where all error components including corrections to the wet tropospheric error, the satellite orbital and clock errors are individually estimated at the rover. During data reception from the reference stations, the corrections are continuously modeled as a time series and accurately predicted for several minutes ahead. The double exponential and ARIMA models were used for this purpose. When a loss of reception of the reference station data takes place, predicted measurement corrections are added to the un-differenced observables, and accurate positioning is carried out in an autonomous precise point-positioning mode. Testing of this method showed that after 10 minutes of prediction, the positioning errors were still in the range of a few decimetres, and it was sufficient for Category III of navigation.

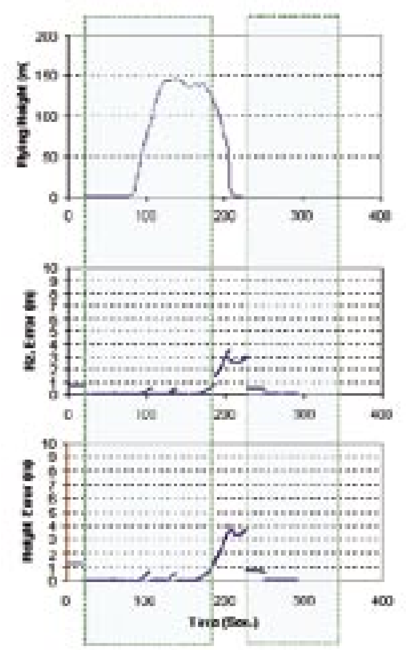

Figure 4. Helicopter test results

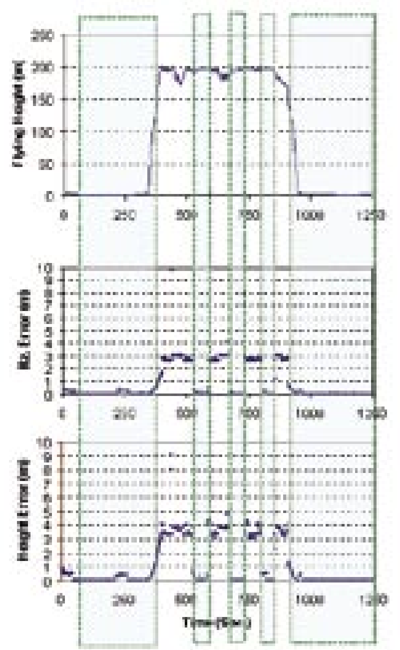

Figure 5. Fixed-wing aircraft test results

## Conclusions

The test results show that the use of RTK multi-station reference networks (e.g. the DVRS network) in precise aircraft navigation is feasible, particularly for the airport area. This new technology can increase the coverage area compared with other GPS-navigation systems, such as airport LAAS, with significant cost reduction. Small airports can thus benefit from this service. Efficient methods for bridging positioning should be implemented when reception of network corrections is interrupted. This can include integration with IMU or predicting the measurement corrections as a time series.

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# Shorten the road to done

# Developing a platform to facilitate sharing spatial data

The creation of an enabling platform for access to information and technology would help to lower barriers to access and use of spatial information and tools within the spatial information industry

Abbas Rajabifard, Andrew Binns and Ian Williamson

Users of positioning and spatial information services and tools require precise spatial information in real-time and real-world objects. Simply an accurate positioning of a future subdivision is no longer accepted, users require it to be visualized as well, in order to take into account outside influences. The capacity to meet such user needs and deliver services and tools within the spatial information market has gone beyond the ability of single organisations (Rajabifard, et al, 2005a). There is now a wide range of products and services available for a wide range of IT applications, and hence the development of an enabling platform can facilitate access to data and sharing resources and tools among different practitioners. The creation of an enabling platform for the delivery of these tools and positioning applications will allow users from diverse backgrounds to work together with current technologies to meet the dynamic market place.

Up until now, individual jurisdictions within Australia for example have started utilizing different platforms in attempting to create mechanisms for accessing and delivering spatial data and associated applications and tools in a coordinated fashion. This has been done through the use of hierarchies of information, where jurisdictions utilize information both by those within a jurisdictional level as well as those at a higher or lower jurisdictional level. The benefits of this sharing of information have been documented, however they do not necessarily break down the barriers between jurisdictions. Just because different information can be gained about Victorian state for example from different jurisdictional levels, does not mean that the information will necessarily be compatible (it may not be of the same accuracy or have the same specifications, utilize the same symbology, etc) (Rajabifard, et al, 2005b). There is now a need to create a common rail gauge within Australia to aid in implementing initiatives which solve cross-jurisdictional and national issues. In order to meet this need, there is a requirement for an enabling platform.

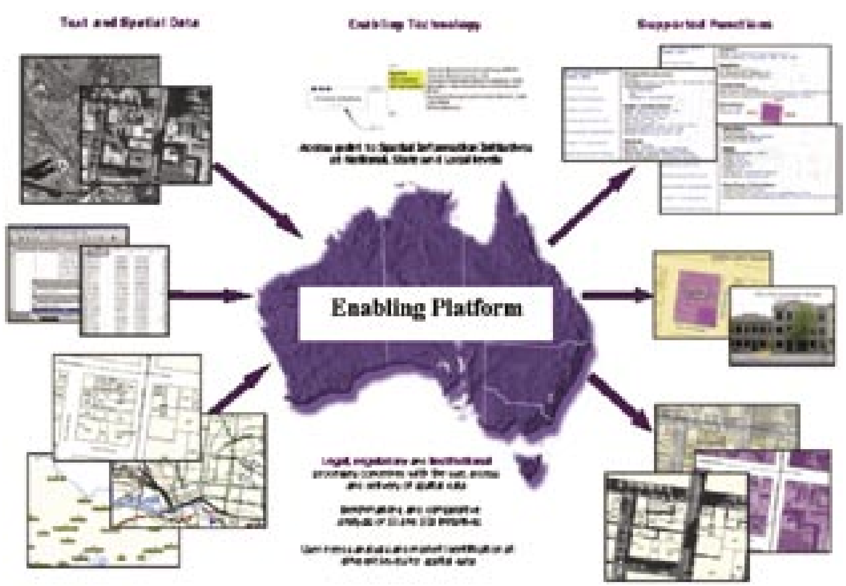


**Figure 1 – Development of an Enabling Platform**

## What is an enabling platform

The development of an enabling platform for a country or a jurisdiction will enhance the capability of government, the private sector and the general community in engaging in systems based, integrated and holistic decision making about the future of that jurisdiction. Applications, tools, and different sorts of information would be available through the platform to build a view of, query and allow decisions to be based on, both the built and natural environments. This platform must also include the administration and institutional aspects of such features, enabling both technical and institutional (eg. policies) aspects to be incorporated into decision-making. This is an aspect of research identified as more challenging than complex technical issues (Rajabifard, et al, 2005a).

