RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th /20th of every month at NDPSO

No: DL(E)-01/5079/08-10
Licensed to post without pre-payment U(E) 28/2008-10
Rs.100

ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume V, Issue 12, December 2009

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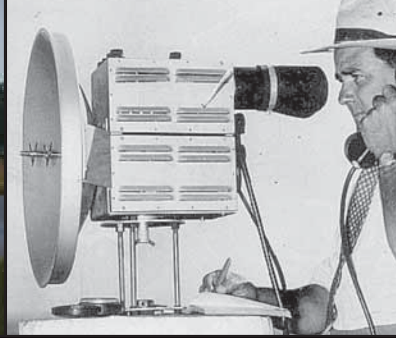

In this issue

Coordinates Volume 5, Issue 12, December 2009

Articles

Practical multivariate statistical multipath detection methods Lawrence Lau 7 **The Tellurometer** J R Smith 15 **Sustainable land governance** Stig Enemark 27 **GPS equipment accuracy testing** N K Agrawal 34

Columns

My Coordinates Editorial 6 **Your Coordinates** 16 **His Coordinates** R Siva Kumar 14 Bryn Fosburgh 17 **News** LBS 35 Galileo update 36 GPS 36 GIS 38 Remote Sensing 39 Industry 40 **Mark your calendar** January 2010 to November 2010 42

This issue has been made possible by the support and good wishes of the following individuals and companies Bryn Fosburgh, J R Smith, Lawrence Lau, N K Agrawal, R Siva Kumar, S L Dhingra, Stig Enemark and Geoeye, Hemisphere GPS, Javad, Magellan, Navcom, NovAtel, NRSC, Leica, South, Trimble; and many others

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Annual subscription (12 issues) [India] Rs.1,200 [Overseas] US$80

Printed and published by Sanjay Malaviya on behalf of Centre for Geoinformation Technologies at A221 Mangal Apartments, Vasundhara Enclave, Delhi 110096, India.

Editor Bal Krishna

Owner Centre for Geoinformation Technologies

Designed at Thomson Press India Ltd.

Printer Thomson Press India Ltd., B 315, Okhla Phase I, New Delhi-110020, India

This issue of Coordinates is of 44 pages, including cover

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Sailed through

Year 2009.

It had a gloomy start.

With uncertainties and apprehensions.

Disappointments and cynicism.

Many whom we banked on went bankrupt.

It was also the time.

To change thinking, strategies and approach.

Explore new opportunities.

Many thought that the crisis would continue.

Or even get worse.

Thankfully, there are some signs of recovery.

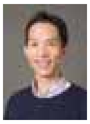
As 2009 comes to an end, seems the worst is on its way out.

Coordinates wishes 2010 a year of hope and growth to all.

Bal Krishna, Editor
bal@mycoordinates.org

Practical multivariate statistical multipath detection methods

The paper investigates the application of a sophisticated multiple outlier detection technique



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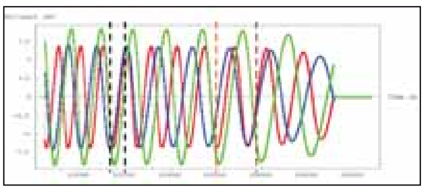

Fig. 1 Simulated GPS three-frequency (red: L1, blue: L2, green: L5) multipath error in PRN02 in the LCPC dataset (relative permittivity =3.9)

Phase multipath is one of the most crucial error sources in centimetre or millimetre level GNSS high precision positioning. Short-delay multipath is still especially difficult to detect or mitigate by the state-of-the-art hardware-based techniques. Therefore, processing algorithm-based multipath mitigation methods are crucial for the further improvement of positioning accuracy, either integrated with other techniques or in a stand-alone mode. The effectiveness of some of these is, however, limited by the degrees of freedom in currently available solutions, i.e. insufficient satellites and signals. This problem is similar to the un-robustness and unreliability of some outlier detection techniques used in RAIM and other integrity algorithms in the current GPS system.

GPS modernization is being undertaken. The GPS Block IIR-M satellites are already transmitting an unencrypted civil signal (L2C) on L2 frequency and Block III satellites will transmit a new civil signal (L1C) on L1. Moreover, the signal power of L2 will be increased. This will make tracking of L2 much easier and more reliable and will increase the use of L2 in high precision kinematic applications. An additional signal, the so-called L5, will be available on GPS Block IIF satellites scheduled for launch beginning in late 2009. Both the modernised L2 and the new L5 civil signals allow coherent tracking of code and phase and so avoid the losses that occur when tracking the current P(Y) code in L2. This had led to the extensive current interest, e.g. (Hatch et al., 2000) in investigating the potential of three-frequency data for a wide range of applications. On the other hand, the European GNSS, named Galileo, is being developed to provide four carrier frequencies and its Full Operational Capability (FOC) is scheduled to be in 2013. Galileo signals are expected to be available to users in four categories: Open Service (OS), Safety-of-Life (SoL) service, Commercial Service (CS), and Public Regulated Service (PRS).

This paper investigates the application of a sophisticated multiple outlier detection technique, which the author refers to as the cocktail multiple outlier detection algorithm, to multipath contaminated measurements in the three-frequency GPS and Galileo systems (only OS Galileo signals are used in this investigation, i.e., L1, E5a, and E5b) and a combined multiple-frequency GPS and Galileo system. It is tested with simulated data as real GPS L5 (only available in one Block IIR-M satellite now) and Galileo data are not yet available. The results, possibilities and weaknesses of the method are analysed. Note that the results of this investigation are not affected by the movement of the roving receiver because single-epoch data processing is used. Moreover, ambiguity resolution is not the main research interest in this paper, which assumes that ambiguities are fixed before the proposed algorithms are applied therefore no ambiguities are simulated in the carrier-phase data.