The development of an enabling platform is being investigated within Australia by researchers in the Department of Geomatics, at the University of Melbourne. As part of this, an investigation within Australia of various spatial information initiatives has been undertaken in order to identify potential concepts and principles to facilitate the development of an enabling platform such as Virtual Australia. Overall, development of data sharing and access mechanisms for each jurisdiction was the major driving force in the majority of government activity at state and national level in Australia. This aims to reduce duplication of effort and expense occurring in creating data, infrastructure and a framework for data sharing throughout jurisdictions at all levels.

A lack of effective interaction between the traditionally strong land and property information focus of spatial information with management of the natural resources, scientific information and socio-economic information was also an issue. State Governments in particular however are addressing these issues through the creation of whole-of-government spatial information initiatives which, when appropriate jurisdictional and institutional practices in place, would contribute to and link off an enabling platform. The development of National initiatives such as Australia's Ocean's Portal and the Australian Disaster Information Network (AusDIN) along with the development of state based land information systems all have similar aims to that of the creation of an enabling platform – making information and applications widely available to users.

As Figure 1 shows, an enabling platform is an infrastructure that supports a knowledge base to access information derived from a model of integrated datasets from different disciplines such as the natural and built environments. It can comprise of individual organizations or partners working as a collaborative network to deliver specialized products and services for various applications such as animal and disease control and counter terrorism, on the basis of common standards (like OGC) and business understanding, creating distributed functions within the organisations (Radwan et al. 2003). It can also support ready access to applications of spatial information to support decision making at different scales for multiple purposes. It could be viewed as an infrastructure linking data users and providers on the basis of the common goal of data sharing across jurisdictions.

The creation of an enabling platform for access to information and technology would help to lower barriers to access and use of spatial information and tools within the spatial information industry. This lowering of barriers will enable industries to concentrate on their core business objectives to greater effect, would reduce duplication of effort, reduce costs and encourage investment in capacity for generating and delivering a wider range of products and applications (CRC, 2005).

## Creating an enabling platform

The investigation of current spatial information initiatives undertaken within the various jurisdictions of Australia provides insight into the facets of research needed to create an effective enabling platform. Government entities have identified the need for improved data access and sharing arrangements and have started building their data access platforms and virtual systems for jurisdictions. The development of an enabling platform needs to link with and build on technical and institutional experience and progress made towards the development and utilisation of ICT within jurisdictions.

The technical basis for delivery of whole-of-government on-line systems, investigated within Australian jurisdictions for example, would form the technical basis for the delivery of an enabling platform. This basis is through an interoperability architecture based on distributed, custodial data management and open standards to meet the needs of producers, users and other stakeholders in order to have the ability for information and services to be created once and used many times. Harmonization of data standards and specifications through the adoption of common data definitions, formats, models and exchange formats will be crucial to the success of an enabling platform. This will ensure that there is an unimpeded flow of data and information between the various users and producers of information and tools within an enabling platform. This will also provide uniform and consistent managed access to distributed web services operated by authoritative custodians. The aim of this architecture is to allow initiatives to grow in an open environment that gives agencies the ability to operate in an integrated manner. This creates an opportunity for a national initiative to develop from the often-fragmented developments occurring at State level in Australia. This type of architecture was seen to be the most effective method of creating a national initiative.

The ability to deliver the concept of an enabling platform for the delivery of spatial information and positioning tools and applications however will also require an investigation of the way that data will be stored in the future. The ability to allow massive consolidation of spatial data sets across all jurisdictions may enable the creation of a seamless enabling platform, although there is the need to look closely at the advantages and disadvantages of both a distributed data model verses a consolidated model. It is important to utilise the latest technology in the creation of an enabling platform, with new data base management software and technology promising to change the way in which data is stored. The benefits of such technology are already being seen in the concept of virtual libraries, the emerging GRID computing technologies and super servers throughout the world. However there is general acknowledgement that the major challenges in implementing an enabling platform are not technical, but institutional, legal and administrative in nature (CRC, 2005).

In order to develop an effective enabling platform, it is important that it is developed with the full cooperation of current initiatives within the research field. Currently in Australia, the majority of whole-of-government initiatives based at a state level are being developed through open standards based distributed network architectures. Technically, existing state based initiatives have the potential to contribute to the development of an enabling environment for Australia – however a lot of work needs to be done with respect to institutional practices to make the technology effective. There must have systematic interaction between developers and potential end-users to understand information and positioning needs as a data centric design approach is not desired. An enabling environment for all needs to be created which includes both a top-down and bottom-up approach based on current spatial information and positioning initiatives. To do this effectively depends on the ability to research and implement key institutional arrangements and a governance framework that encourages whole-of-government solutions to major economic, social and environmental issues. A pervasive feature of organisations world-wide, including Australian governments and industry is a reluctance to collaborate with others outside ones immediate work group. Where a strong business driver exists, then collaboration and sharing is possible, however negotiations are generally time-consuming and difficult and at best short-term rather than strategic long-term. This makes multi-agency cooperation on long-term projects very difficult to organize. An enabling platform would not only provide ready and seamless access to spatial data, information products and tools, but would also comprise jurisdictional governance & inter-agency collaborative arrangements for such cross jurisdictions and government-industry collaboration.

## Conclusion

An enabling platform aims to link public and private industries, facilitating the sharing of spatial information and positioning data, services and applications. The development of an enabling platform for Australia shows that it will enhance the capability of government, the private sector and the general community to engage in systems based, integrated and holistic decision making about the future of Australia. It will allow decisions to be based on a model where a wide variety of data/information in both vector format and raster format can be accessed to build a view of the nation's social, environmental and economic management. Development of information and communications technology, as well as developments in the area of computing and database management may begin to provide some other ways of going about the creation of an enabling platform. The research being undertaken within the Department of Geomatics aims to overcome the inherent, locked-in effects that current systems have created over time, providing an enabling environment in which spatial based applications and user communities can grow.