Cocktail multiple outlier detection algorithm

For high precision GPS positioning, the observation equations used in parameter estimation are usually linearized as:

$$E(y) = l + v = Ax \quad (1)$$

$$E(v) = 0, l\, D(v) = D(l) = \sigma^2 C_l \quad (2)$$

where E( ) denotes the expectation operator, D( ) denotes the dispersion operator, l denotes the vector of double difference carrier phase observations, v denotes the vector of "true" residuals, A denotes the Jacobian matrix, x denotes the vector of unknown parameters,   denotes the measurement variance factor, and   denotes the cofactor matrix of observations.

The unbiased estimate $\hat{x}$ of x is based on double-difference single-epoch least squares solutions. Such a solution has known statistical properties and an expectation of the residuals of zero. It is given by the following formula.

$$\hat{x} = (A^T WA)^{-1} A^T Wl \text{ with } W = C_l^{-1} \tag{3}$$

or in simplified form:

$$\hat{x} = N^{-1}b \text{ with } N = (A^T WA), b = A^T Wl \tag{4}$$

where W, the weight matrix, is the inverse of the covariance matrix of observations. Observations contaminated by un-modelled error are generally referred to as outliers and will have the following statistical characteristics:

$$E=(v_l) \# 0 \text{ and/or } D(v_i) > \sigma^2 C_{l,\mathrm{ii}} \tag{5}$$

Since a multipath error is an un-modelled error in the observation model and since more observations will be available in the modernised GPS and/or the new Galileo, the hypothesis that is to be tested here is that the increased redundancy might make multipath detection possible by statistical means.

The author proposes to consider a phase observation affected by multipath as an outlier and seek to detect it by statistical testing. Cross (1994), based on Baarda (1968), which first introduced the classical outlier detection method widely used in geodetic network analysis, describes the test statistic $\hat{w}_i$ for the ith correlated observation (i.e. where the weight matrix W contains off-diagonal elements) as:

$$\hat{w}_i = \frac{-e_i^T W\hat{v}}{\sqrt{-e_i^T WC_{\hat{v}} We_i}} \tag{6}$$

where

$$C_{\hat{v}} = W^{-1} - AN^{-1} A^T \tag{7}$$

$$e_i = [0\ 0 \ldots 1 \ldots\ 0\ 0]^T \tag{8}$$

$$\hat{v} = A\hat{x} - l \tag{9}$$

The test statistic is tested against a critical threshold c to test if   contains a single multipath error   whilst all other observations have only random and normally distributed errors ε_i :

$$H_0 : l_i = \bar{l}_i + \varepsilon_i \tag{10}$$

$$\mathrm{H}_1 : l = \bar{l}_i + \varepsilon_i + \Delta_i \tag{11}$$

where $\bar{l}_i$ denotes the true value of the quantities that have been observed. The Tau rejection criterion c described in (Pope, 1976) is used as the critical threshold and the observation is rejected when:

$$\left| \frac{\hat{v}_i}{\hat{\sigma} v_i} \right| \geq c \tag{12}$$

with

$$\mathrm{c} = f\,(TN,\ TU, \alpha\,) \tag{13}$$

where NT is the number of (non-outlying) observations, NU is the degree of freedom, and α is the desired probability of Type I error. By shifting the position of the unity in the vector e_i of Eq. 8, this method can be used to detect outliers in all measurements. The author named this method as MOD in this paper.

Investigations described in (Lau, 2005) show that MOD is not sufficiently robust to tackle frequency-dependent multipath errors because it cannot handle the worst case scenario when multiple frequency multipath errors from a particular satellite are all (or any two of the three frequencies) in-phase. Therefore a Cocktail Multiple Outlier Detection (CMOD) algorithm is proposed in this section. The basic principle of this algorithm is based on the MOD method. In the MOD method, the test statistic of each measurement is tested against a critical threshold. However, the CMOD algorithm simultaneously tests all residuals of each satellite against a critical threshold and performs the test for all satellites in sequence. The test statistic (absolute value) of the measurements made on the three frequencies φ_{f_1}, φ_{f_2} and φ_{f_3} of a particular satellite s from a GNSS system is given by:

$$\hat{w}_s = \frac{-e_s^T W\hat{v}}{\sqrt{-e_s^T WC_{\hat{v}} We_s}} \tag{14}$$

where

$$C_{\hat{v}} = W^{-1} - AN^{-1} A^T \tag{7}$$

$$e_s = [1\ 0 \ldots 1\ 0 \ldots 1\ 0 \ldots]^T \tag{15}$$

in which the measurements of n satellites are arranged as:

$$[\varphi_{f_1}^{s_1} \ \ldots\ \varphi_{f_1}^{s_n}\ \varphi_{f_2}^{s_1}\ \ldots\ \varphi_{f_2}^{s_n}\ \varphi_{f_3}^{s_1}\ \ldots\ \varphi_{f_3}^{s_n}]^T \tag{16}$$

and

$$\hat{v} = A\hat{x} - l \tag{9}$$

Although Eq. 14 is theoretically restricted to the detection of only one outlier in the measurements, here the author tests the use of the formula to detect more than one. The author appreciates that this is theoretically incorrect, which is why the author uses the word 'practical' in the title of the paper.

In order to tackle all possible cases when multipath errors of two or more frequencies from a satellite are in-phase as described in the previous section and shown in Fig. 1, the CMOD algorithm carries out statistical tests for residuals from all possible combinations of frequencies of a satellite. This is done by using different combinations of frequencies in the vector e_s (with the measurements are arranged as in Eq. 16) as:

Test I: This test aims at the detection of the measurements of a satellite contaminated by significant in-phase multipath errors in all the three frequencies at the same time, as illustrated in the two black dotted lines of Fig. 1.

$$e_s = [1\ 0\ \ldots\ 1\ 0\ \ldots\ 1\ 0\ \ldots]^T \tag{17}$$

Test II: This test is for significant in-phase multipath errors on both f_1 and f_2.

$$e_s = [1\ 0\ \ldots\ 1\ 0\ \ldots\ 0\ 0\ \ldots]^T \tag{18}$$

Test III: This test is for significant in-phase multipath errors on both f_1 and f_3.

$$e_s = [1\ 0\ \ldots\ 0\ 0\ \ldots\ 1\ 0\ \ldots]^T \tag{19}$$

Test IV: This test is for significant in-phase multipath errors on both f_2 and f_3.

$$e_s = [0\ 0\ \ldots\ 1\ 0\ \ldots\ 1\ 0\ \ldots]^T \quad (20)$$

Tests II to IV are intended to detect and reject serious multipath errors in any two of the three frequencies' data of a satellite in cases where the multipath error in another frequency is insignificant. An example is shown in the orange dotted line of Fig. 1.