## Acknowledgements

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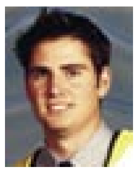


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# Signal propagation through the ionosphere

The Indian ionosphere is characterized by large horizontal gradients, intense irregularities, large day-to-day variations and equatorial anomaly conditions, there is clear necessity to thoroughly understand the ionospheric time delay effects on the GPS signals. The ionospheric delay error is a function of Total electron content (TEC) which is one of the dominant errors.

The ionosphere is the upper part of the earth's atmosphere between approximately 60 to 70 and 900 - 1000 km above the earth. The signal propagation is mainly affected by free charged particles. As the GPS signals travel through the medium, it is slowed down in a proportion that varies according to time of the day, solar activity etc. When light travels through the ionosphere it slows down at a rate inversely proportional to its frequency squared. The generation of ions and electrons in ionosphere is proportional to the radiation intensity of the sun, and to the gas density. Chapman profile is an indicative of the number of ions produced as a function of height. The exact shape of the profile and the related numerical numbers depend on several parameters. The spatial distribution of electrons and ions is mainly controlled by insolation of the sun and consequent motion of ionized layers. These processes create different layers of ionized gas in different heights. The main layers are known as the D, E, $F_1$ and $F_2$ layers . In particular, the $F_1$ – layer, located directly below the $F_2$ – layers, shows large variations that correlate with the respective sun spot number. The four principle layers are designated with height domains corresponding to approximately to 60-90 km (D layer), 90-140 km (E layer) 140- 200 km (F1 layer) 200 -1000 km (F2 layer). Also, geomagnetic influences play an important role. Hence, signal propagation is affected by solar activity, near the geomagnetic equator, and in high latitudes. Near the geomagnetic equator, the earth's magnetic field is horizontal along with the orthogonal dynamo electric field at E region heights. The electric field is eastward during the day and westward during the night. As a consequence, the dynamic eastward field ionospheric plasma from equatorial F region moves upward and then diffuses downward along the sloping magnetic field lines to low altitudes on both sides of the equator. The electron concentration is thus depleted on the magnetic equator and enhanced in two regions, one on each side. The phenomenon is known as equatorial ionization anomaly. Due to the variable insolation of the sun the spatial distribution of the layers varies during the day. The D-layer is only generated at the daylight side the earth. The distribution of ionospheric plasma is also affected by solar and magnetic disturbances like occurrence of solar flares etc. There is a short term i.e. 27 days and long term i.e. 11 years periodicity in solar activity. A radio signal when penetrates the ionosphere is modified by the medium due to the presence of electrons in the earth's magnetic field. The impact of the state of the ionosphere on the propagation of waves is characterized by the electrons content . The electron density is quantified by counting the number of electron in a vertical column with a cross sectional area of one square meter called TEC. The TEC is a function of amount of solar radiation. On the night side of the earth, the free electrons have a tendency to recombine with the ions, there by reducing the TEC. As a consequence, the TEC above a particular observation station on the earth has a strong diurnal variation.

The ionosphere is a disperse medium for radio waves.
Dispersion or differential time delay due to the ionosphere, causes pulse distortion and produces a difference in pulse arrival time across a band width $\Delta f$. If Ne is electron density then approximate correction "a" for the delay in signal propagation with reference to phase velocity component can be computed from

$$a = 1 - 40.3\ Ne / f^2.$$

The correction for group velocity component "b" is

$$b = 1 + 40.3\ Ne / f^2.$$

The effect of ionosphere on the phase and group velocity is equal in magnitude but has a different sign. The relationships for a and b indicate that the index of refraction, and thus the time delay of signal propagation, is proportional to the inverse of the squared frequency. Consequently, one part of the ionospheric delay can be modeled when two frequencies are used.

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*The Coordinates Class room espouse readers to graticules of Mathematics and Physics that epitomize the Geospatial Information Technology. A chain of structured presentations related to interdisciplinary principles that define Geodesy, GPS, GIS, Geospatial data management and Image processing are to be en suite in this section in each issue of the Coordinates. Initially the chain trembles with Geodesy which is the mother of technologies to position the Coordinates.*

# NSDI in India: The reality behind the dream

The National Informatics Centre, Government of India is organizing NSDI-V during December 18-21, 2005 at Hyderabad, India. On the occasion we present here the excerpts of recommendations of last four NSDI conferences. They, with the subsequent interviews, reveal moments of euphoria and despair, issues discussed and debated, and more importantly a resolve to pursue this dream

## 1st NGDI Workshop

February 5-6, 2001, New Delhi

Encapsulating the maps and images into National Spatial Data Infrastructure (NSDI) is the need of the hour and the emphasis has to be on information transparency and sharing, with the recognition that the spatial information is a national resource and citizens, society, private enterprise and government have a right to access it, appropriately. Only through common conventions and technical agreements, standards, metadata definitions, network and access protocols will it be easily possible for the NSDI to come into existence," Dr. K. Kasturirangan, Chairman, Indian Space Research Organisation (ISRO) writes in the foreword of Discussion Document on National Spatial Data Infrastructure (NSDI): Strategy and Action Plan. During the valedictory session, two sub groups were constituted. One Standard subgroup that was to recommend data standards, metadata standards, exchange standards and the formats while the other Network subgroup was supposed to focus on technological issues connected with networking and accessibility. The need was also felt to evaluate the needs of Human Resource Development.

The workshop can be considered as a landmark development on two counts: one, it was a first public poser of Government of India on NGDI and second, is the release of a discussion document NSDI: Strategy and Action Plan. The discussion document was well received and appreciated during the workshop and held long term prospects in making NGDI a reality. The document is very comprehensive as it discusses not only the need, content, design elements of NSDI but elaborates upon its organisational framework, funding mechanism and implementation.

*The first NGDI workshop enthused the geomatics community in India with an anticipation of new era. Also there were interesting debates on the name itself whether 'spatial' or 'geospatial'. Later on it was the spatial lobby that got its way. And one can notice the change in name from NGDI to NSDI onwards.*

## 2nd NSDI Workshop

Ooty, Tamil Nadu,
July 29-31, 2002

This Ooty Communiqué for NSDI is adopted at the 2nd NSDI Workshop at Udhagamandalam (Ooty), Tamil Nadu.