The final test is required to detect any multipath error from just one frequency as indicated with the brown line in Fig. 1. This vector e_i is the same as the one used in the MOD method:

Test V: This test is for significant multipath errors on (f_1, f_2, or f_3).

$$e_s = [1\ 0\ \ldots\ 0\ 0\ \ldots\ 0\ 0\ \ldots]^T \quad (8)$$

Tests I to V are performed for all combinations of all satellites at every epoch in order to detect multipath errors on all combinations of frequencies.

Description of testing

Description of simulated test datasets

The first two simulated datasets are referenced to the setup of a real multipath experiment carried out at the Laboratoire Central des Ponts et Chaussées (LCPC) near Nantes in France during May 2002 [6]. The real data was used in the validation of the multipath model used in the simulation of multipath data for the investigations of this paper, the validation results show that the model can generate very realistic phase multipath error (Lau and Cross, 2007). In the experiment, two Leica Geosystems System 530 receivers attached to lightweight AT502 antennas were used and a 5m by 2.5m steel panel

Fig. 2 Diagram showing the geometry of the LCPC test datasets

was constructed and placed about 5m to one of the receiving antennas in order to create a sufficiently large multipath signal. The antenna-reflector geometry is shown in Fig. 2. The geometry of the first two simulated datasets are the same but the reflectors with the assumed relative permittivities of 10 (e.g. flint glass) and 20 are used in multipath simulation. Therefore, the test datasets are denoted as LCPC-10 and LCPC-20 according to the relative permittivity used. The baseline length is about 86 m. The information used in multipath simulation is summarised in Table 1. The sky plot of the satellites-reflector-antenna geometry is shown in Fig. 3. Moreover, details of the satellites whose signals are contaminated by multipath are shown in Table 2.

Another virtual test site is at the IGS global tracking station LBCH in Long Beach, United States. In the LBCH test dataset, a concrete wall (reflector) is set 5m to the north of the antenna and a reference station 100m to its south. A relative permittivity of 7 (see Table 1) was used in the simulation of multipath in order to create strong multipath. This value is based on Stavrou and Saunders (2003), which found that the real part of the complex permittivity of concrete varied from 6.2 to 7 (for signals in the range of 1 to 95.9 GHz). Table 2 summarises the multipath simulation.

Also a kinematic data set, denoted as K-HK7-300, was simulated based on a 720m trajectory along a real street in Hong Kong. The roving antenna was assumed to set about 29cm (measured to L1 phase centre) above a 1m by 1m steel carry platform that travel at 1ms-1. The buildings were assumed to be made of concrete with a relative permittivity of 7. The reference station was assumed to be about 500 m to the north of the road. Table 3 summarises the simulation – note that some satellites are blocked for some of the time.

In the all of the test datasets, Leica System 530 receivers and AT502 antennas were assumed to have been used in data collection. Moreover, normal distributed random measurement noise with the standard deviation of 1 mm was generated

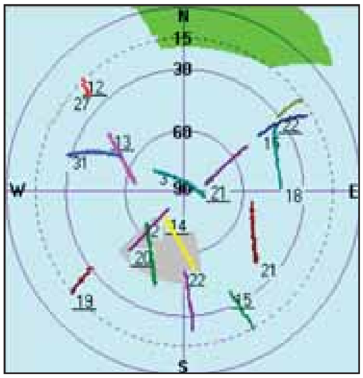

Fig. 3 Sky plot of Galileo (underlined) and GPS satellites in the LCPC datasets; the green area represents the reflector; the grey area indicates that the data from the satellites in this area are contaminated by multipath

in each phase measurement. It should be pointed out that it was necessary to assume the use of a particular receiver and antenna because factors such as receiver correlator spacing and antenna gain pattern have an impact on the simulated multipath. The author does not believe the choices the author has made affect the overall conclusions of this research.

Testing methodology

Five scenarios with different GNSSs or combinations of frequencies have been tested and results compared with the known positions in all cases:

- Scenario 1: the current single frequency GPS data;
- Scenario 2: the modernised dual-frequency GPS data,
- Scenario 3: the future three-frequency GPS data,
- Scenario 4: the future OS three-frequency Galileo data, and

Dataset	Distance	Reflector angle	Material	RP	Mask angle (°)
LCPC-10	~ 5 m	Tilted	Flint glass	10	15
LCPC-20	~ 5m	Tilted	Hafnium oxides	20	15
LBCH-7	5 m	Vertical	Concrete	7	15

Table 1 Information for multipath simulation in the static test datasets

	Multipathing satellites (PRN/SV ID)		Number of available satellites at epochs	Number of multipathing satellites
Dataset	GPS	Galileo		
LCPC-10	2, 22	14, 20	13 - 15	4
LCPC-20	2, 22	14, 20	13 - 15	4
LBCH-7	7, 13, 31	17, 18, 22, 23	14 - 17	7

Table 2 Multipathing satellite information in the static test datasets

	Multipathing satellites (PRN/SV ID)		No. of available satellites	No. of multipathing satellites
Dataset	GPS	Galileo		
K-HK7-300	5, 6, 14, 15, 18, 22, 25, 30	4, 5, 6, 7, 24, 25, 26, 27	12 - 16	16

Table 3 Multipathing satellite information in the kinematic test datasets

- Scenario 5: the future OS Galileo + GPS multiple-frequency data.

Note that the reason for Scenario 1 is that many surveying and geodetic applications only use L1 data in fixed solutions. Although L2 may have been used at the ambiguity fixing stage it may be too noisy to contribute usefully to the final solution.