In the Indian context, NSDI envisions the creation of a structural framework of spatial information for sustainable development at all levels – individual, community, village/city, district, State and the Nation and to leverage economic growth. The Department of Space and Department of Science and Technology have taken the initiative to define the NSDI Strategy and Action Plan - which has been enthusiastically endorsed by all concerned government departments, the corporate sector, academia and NGOs.

It is recognised that core competence has been created - in terms of human expertise, GIS databases, software tools, operation and maintenance of a spatial databases and utilisation. The NSDI datasets would include the holistic domain of varying types of data that are based on top-down and bottom-up collection strategies. Many of the major spatial data producing agencies are ready to provide their spatial datasets to the NSDI. Further, it is also clear that the definition, vision, perspective and implementation plan for NSDI now exists.

It is noted that the NSDI Task Force has made considerable progress in defining the technical design of NSDI and its attendant Standards on: NSDI Web-Server, NSDI Content, NSDI Metadata, Search and Access, NSDI Network and NSDI Exchange. It is also noted that work is in progress for defining NSDI Quality Standards; the NSDI Datum/Projection Standards; the NSDI Access Rules and a plan for human resources development for supporting the NSDI.

It is resolved that NSDI should become operational at the earliest.

### Recommendations

The Workshop tasks the NSDI Task Force to urgently prepare a well researched, comprehensive policy document which is consistent with the NSDI objectives. The Workshop urges that such a policy document be collectively endorsed by the stakeholders of NSDI and placed before the highest levels of decision making in the Government for consideration and adoption at the earliest.

The NSDI should emerge as an empowered apex authority for making and administering policies with reference to spatial data, definition and evolution of NSDI standards, designing and implementation of NSDI Servers, define mechanisms for spatial data quality for NSDI, define rules and guidelines for NSDI Access, define rules/guidelines for agency participation in NSDI, constantly widen the scope of NSDI and ensure support for better governance and socio-economic development.

All organisations, institutions and persons in the public or private sector having spatial data assets which can conform to NSDI standards must be encouraged to participate in NSDI.

The NSDI Metadata Standard and the NSDI-Exchange Format as prepared by the NSDI Task Force should be taken up for a Standards Adoption Process by notifying them for public discussion (on the net) and then adopting them. The Workshop tasks the NSDI Task Force to initiate this process and formalize the Standards before adopting them as Version 1.0. The Workshop also charges the NSDI Task Force to formalize the NSDI Metadata Server, as designed, at the earliest so that it can be the first step towards NSDI operationalisation.

Make optimum use of the presently available NICNET, other high bandwidth public/private networks to support NSDI; continuously support the expansion and enhancement of such networks to eventually enable effective utilisation of NSDI.

User requirements must be yet another driver of NSDI and thus the target application potentials of NSDI must be properly assessed and defined. The NSDI Task Force could take up a specific assessment on this.

NSDI Task Force is urged to make specific efforts to quickly complete important mapping programmes - availability of topographic maps in digital format for developmental applications by (March 31, 2003 as mentioned by SOI); availability of information on village location and boundaries and other applications (in about a year's timeframe by involving Census, SOI and NRSA).

The private sector is seen as a partner in the NSDI initiative and its role is envisaged as providing IT solutions, services, human resources development and infrastructure, as also for committing its own data assets to such an infrastructure. The NSDI will proactively work towards bringing in an attitudinal change in the business environment governing spatial data in the country and usher in an era of innovative public-private partnerships towards the growth of a knowledge-based economy and society.

## 3rd NSDI Workshop

### 12-14 November 2003, Agra

### Recommendations

The recommendations in the communiqué are:

- The National Map Policy must be formalized at the earliest and its operational implementation taken up.
- An assessment of any consequential impact of the National Map Policy on NSDI and its activities must be made and solutions enabled by the NSDI Task Force.
- The efforts to institutionalize NSDI must continue and all formal clearances and approvals obtained at the earliest – so that the NSDI, as an institution, can be positioned.
- All organizations, agencies, institutions, be they from the government, private or non-government sector, and who have spatial data assets must be encouraged to participate in the NSDI. NSDI may establish procedures and mechanisms for this to happen.
- The NSDI Metadata Standard (Version 3.0) is hereby adopted and all NSDI agencies are encouraged to generate their Metadata according to this Standard. However, a review mechanism of the Standard could be established to regularly update the Standard.
- Similarly, the NSDE Standard (Version 1.0) is also adopted and all NSDI agencies are encouraged to conform to this exchange standard. NSDI, by involving GIS vendors and others, must enable the development of solutions and translators for the NSDE.
- NSDI recognizes the need for technical, institutional and organizational inter-operability and recommends that NSDI commit itself to enable inter-operability and be in line with international efforts, such as OGC, ISO.
- The NSDI Metadata Server and the NSDI Portal efforts be integrated and the NSDI services made operational at the earliest. Agencies are urged to populate their Agency Metadata for the NSDI Metadata Server using the NSDI Metadata Utility at the earliest.
- The demonstration efforts of the NSDI Data and Application Services be continued to evolve a sound design for the Data Servers and value-addition on NSDI. Appropriate standard documents for the Data Server and Applications Services need to be prepared.
- There is an urgent need to take up standardization efforts in the following areas:
  - — Content and Design of NSDI
  - — Applications and Value-Addition
  - — Quality Standards
  - — Network design
  - — NSDI Policy/Guidelines for agency-participation and Access Rules
- The scoping of NSDI must now address assimilating spatial data available at large scales – and especially those which are not based on spatial framework of SOI maps. Studies and assessments need to be made in this direction – especially on standards, linkages and applications of such datasets.
- The NSDI must enable a framework under which spatial information systems and

applications can be encouraged at village, district and state level and these need to be assimilated into the infrastructure. In this manner, NSDI could become a tool for empowering people.

- The private sector has a major role to play in NSDI and leverage its capabilities in providing SDI technologies, SDI solutions, SDI services, SDI human resources development and infrastructure establishment, as also for committing its own data assets to such an infrastructure.
- A separate assessment for Public-Private Partnership model for NSDI – with clear definition of roles and responsibilities of stakeholders and sharing of benefits from NSDI needs to be made.
- The NSDI framework must position foundation partnerships with stakeholders based on financial equity principles and build for itself a viable financial model of growth and sustenance through public-private funding approaches.
- NSDI must develop bi-lateral links with nations that have strong SDI programmes for establishing a mutually beneficial partnership. Similarly, NSDI must also actively participate in multi-lateral SDI programme and leverage Indian competitiveness in the global arena.

## 4th NSDI Workshop

17- 19 November 2004

### Recommendations

This Lucknow Communiqué for NSDI is adopted, by the 98 delegates from 35 departments/agencies, at the 4th NSDI Workshop at Lucknow, Uttar Pradesh on 19th day of November, 2004.

1. Work for establishing a mechanism for NSDI opera tionalisation through appropriate clearances and approvals.
2. Urge the early release of the National Map Policy which will enable the positioning of spatial data and application/services on networks and enable the implementation of the NSDI vision and goals. The policy must be comprehensive and inclusive of spatial data/information.
3. Agencies from the government, private and non-government sector - who have spatial data assets and solutions are urged to integrate their efforts and participate in NSDI. It is the collective efforts of all agencies that can bridge the gaps in supporting critical applications like disaster management, infrastructure development, natural resources management etc
4. Urge all agencies to populate their metadata and position metadata servers. An immediate effort to develop an integrated national Metadata server/clearinghouse, encompassing links to agency servers is required. This would enable the first element of NSDI - Metadata Services to become operational.
5. Encourage generation of national-level innovative content through the use of advanced technologies and positioning updated and accurate theme-oriented maps.
6. Developing national standards for NSDI - encompassing Content standards; GIS Design standards; Toponymy standards; Quality Standards; Application Metadata Standards; Network design and protocols and appropriate Policy/Guidelines for agency-participation and Access Rules is critical for the further progress of NSDI. Noting the efforts being made by different agencies (like the efforts of NNRMS to draft GIS Standards), it is essential to integrate standardisation efforts and position a National Spatial Data Standard for adoption by all.
7. NSDI must aim to establish interoperable spatial data and products/services across platforms and software products. To this end, NSDI needs to examine the level of compatibility and harmonization of national NSDI standards with international efforts of standardisation through the works of OGC, ISO etc. In this, the involvement and commitment of the software product suppliers is important.
8. It is recognized that private sector would be the main source for SDI technology, solutions and services - which would be the backbone for NSDI. With a concerted effort towards Public-Private partnership for NSDI, there is a need to articulate the mechanisms for active private sector participation in NSDI.
9. There is a need to pursue a research agenda for NSDI - specifically encompassing topics like, standardisation, semantics, ontology, toponymy, GI market, pricing policy, GI Business Models etc. The mechanics of involving academia and enabling research projects at universities and institutions needs to be looked into.
10. The demonstration efforts of NSDI for supporting national development must be continued to bring about a larger awareness of the benefits of NSDI.
11. With the aim of leveraging the benefits and advantages of NSDI in society, a concerted campaign for generating larger awareness on NSDI amongst professionals, stake-holders, users and the public needs to be continued.
12. Noting the successful conduct of the GSDI-7 Conference and the acceptance of the offer made by India to the GSDI Association to host the GSDI International Secretariat in India, efforts to strengthen the linkages with GSDI, through development of institutional and programmatic linkages, and establishment of the international Secretariat must be pursued.
13. NSDI must continue to strengthen and further develop bi-lateral links with nations that have strong SDI programmes and enable mutual benefit.

## "NSDI has come a long way"

says Dr R Siva Kumar, head, NRDMS & NSDI Division, Ministry of Science and Technology, Government of India while assuring that it will be reality very soon

### Where is NSDI at the moment?

NSDI has come a long way after Lucknow. We had successfully gone through the process of consultation and now we have agreed to create NSDI as envisaged by the Task Force and all the stakeholders. It is at the final stage of approval and Government notification is likely to be issued very shortly.

### Any time frame?

It should not take more than three months time.

### Any hurdles in creation of NSDI?

I do not foresee any hurdles in issuing of government notification at the moment. What is bothering me is the preparation of stakeholders within their organizations with regard to establishment of their nodes, converting their own data into digital data and making the data accessible and available as envisioned in the NSDI.

### Is it an institutional issue or temperamental issue?

It is basically an Indian issue. It takes time for us to assimilate and carry forward and there is some justification for lethargy as there was delay in realizing NSDI in India for various reasons. All these contentious issues have been buried and we do not have any controversial issue at the moment. We are very hopeful now.

### What about the synergy needed among various participants in NSDI?

We are expecting total synergy to be there and there is a lot of enthusiasm and more people are coming forward to take part in the NSDI – both government and non-government.

### Any landmark happening in NSDI-V?

With regard to NSDI-V, we would like to show some of the technical activities we have done and probably we would be able to share some prototypes of electronic clearing house and conceptually we will be able to demonstrate the activities at NSDI-V.

### NSDI is for whom? For the Government of India or for the people of India?

NSDI is for the people of India. Had it been as for the government, there would have no problem or delay.

## "NSDI is a reality"

observes Dr Vandana Sharma, Senior Technical Director, National Informatics Centre

### NSDI, a dream or a reality?

NSDI is a reality. Many organizations are working together to make it a reality. This has been a dream long time back and now converted into reality by the efforts many organizations including NIC. NSDI definitions have emerged later but NIC is working in this area for more than 15 years. It has been working in this direction by speeding up digitization process through joint support of many organizations, conceptualization of NSDI and by evolving processes systematically.

### How much NIC is prepared to function in proposed framework of NSDI?

It is not the question of being prepared. NIC has been playing a leading role in achieving the goals of NSDI. NSDI has deliberated extensively the metadata standards and data exchange formats. NIC has already made database operational with mirror side concepts. The website of NIC provides spatial data conforming map policy and is being used by more than 3000 users all across the country. NIC is also making models for grassroots levels deliverable systems up to district levels.

### Who leads NSDI?

NIC is a partner to NSDI concepts. We feel that that many organizations have to play the lead role depending upon there core competence and vision. It is a joint initiative.