Results of the cocktail multiple outlier detection (CMOD) algorithm for multipath error detection

Summaries of the positioning errors after rejection of measurements with detected multipath by CMOD in the test scenarios 3 to 5 for LCPC-10, LCPC-20, LBCH-7 and K-HK7-300 datasets are shown in Tables 4, 6, 8, and 10 respectively. The percentage improvements (or deteriorations) when compared with single-frequency GPS and the same scenarios using MOD are also shown in the table. The results of scenarios 1 to 5 without using MOD and CMOD (i.e., standard least squares) are also shown in the table for comparison. Tables 5, 7 and 9 show the successful rates for detection of multipath errors in scenarios 3, 4 and 5 for LCPC-10, LCPC-20, and LBCH-7 datasets respectively.

In the results of K-HK7-300 dataset, CMOD shows deteriorations in 3D position accuracy in scenarios 3 to 5 (see the right-most column in Table 10) when compared with the current single-frequency GPS system or the multiple-frequency least squares only solutions. This is because the multipath errors on GPS L2 and L5 and/or Galileo E5a and E5b frequencies are highly correlated (their frequencies are very similar) when reflections occur at the very close carrying platform. The introduction of another highly correlated multipath error clearly further drags the estimated position away from the true position. Table 11 shows the coherence of phase multipath errors against the differential path delays and Table 12 shows the correlation functions between frequencies and differential path delays. The orange highlighted values in Table 12 show that the high correlations (correlation functions are greater than 0.95) of some frequency pairs occur when the differential path delays (also antenna-reflector distance) are very short (about less than or equal to one metre). The performance of CMOD is worse than that of MOD in this dataset.

There are two potential reasons. Firstly, the relatively small multipath errors may not be detected by MOD but they may be detected by CMOD, which should have a positive impact. However, since there are many multipath contaminated measurements at each epoch in this dataset as shown in Table 3, many measurements are rejected, which then weakens the satellite geometry. Secondly, the highly correlated low-frequency multipath errors from the very close reflector (the carrying platform) may lead to false detection of measurements without multipath error.

In addition to the problem of correlation of multipath errors, the number of multipath contaminated measurements in this dataset is much more than the number of good measurements. This in itself leads to difficulty in the detection of multipath errors.

Conclusion

A practical cocktail multiple outlier detection algorithm, called CMOD, is proposed to tackle the undetected outlier problem in classical multiple outlier detection method (MOD) when phase multipath errors in two or more frequencies of a satellite are in-phase.

Tests with static test datasets showed that using CMOD with GPS or Galileo three-frequency data may not improve positioning accuracy when compared with MOD results. The author believes that this is due to the fact that there is insufficient redundancy to take advantage of the multiple outlier detection process used in CMOD. The result is the rejection of too many measurements/satellites, which then weakens the satellite geometry. However, using CMOD with combined GPS and Galileo multiple-frequency data (scenario 5) shows a substantial increase in correct detection of multipath errors and significant reduction in false detection. Only one false detection occurred in only one of the static test datasets that were tested.

Scenario	N	E	H	3D	% improvement to scenario 1	% improvement to MOD
1: Single-frequency GPS	1.611	1.410	3.879	4.431	-	
2: Dual-frequency GPS	1.171	0.976	2.642	3.051	31.1	
3: Three-frequency GPS	0.948	0.830	2.341	2.659	40.0	
3: Three-frequency GPS with MOD	0.970	0.823	2.294	2.623	40.8	
3: Three-frequency GPS with CMOD	0.911	0.775	2.109	2.425	45.3	7.6
4: Three-frequency Galileo	0.985	1.059	1.940	2.420	45.4	
4: Three-frequency Galileo with MOD	0.980	0.984	1.965	2.406	45.7	
4: Three-frequency Galileo with CMOD	0.998	0.986	1.996	2.440	44.9	-1.4
5: Multiple-frequency GPS+Galileo	0.696	0.533	1.386	1.640	63.0	
5: Multiple-frequency GPS+Galileo with MOD	0.686	0.529	1.348	1.602	63.8	
5: Multiple-frequency GPS+Galileo with CMOD	0.668	0.522	1.309	1.559	64.8	2.7

Table 4 RMS positioning errors in millimetres and percentage improvement of using CMOD for the test scenarios in LCPC-10 dataset

Scenario	Approx. % of correct detection	Approx. % of false detection
3: Three-frequency GPS with CMOD	20.8	0.1 (16 cases)
4: Three-frequency Galileo with CMOD	8.3	0.9
5: Multiple-frequency GPS+Galileo with CMOD	9.8	0.0

Table 5 Approximate percentages of correct and wrong detections of using CMOD for scenarios 3 to 5 in the LCPC-10 dataset

Scenario	N	E	H	3D	% improvement to scenario 1	% improvement to MOD
1: Single-frequency GPS	1.818	1.540	4.093	4.736	-	
2: Dual-frequency GPS	1.290	1.062	2.771	3.236	31.7	
3: Three-frequency GPS	1.049	0.928	2.619	2.970	37.3	
3: Three-frequency GPS with MOD	1.020	0.865	2.410	2.757	41.8	
3: Three-frequency GPS with CMOD	0.879	0.739	2.002	2.308	51.3	16.3
4: Three-frequency Galileo	1.109	1.192	2.044	2.613	44.8	
4: Three-frequency Galileo with MOD	0.974	0.937	2.025	2.434	48.6	
4: Three-frequency Galileo with CMOD	1.027	0.958	2.094	2.521	46.8	-3.6
5: Multiple-frequency GPS+Galileo	0.790	0.596	1.542	1.832	61.3	
5: Multiple-frequency GPS+Galileo with MOD	0.715	0.563	1.416	1.683	64.5	
5: Multiple-frequency GPS+Galileo with CMOD	0.661	0.532	1.315	1.565	67.0	7.0

Table 6 RMS positioning errors in millimetres and percentage improvement of using CMOD for the test scenarios in LCPC-20 dataset