### Are you still struggling with issues pertaining to data ownership?

NIC has extensively deliberated this issue with concerned organizations. We strictly believe that ownerships rights need to be preserved with the data providing agencies. However part of the data must flow to national database around which various applications can be customized. We feel that many organizations are willing to disperse the data to various users and looking for web based methods to do so. But wherever it concerns with the sale of formatted data, we shall go totally by data owner's policy. We can display data but downloads should be done according to the policies of the concerned agencies.

### What do you expect from coming NSDI workshop?

Every time we meet at NSDI, issues are to be discussed, progress should be assessed and solutions should be explored, and future goals need to be set. NSDI is an ongoing process and this yearly meet does provide an opportunity to various stakeholders and to discuss and deliberate together various important issues. This year the theme is Bharat Nirman.

## “NDC is ready with image data”

says R Joseph Arokiadas, Group Head, NRSA Data Centre while sharing his perspectives about NSDI

### What role you see of NRSA in NSDI?

We have developed a image portal and we hope that will be very useful to the user community. In fact, we have categorizing our data in three categories, Data of 56 m resolution are categorized in coarse data. Medium data with resolution of 23 m and in high-resolution category we have data of better resolution than 5 m. Data up to 5 m resolution are available to all.

### How to access these data?

We are planning to make data available on the web. Once that happens then users form government and non-government both can get the benefit from it. We are also planning to make cartosat 2 data available off the shelf.

### Your perception about NSDI?

The idea to make data available for developmental purpose in itself is very good. The positive thing is that all the leading organisations including Department of Space, Department of Science and Technology and National Informatics Centre are working together very closely and in a positive direction. As far as NRSA Data Centre, NRSA is concerned we are ready with image data.

### There is a perception that to get high resolution data from NRSA is a tedious process. Comment.

We follow Remote Sensing Data Policy. An open sky policy is followed for data of poor resolution than 10 m. However, we mask certain areas of security concerns if images are of better resolution than this. In case it is of 1 metre or better resolution than 1 metre, then such requests need to get approved by a committee.

### What relevance you see of such policies in view of images available with google earth given the concerens expressed by President of India himself?

We are also concerned.

## “There has been a sea change in attitude of spatial data users and provider”

says Brig M V Bhat, Deputy Surveyor General, Survey of India while sharing the recent developments in NSDI with Coordinates

### What are the initiatives to ensure availability of spatial data?

Several initiatives have been taken by the Government of India to ensure availability of reliable and accurate Spatial Data to users. Prominent amongst them being the NSDI initiative and the National Map Policy of Government of India. National Spatial Data Infrastructure initiative of Department of Science and Technology and Survey of India provide a platform for interaction between data providing agencies and users. The primary objective of NSDI is to act as a gateway between the information generating agencies and users. The right to information act passed by the Parliament (Govt. of India) is a constructive and positive step.

### What is so great in National Map Policy?

The NMP envisages unshackling of many of the extant restrictions as regards to availability of and access to Survey of India maps. A new generation of maps based on the WGS-84 system called the “Open Series Maps (OSMs)” will be put in the public domain. This is expected to open up unprecedented opportunities in business, involving maps. All players will be able to access accurate and updated spatial data for use or subsequent value addition.

### National Map Policy was announced some time in May? It was to be followed by guidelines from Survey of India?

Guidelines have already been framed and would soon be in public domain.

### Has the life of map users changed since the map policy was announced?

Although data are yet to be provided as per the new map policy, it has surely impacted a sea change in the attitude of spatial data users and data providers. This is evident from the fact that the number of major data users, both in government sector and other public users, has increased considerably.

### Has NSDI in India is lost somewhere? We have not heard anything about this since long.

I would like to inform you that NSDI is very much on the agenda of the Government. Only the publicity has not been there. The NSDI bill has been accepted by the Committee of Secretaries. It is a major step forward and very soon it is hoped to be a reality.

### NSDI is for whom? Is it meant for the government or for other data users also?

NSDI is a gateway of information from information providers to various stakeholders which include government agencies, private sector, industry, academia and common man.

# Photogrammetric Mapping

A case study on advantages of digital photogrammetry to analytical photogrammetry

MRIDUL KUMAR

A case study of El Salvador City has been done using various photogrammetric techniques. This project comprised the complete new mapping of the town including all features like buildings, boulevards, roads,manhole/ drainage, light / telephone polls, trees /tree areas, ponds, river and streams (with break lines), Monuments, playground / Parks etc. The vectorization of the model has been done on Digital (Socket Set) and analytical systems both. From speed point of views digital systems are as good as analytical systems. It also depends on the skills / expertise of the Operator who is preparing the maps.

Material used Two Diapositive with a scale of 1:5000, Two scanned images with 14 micron per pixel and two images with a resolution of 24 micron per pixel. Scale of Photographs: 1: 5000

## Methodology

An appropriate method for assessing the accuracy of derived data and the impact of parameters on the data is to carry out tests using independent check data in the object space. Quality control, or checkpoints with a known elevation considered to be true, were used for accuracy assessments and were measured using DGPS (differential global positioning system). Diapositives are used in Analogue (A8 & AMH) and Analytical plotters (BC3, SD2000).

To start a project on analogue/ analytical systems, Ground Control Points (CP File) is required or created for the entire area / model. In these plotters one MD file (orientation parameter file) is created for every model using control points.

In Analogue Machines, orientation is totally manual. Inner Orientation is done on a light table where four fiducial points are brought in fiducial axis marked on the picture carrier plate on which the diapositive is mounted. Later, it is mounted on instrument for RO and AO. In Relative Orientation Y-parallax are removed using Kappa, Phi and Omega. After that Absolute orientation is performed where Known GCP's are measured. It takes more than half an hour to orient a single model.

In Analytical Plotters, orientation is automatic. For making orientation parameter files (MD Files), first of all, diapositives were mounted on instrument and started with Inner Orientation. It starts with left image followed by right image. These are automatic instrument even then coordinates at first two fiducial points were measured manually. Later it reads remaining six fiducial points automatically. The same process is done for right photograph. The RMS value of IO should be less than 10. Epipolar Orientation follows inner Orientation where parallax is removed manually at two points. After the Epipolar orientation, Relative Orientation is performed. During RO process, Y parallax is removed at least at six points or maximum at 10 points. For Absolute Orientation, ground control points are measured and RMS is noted. After AO process, model becomes ready for data extraction / map production.

For Digital Photogrammetry, photographs were scanned, using an LH System's photogrammetric scanner, at a resolution of 14 microns and 24 microns per pixel prior to reformatting and transfer into the Socket set Digital Photogrammetric Workstation (DPW). Full details of camera calibration parameters were supplied to enable interior orientation to be carried out. All processes like IO, RO and AO are done for digital systems also. Stereo model were constructed using pre-marked ground control points positioned using post-processed differential GPS. Subsequent analysis involved the calculation of residual values produced by comparing the computer-generated surface with a set of test points measured using differential GPS. This research demonstrates that the optimal digital system matched the performance of analytical photogrammetry for the feature extraction.

## Observations

After AO process, RMS is checked. About 20 points were observed in Analytical and Digital system. Later these points were compared with known GCP's.

### Following RMS values are obtained in Analytical system:

Residuals on photo coordinates (microns) and ground coord. ( Metres )

| | PY | DXG | DYG | DZG |
|---|---|---|---|---|
| RMS: | 1.2 | 0.036 | 0.031 | 0.078 |

Planimetry = 14.0 cm

Altimetry = 10.0 cm

### Following RMS values are obtained in Digital system:

Residuals on photo coordinates (microns) and ground coord. ( Metres )

| | PY | DXG | DYG | DZG |
|---|---|---|---|---|
| RMS: | 1.4 | 0.056 | 0.081 | 0.098 |

Planimetry = 17.0 cm

Altimetry = 12.8 cm

The above result is from photographs with a scale of 1:5000

Note: - If photographic scale is small like 1:25000, then RMS may be different. Planimetry accuracy may go around 50 cm and Altimetry accuracy may go around 80 cms.

## Discussions

For stereo compilation, the Analytical plotter is a clear winner. For large-scale mapping, softcopy systems couldn't resolve the finer details that Analytical plotters could do.Through observation it has been found that Analytical systems give better accuracy up to 5-10 cms whereas digital systems give an accuracy of 09-13 cms. Since diapositive has continuous tone so it doesn't get blurred while zooming and gives better view and results whereas digital images can't give the same results as these are having pixel. The size of the pixel of these images depends on the scanning (DPI) and resolution of Photographs. If one image has a pixel size of 14 microns (Scale 1:10000) and other image has pixel size of 24 microns (Scale 1:10000) than we would get better accuracy with the image having pixel of 14-micron size. That means if the resolution were better, the accuracy would be better.

With regards to Image Quality the vote went in favour of the Analytical plotters although several users said that the difference, particularly on the higher resolution (15 microns) was not that great.

For DEM generation, there is a positive feeling amongst users that softcopy system are as accurate or better than Analytical plotter and that correlation gave the softcopy system a distinct advantage.

Aerial triangulation is also an area where the softcopy system performed well and many users stated that they achieved faster and easier production. If the only function of softcopy was stereo plotting, it appears that their impact would be considerably less than we are experiencing. However, the softcopy systems are more in use and covers in many areas of map production in a single system.

Through softcopy systems, one has the option for number of applications, all in the same environment (compilation, DEM, draping of contours, orthogenertion etc.) and softcopy systems are less expensive.

## Results

Evaluated the accuracy of orientation parameters as well as the quality of datasets of analytical and digital systems. Also checked the data accuracy obtained through images with a pixel size of 14 microns and 24 microns. Dataset from 24 microns per pixel is of inferior quality.

## Production Accuracy

From accuracy point of views, for stereo plotiing, Analytical Plotters give better accuracy as compared to Digital Workstations. Regarding DTM generation, softcopy can be considered better.

## Conclusion

In Photogrammetry, aerial data is being used for Mapping and Up gradation of urban sprawl. Both digital and analytical techniques offer potential for those interested in recording surface features. However, selection of the technique needs to be based on a careful consideration of the end products required. In general, this research shows that digital photogrammetry performs well but comparative analysis of Analytical and digital dataset, on the basis of equal resolution, shows that analytical instrument give a better planimetric and altimetric (Z-value) accuracy than Digital workstations.

At present, both analytical and digital

## Advantages of softcopy photogrammetry

This comparison of analytical and digital techniques has shown that Digital Photogrammetry have greater advantages to analogue / analytical plotters as better stability (geometry and radiometry), good accuracy, and the ability to process images. It is also possible to display vector data in the images on the screen and to produce transformed images (rectification, Orthophoto). Today the handling and use of digital images on standard PC's is possible up to the final production of orthophoto mosaics and contour lines without problems. Digital Photogrammetry Workstation offer other additional products including fly-through, image drapes, view shed analysis tools, orthophotographs and image analysis tools.

There are several other advantages connected with using digital images which are as follows:

- Production Efficiency is very good.
- No Instrument calibration is needed.
- Measurements are automatic and faster.
- No repetitive IO, RO & AO to start a model.
- Stereo images can be reconstructed very fast.
- DTM and Orthophoto generation is automatic.
- Single model as well as strip / block orientation is possible.
- No constraint of focal length bracket as in analogue system.
- Digital images are more stable as compared to film material.
- Integration with Remote Sensing facility, real time data updation.
- 3- D graphical superimposition facility for automatic feature extraction.
- Automatic measurements possible with correlation techniques.
- Digital image processing techniques can be used for image enhancement.
- Simple to Operator, no wear and tear of mechanical and optical parts compared to Analogue and Analytical Instruments.

systems offer solutions for utility mapping and research. However, as shown in this case study, the digital data capture systems can't compete on accuracy terms with analytical systems but offer many potential advantages in terms of data collection time and other end products, which are available. However, despite the increasing user friendliness of many of the digital systems, a high level of expertise is still required.