Scenario	Approx. % of correct detection	Approx. % of false detection
3: Three-frequency GPS with CMOD	37.8	0.1 (10 cases)
4: Three-frequency Galileo with CMOD	18.9	1.0
5: Multiple-frequency GPS+Galileo with CMOD	25.6	0.0 (1)

Table 7 Approx. percentages of correct and wrong detections of using CMOD for scenarios 3 to 5 in the LCPC-20 dataset

Scenario	N	E	H	3D	% improvement to scenario 1	% improvement to MOD
1: Single-frequency GPS	5.086	2.336	5.175	7.622	-	
2: Dual-frequency GPS	3.522	1.745	3.713	5.407	29.1	
3: Three-frequency GPS	3.208	1.340	2.610	4.347	43.0	
3: Three-frequency GPS with MOD	3.689	1.257	2.293	4.522	40.7	
3: Three-frequency GPS with CMOD	4.308	1.439	2.910	5.394	29.2	-19.3
4: Three-frequency Galileo	2.460	0.685	3.907	4.668	38.8	
4: Three-frequency Galileo with MOD	1.214	0.494	1.911	2.317	69.6	
4: Three-frequency Galileo with CMOD	1.755	0.582	2.355	2.995	60.7	-29.2
5: Multiple-frequency GPS+Galileo	1.997	0.667	2.279	3.103	59.3	
5: Multiple-frequency GPS+Galileo with MOD	1.734	0.477	1.449	2.309	69.7	
5: Multiple-frequency GPS+Galileo with CMOD	1.509	0.443	1.290	2.034	73.3	11.9

Table 8 RMS positioning errors in millimetres and percentage improvement of using CMOD for the test scenarios in LBCH-7

Scenario	Approx. % of correct detection	Approx. % of false detection
3: Three-frequency GPS with CMOD	46.6	0.7
4: Three-frequency Galileo with CMOD	36.6	0.0 (7 cases)
5: Multiple-frequency GPS+Galileo with CMOD	55.0	0.0

Table 9 Approx. percentages of correct and wrong detections of using CMOD for scenarios 3 to 5 in the LBCH-7 dataset

Scenario	N	E	H	3D	% improvement
1: Single-frequency GPS	0.558	0.466	1.103	1.321	-
2: Dual-frequency GPS	0.403	0.330	0.772	0.931	29.5
3: Three-frequency GPS	1.884	1.877	4.592	5.306	-301.6
3: Three-frequency GPS with MOD	1.592	1.570	3.716	4.337	-228.2
3: Three-frequency GPS with CMOD	2.795	3.027	7.350	8.426	-537.6
4: Three-frequency Galileo	2.003	2.356	4.279	5.280	-299.5
4: Three-frequency Galileo with MOD	1.536	1.801	3.350	4.102	-210.4
4: Three-frequency Galileo with CMOD	3.439	4.001	7.668	9.308	-604.3
5: Multiple-frequency GPS+Galileo	1.322	1.507	2.963	3.577	-170.7
5: Multiple-frequency GPS+Galileo with MOD	0.572	0.579	1.088	1.358	-2.8
5: Multiple-frequency GPS+Galileo with CMOD	1.779	1.945	4.780	5.458	-313.1

Table 10 RMS positioning errors in millimetres and percentage improvement of the test scenarios in K-HK7-300 dataset

However CMOD shows a significant deterioration when compared with MOD and the current single-frequency GPS system when dealing with our kinematic data set. The reason has been identified as being due to a very close reflector, which led to a large number of highly correlated multipath contaminated observations (almost all signals are affected by multipath). Actually the author believe that any very close reflector (less than one metre) has the potential to lessen the advantage of using multiple-frequency GNSS data, this is because the frequencies of GPS L2 and L5, and Galileo E5a and E5b are extremely close and hence the magnitude and phase of carrier-phase multipath errors are extremely close. Note that the results of this paper are not affected by the movement (static/kinematic) of the roving receiver because single-epoch data processing is used.

DPD (m)	Phase Multipath Error (radian)					
	GPS			Galileo		
	L1	L2	L5	L1	E5a	E5b
0.1	0.263	0.205	0.196	0.263	0.196	0.201
0.2	0.526	0.409	0.392	0.526	0.392	0.403
0.3	0.788	0.614	0.589	0.788	0.589	0.604
0.4	1.051	0.819	0.785	1.051	0.785	0.805
0.5	1.314	1.024	0.981	1.314	0.981	1.007
0.6	-1.565	1.228	1.177	-1.565	1.177	1.208
0.7	-1.302	1.433	1.373	-1.302	1.373	1.409
0.8	-1.040	-1.504	1.570	-1.040	1.570	-1.531
0.9	-0.777	-1.299	-1.376	-0.777	-1.376	-1.330
1	-0.514	-1.094	-1.179	-0.514	-1.179	-1.128
1.1	-0.251	-0.889	-0.983	-0.251	-0.983	-0.927
1.2	0.011	-0.685	-0.787	0.011	-0.787	-0.726
1.3	0.274	-0.480	-0.591	0.274	-0.591	-0.524
1.4	0.537	-0.275	-0.395	0.537	-0.395	-0.323
1.5	0.800	-0.070	-0.198	0.800	-0.198	-0.122
1.6	1.062	0.134	-0.002	1.062	-0.002	0.080
1.7	1.325	0.339	0.194	1.325	0.194	0.281
1.8	-1.554	0.544	0.390	-1.554	0.390	0.482
1.9	-1.291	0.748	0.586	-1.291	0.586	0.684
2	-1.028	0.953	0.783	-1.028	0.783	0.885

Table 11 Phase multipath errors of the GPS and Galileo frequencies for various differential path delay (DPD)