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*This article is printed in our efforts to promote new authors*

## MARK YOUR CALENDAR

### December 2005

Gulf First Urban Planning and Development Conference
12-14 December 2005, Kuwait
http://www.gulfurban.com

Gulf Traffic - GIS Zone
12 - 14 December, Dubai UAE
**davyd.farrell@iirme.com**
http://www.gulftraffic.com

ITC 55 years Lustrum Conference
14 - 16 Dec 2005
The Netherlands, Enschede
**verburg@itc.nl**
http://www.itc.nl/news_events

Vietnam Crop Information System International Seminar,
15 December 2005, Army Hotel, Hanoi, Vietnam.
http://vicis.airects.net/

5th International Workshop on Web and Wireless
Geographical Information Systems, Lausanne, Switzerland
15-16 December 2005
http://lbd.epfl.ch/e/conferences/w2gis05/

NSDI for Bharat Nirman
18-21 December 2005
Hotel Sitara, Ramoji Film City, Hyderabad, India

### January 2006

First Asia-Pacific Conference for ESRI Users
January 12-13, 2006 · Hong Kong, China
http://www.esrichina-hk.com/apuc2006/

International Symposium: Informatics for Geoinformatics
23-25 January 2006 Ostrava, Czech Republic
**www-gis@vsb.cz.**

Regional GBIF training workshop for Southeast Asia
25-27 January 2006. Lucknow, India
**www.gbif.org.**

### February 2006

International LIDAR Mapping Forum 2006
13-14 February, Denver, U.S.A
**organizer@lidarmap.org.**

Urban Planning & Regional Development in the Information Society
13-16 February Vienna, Austria
http://ivfl.boku.ac.at/3DRSForestry

International Map Trade Association (IMTA) Global Conference and Trade Show 2006
24-25 February Cesky Krumlov, Czech Republic

10th Annual Integrating GIS & CAMA Conference
19-22 February, Orlando, Florida
www.urisa.org

### March 2006

Asia GIS 2006 International Conference
9-10 March, Universiti Teknologi Malaysia
**b-haris@utm.my**

United NationsGroup of Experts on Geographic Names (UNGEGN)
28 March-4 April, Vienna, Austria
http://unstats.un.org/unsd/geoinfo/ungegn.htm

### April 2006

Location Intelligence Conference 2006,
3-5 April, San Francisco, U.S.A
http://www.locationintelligence.net/conference

GITA's Annual Conference 29
23-26 April, Tampa, Florida, USA
http://www.gita.org/events/annual/29/index.html

### May 2006

ASPRS 2006 Annual Conference
1-5 May, Reno, Nevada, U.S.A
http://www.asprs.org/reno2006/

Intergraph 2006 Conference
7-12 May, New Orleans, Louisiana USA
http://www.intergraph2006.com/default_flash.asp

### June 2006

2006 GeoTec Event
18-21 June, Ottawa, Canada
http://www.geoplace.com/calendar

### July 2006

COAST - GIS 06 – 7th International Symposium on GIS and Computer Cartography for Coastal Zone Management
13-17 July Wollongong and Sydney, Australia
http://www.coastgis.org/

### August 2006

3D GeoInfo '06 Workshop
7-8 August, Kuala Lumpur, Malaysia

2006 ESRI International User Conference and 4th Survey and GIS Summit
7-11 August, San Diego, California
http://www.esri.com/events/uc

3D GeoInfo '06 Workshop,
7-8 August 2006. Kuala Lumpur, Malaysia
**alias@fksg.utm.my**
www.gdmc.nl/zlatanova/3Dgeoinfo2006/index.html

# Galileo update

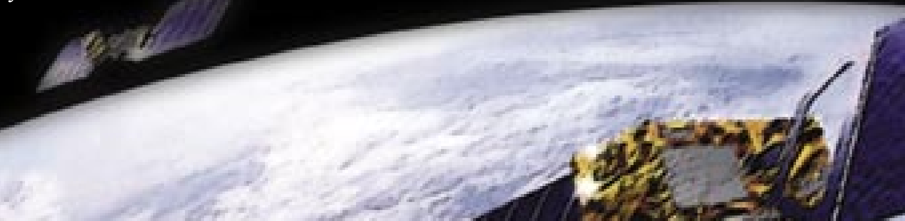
**Galileo – the European Programme for Global Navigation Services for civil purposes is an initiative led by European Union. We provide regular updates to our readers on the Galileo programme.**

## China joins Galileo space-based application projects

A Chinese general contractor for the European Galileo Project in Beijing recently obtained three space-based application projects. The Galileo Joint Undertaking (GJU) endorsed the China Galileo Industries (CGI) to develop search and rescue radar transponders (SART), laser retro-reflectors and up-link stations (ULS). Meanwhile, the Early Galileo Services in China (EGSIC) and the Galileo Olympic Games Demonstration (GOGD) are also open for public bidding. China was the first country outside Europe to join the Galileo Project, agreeing to invest a total of 200 million euros into the global consortium. About 70 million euros of the Chinese investment have been put into technologies development and the remaining 130 million euros into deployment of space and ground infrastructure. http://english.people.com.cn

## EU unveils first Galileo satellite

The first of some 30 satellites of the European Union's Galileo satellite navigation program was unveiled one month before it will be launched into space. The "Giove A" satellite will be launched in the second half of December by a Russian Soyuz rocket from the Baikonur Cosmodrome in Kazakhstan. The Galileo program will now truly begin with the launch of this first satellite. The satellite was unveiled at a brief ceremony at the European Space Research and Technology Centre in Noordwijk, the Netherlands. A second satellite named "Giove B" - 'Galileo In-Orbit Validation Element' - will be launched in the Spring of 2006. The first two satellites are important for testing the Galileo program from space, the European Space Agency said in a statement. http://seattlepi.nwsource.com




## The world's lightest cable-free RTK GPS system – the latest innovation from Leica Geosystems

SmartRover is the lightest cable-free RTK GPS system in the world and is fully compatible with SmartStation, the world's first total station with integrated GPS. Use SmartStation to position your total station and then transfer the SmartAntenna and continue RTK GPS surveying with the cable-free SmartRover. Enjoy outstanding performance at a fraction of the weight of current all-on-the-pole systems. Reduce operator fatigue and maximize productivity, the new SmartRover from Leica Geosystems, the surveying specialist.

**Leica SmartRover**

- All-on-the-pole convenience
- Weighs only 2.8 kg
- Full compatibility with Leica TPS1200 and SmartStation
- WinCE and Bluetooth™ wireless technology
- Best GPS result with SmartTrack and SmartCheck
- Your perfect companion for demanding tasks

The state-of-the-art Leica SmartRover delivers outstanding performance, is fully compatible with SmartStation and is designed to grow with your needs. Take a load off your mind and shoulders; call for a SmartRover demonstration today and experience it for yourself.

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