DPD (m)	Correlation Function				
	GPS L1 and L2	Galileo L1 and E5b	GPS L1 and L5 or Galileo L1 and E5a	GPS L2 and L5	Galileo E5a and E5b
0.1	0.78	0.77	0.75	0.96	0.97
0.2	0.78	0.77	0.75	0.96	0.97
0.3	0.78	0.77	0.75	0.96	0.97
0.4	0.78	0.77	0.75	0.96	0.97
0.5	0.78	0.77	0.75	0.96	0.97
0.6	0.78	0.77	0.75	0.96	0.97
0.7	0.91	0.92	0.95	0.96	0.97
0.8	0.69	0.68	0.66	0.96	0.98
0.9	0.60	0.58	0.56	0.94	0.97
1	0.47	0.46	0.44	0.93	0.96
1.1	0.28	0.27	0.26	0.90	0.94
1.2	0.02	0.02	0.01	0.87	0.92
1.3	0.57	0.52	0.46	0.81	0.89
1.4	0.51	0.60	0.73	0.70	0.82
1.5	0.09	0.15	0.25	0.36	0.61
1.6	0.13	0.07	0.00	0.02	0.03
1.7	0.26	0.21	0.15	0.57	0.69
1.8	0.35	0.31	0.25	0.72	0.81
1.9	0.58	0.53	0.45	0.78	0.86
2	0.93	0.86	0.76	0.82	0.88

Table 12 Correlation functions of phase multipath errors among different GPS and Galileo frequencies in Table 11 against the differential path delay (DPD)

Finally the author remarks that, when combining GPS and Galileo, if the number of measurements contaminated by multipath is small compared to the total number of measurements at any epoch, and if there are no very close reflectors (or at least no reflectors that lead to small additional path lengths), then the author believes that the performance of CMOD will be better than that of MOD. Moreover in this case CMOD will be an extremely effective way to reduce the impact of multipath by 3-12% when comparing with MOD and by 65-73% when comparing with the standard least squares solution using the current reliable GPS L1 data. This in turns leads to the recommendation to avoid, as far as possible, locating GNSS antennas close to reflecting surfaces even for the future multiple-frequency GNSS.

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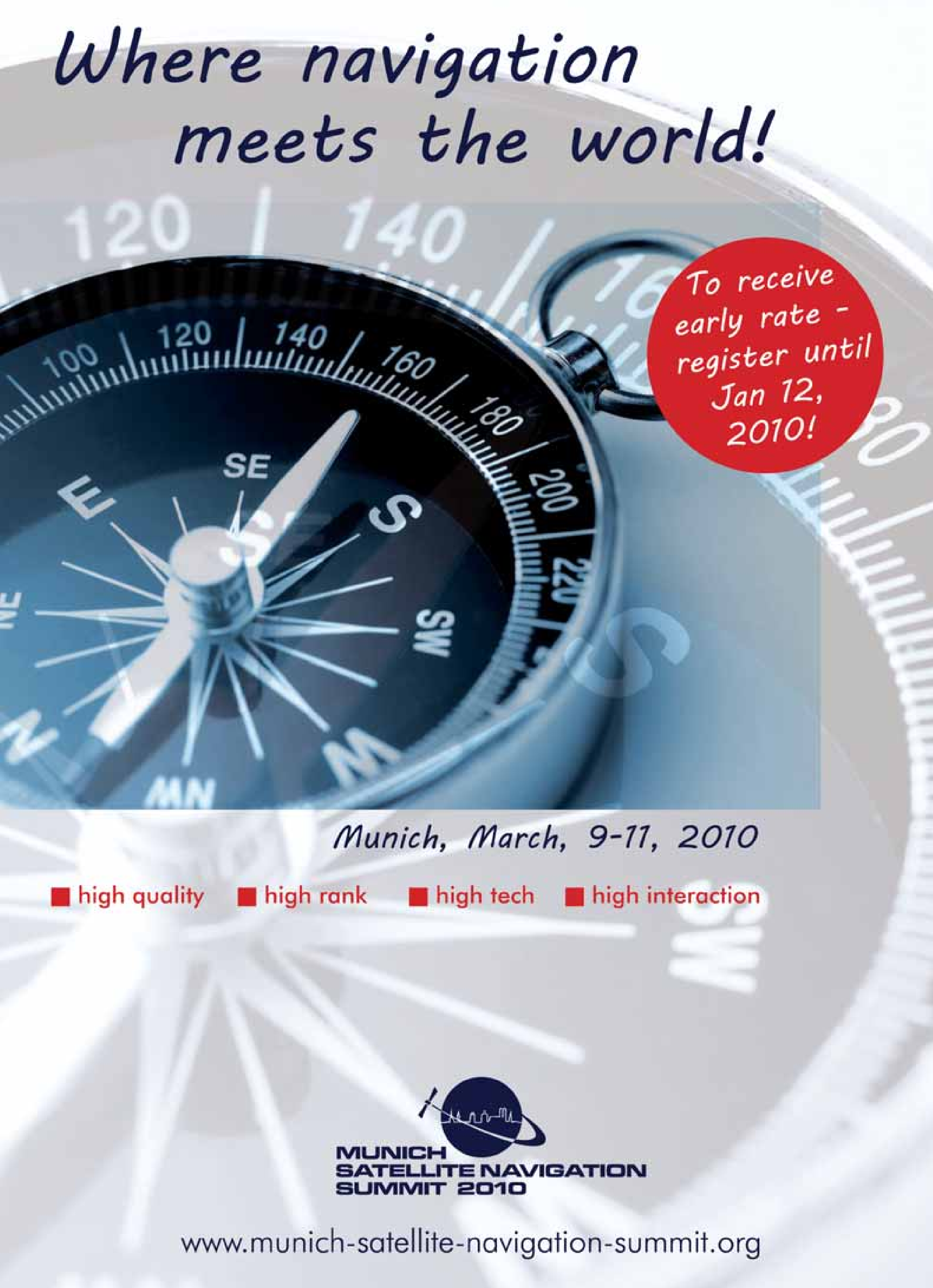
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"The consensus attained during the evolution of NSDI is a demonstrator of its relevance to the society"

Says Maj Gen (Dr) R Siva Kumar, CEO, NSDI while explaining the status of NSDI in India

Maj Gen (Dr) R Siva Kumar
CEO, NSDI

The NSDI Annual event, NSDI-9 is around the corner. What has been the progress of NSDI in the past year?

The major achievement during the intervening period is release of NSDI metadata standard ver.2.0. The earlier version was brought out before ISO (TC.211)/OGC, released the standard on metadata ISO 19115. Now, this standard conforms to the international standards.

Taking the SDI a step forward, the Karnataka Geo-portal of Karnataka Spatial Data Infrastructure is being launched during NSDI-9 and Delhi Geo-portal has already been launched in November 2009. Kerala has sanctioned the requisite resources for creating Kerala State SDI. The process of building Kerala Geo-portal is on and the RFP is already issued.

Please tell us about the advanced research lab being set up at IIT Bombay to develop tools for NSDI?

It has been felt that the current human resources at higher level are not commensurate with the requirements and there are many research issues especially in the zone of last mile research. This being a multi domain issue, there is a need to build a facility for carrying out work on SDI related problems. It is also necessary to make this Geo-spatial Technology an integral part of Information Technology. The Computer Science Department of IIT, Bombay has been working on a number of issues on interoperability, decision support systems and other NSDI issues. The advanced lab on geo-spatial information science and engineering is expected to yield 20 PhDs and 50 M.Tech at the end of five years. This lab will also network other research institutions both in the country and outside. The professionals and industry could work in the lab and provide requisite domain expertise for enabling solutions in empowering people through geo-spatial data. As a first step, an Indo-US workshop is being organized from 16-18, December 2009 at IIT, Bombay with the support from Indo-US Forum on Science & Technology.

Are the state level SDIs in a position to contribute meaningfully to the National SDI today?

At the National Level, NSDI is striving to provide metadata for users to discover, explore and exploit geo-spatial data. The State SDIs will be able to provide the data of higher resolution for problem solving at the local and community level. NSDI has been actively promoting the growth of SDIs in the country.

What kind of an impact do you the recently established OGC India Forum will have on NSDI?

Department of Science and Technology is a Principal Member of OGC and has been actively participating in the activities. OGC India Forum will be able to play a meaningful role in addressing India specific issues in ensuring interoperability, capacity building and problem solving. However, it is yet to take shape in spite of good efforts by a few committed persons from the industry.

Besides the 18 Collaborative Agencies listed on your web portal do you think there is scope for other agencies like National Hydrographic Office (NHO) and Ministry of Rural Development (MoRD) to contribute to the NSDI initiative?

The initial list of collaborative agencies is indicative and all geo-spatial data providing organizations should be part of NSDI initiative.

Do you think initiatives like Google and Bhuvan are complimentary or competitive to NSDI?

Google and Bhuvan are certainly complementary and not competitive to NSDI. Bhuvan is also helping in achieving the objective of NSDI and linkages for Bhuvan exist in India Geo-portal.

In the last 10 years the spatial data scenario in the world and even in India has changed with more and more data being declassified and many new players entering the market of acquiring and distributing data. In this fast changing scenario do you think the time has come for NSDI to also adopt a new strategy to achieve its goals?

Spatial Data Policies are continuously being fine tuned to keep pace with the technological advancements.

What do you think is a realistic timeline for the NSDI to be implemented before it loses its relevance?

NSDI, today, is relevant and functional. NSDI should not for the time being, be seen as a data repository. It is in effect a combination of technologies policies and standards. The consensus attained during the process of evolution of NSDI is a demonstrator of its relevance to the society.

The Tellurometer

The background of invention of the Tellurometer on the occasion of its 50th birthday

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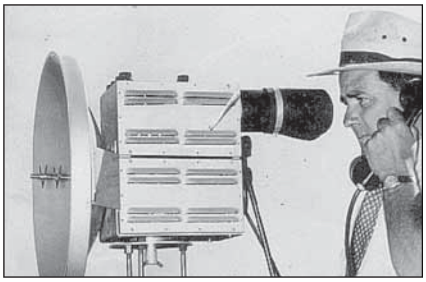

Dr Wadley with the prototype Tellurometer

It was in the late 1950s that the Tellurometer hit the surveying profession. Certainly it was not the first EDM instrument on the market, that title goes to the Geodimeter which appeared in 1947, but there was a difference. The Geodimeter worked on a light source and as such its maximum range was limited by visibility. The Tellurometer operated on a radiowave which could penetrate most weather conditions and achieved distances up to 100 miles. Since the early 1900s any long distance that was required to be measured as accurately as possible, e.g. a survey baseline, was determined using long tapes or wires suspended in catenary. Numerous baselines around the world were measured this way with each requiring 20 to 40 personnel over a period of several weeks. Then, suddenly, the profession had new tools that would allow such a task to be completed in 20 minutes by two persons. It was a revolution that completely changed the manner in which surveying operated.

Recently the Tellurometer passed its 50th birthday and so it is opportune to record the background to its invention.[3]. The 2nd World War saw developments in radar for detection purposes based on speed and time to determine distance. The speed element here was the "known" value for the velocity of propagation of the waves. At that time the accepted value was around 299776 km/s but the uncertainly in this was such that the figure was not suitable for surveying purposes. By 1944 Shoran was active in the location of bombing targets and this soon developed into a system for use in areas where traditional triangulation was not possible. An example was the measurement in Italy of a line of 618 km from 22 flight passes across the line between the terminals. Such was the interest in this that it was found to highlight an error in the accepted velocity value of some 18 km/s. By the mid 1950s Shoran and its development, Hiran, were used for geodetic purposes including the measurements over the Mediterranean to connect the triangulations of Southern Europe to those of North Africa and in particular complete a connection between the Struve Geodetic Arc and the Arc of the 30th meridian.

In 1954 Col. Baumann, then Director of Surveys at the Trigonometrical Survey of South Africa, and a member of the Council for Scientific and Industrial Research (C.S.I.R.), put in a plea for an instrument to be developed that – (a) would have an accuracy suitable for first order triangulation, (b) was simple to operate by surveyors unfamiliar with electronics, (c) would achieve an accuracy of better than 1 in 105 at over 30 miles with resolution of a few inches and (d) would be light, portable, rugged and versatile. A very tall order it would seem. However later the same year Trevor Wadley who was at the Telecommunications Research Laboratory (T.R.L.) within the C.S.I.R., became available and was put to work on developing the idea.

In a matter of little more than two months he was making measurements on a test site north of Johannesburg, with a first "routine" measurement on 14 June 1955. This was followed by close cooperation with the Trigonometrical Survey Office to make further test measures over lines for which accurate results were known. Various sites were chosen around South Africa and the results calculated on the basis of a velocity value of 299792.0 km/s. The results were good but raised some doubts. There appeared to be a 15 ppm discrepancy against a baseline that had been measured in catenary in 1903. Over half of this was later accounted for by virtue of the difference between the South African Geodetic foot and the British foot. Much of the residue was laid at the door of the velocity figure which, it was calculated, probably needed to be increased by near 2 pm to 299792.6 km/s. In 1956 the Director of the Survey and Mapping Branch, Dept. of Mines and Technical Surveys in Canada heard rumours about this new

The control panel of the MRA2 Tellurometer instrument and sought a demonstration. They were welcomed to South Africa on the understanding that it would not then be able to discuss the working principles. The Canadians were suitably impressed and departed with the comment "I will give you a firm order for the first six you produce and I don't mind the cost."

By 22 January 1957 a demonstration was given at a hotel in Constantia, south of Cape Town, to an audience of notable national and international members of the surveying fraternity. The instrument was launched and in a matter of months was being tested out around the world. In March-April that year Wadley was involved in tests in England over the Ridgeway baseline and its extension figure. These suggested, as had the tests in South Africa, that the velocity figure should be 299792.6 rather than the then accepted value of 299792.0 km/s. The same year the International Scientific Radio Union adopted a figure of 299792.5 and in 1973 the recommended value for practical use was 299792.458 km/s. It is interesting to note here that there was a further third occasion when the survey profession assisted in the determination of the value for the velocity. In 1926 Albert Michelson had requested the U.S. Coast & Geodetic Survey to supply a highly accurate line for his velocity experiments and this task fell to William Bowie.[1]. Michelson's result was 299798 km/s.

The effect of the introduction of this new tool was graphically illustrated in Kenya. At that time, 1957, the Directorate of Colonial Surveys (D.C.S.) of the U.K. was involved in major triangulation and traversing schemes within the country both involving the use of catenary measurements. Some few days after completing the tedious measurement of the baselines at Malindi and Isiolo (of 13 and 21 km respectively) along came representatives to demonstrate this new EDM instrument. They were able to measure in 20 minutes to comparable accuracy one of the baselines that had taken some six weeks and numerous personnel to measure by catenary. How soul destroying that must have been. Then the D.C.S. surveyors were able to complete in 28 days the traversing for which the estimate had been 2 to 2½ years. So fifty years ago surveyors had to begin turning away from triangulation to trilateration and traverse. The added complication was that mechanical equipment was replaced by electronic black boxes and the traditional use of a screwdriver to cure many of the surveyors' problems was replaced by a technology that was not screwdriver friendly.

So who was Dr Wadley? [2]. Born in 1920, he was the seventh of ten children of a former Mayor of Durban. He attended Durban Boys' High School and then Natal University. He was a brilliant, if somewhat unorthodox, student and graduated in Electrical Engineering in 1940. During World War II he served in the Special Signals Services of the South African Corps of Signals where he was involved in various secret activities. After the War he joined the National Institute for Telecommunication Research (N.I.T.R.) as a designer of radio equipment.

He developed an Ionosonde, which was a form of frequency scanning radar. Later his interests turned underground for a while with research into communications underground for the deep mines. After this, and just prior to his involvement in the Tellurometer he developed a very successful radio receiver, the RA17, manufactured in conjunction with Racal. This was sold in large numbers worldwide.Wadley left C.S.I.R. in 1964 and turned his interest back to the successful radio. He died at Warner Beach in Natal in 1981 aged 61.

Among the many academic and other recognitions of his talents was the issue in 1979 of a commemorative stamp. Since those early days of the Tellurometer the firm that manufactures it is now called Tellumat. Whilst their core business ranges far and wide in the electronics field they still produce Tellurometers with the latest model as the MRA 7. This has found a very useful niche in the deep mines of South Africa. There it operates in a safety role in relation to the movement of the cages in the various very deep shafts.

Acknowledgement

The illustrations are all courtesy of Tellumat (PTY)Ltd, Cape Town

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YOUR COORDINATES

Impressive

The articles particularly on BWSL, Sustainable Land Governance, in Coordinates are very interesting. More particularly BWSL where I have been on the Technical Advisory Committee of BWSL right from Conception to its Implementation. The article is written in an impressive manner, although we could have created a much bigger land mark / signature structure. Each one of the authors has contributed immensely as they have been deeply involved and contributed sincerely for the completion of the project and must need a loud applause.

For "sustainable Land Governance" probably they have to learn systems concept with inter woven components of the total system, particularly component interrelationships with each other to meet the over all set objectives of the society as a whole. Congratulations and good wishes to authors and editors.

Prof S L Dhingra
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Correction

The correct email address of Mr Len Gower is len.gower@gmail.com. It was printed wrongly in November issue of Coordinates on page 12. The error is regretted.
-Editor

"Indian market is fascinating"

Says Bryn Fosburgh, Vice President, Trimble while sharing his vision for Trimble expansion plans in India

Bryn Fosburgh
Vice President, Trimble

What is your vision with regard to Trimble expansion plan in India?

Our vision is to determine the challenges that our Indian customers are trying to solve in the Utilities, Construction, Infrastructure, Mobile Resource Management, GIS and Mapping, Public Safety and Surveying industries to develop localized software and hardware solutions that meet their needs for increased productivity and reduced rework. We offer solutions that have been proven worldwide and now we must determine if these solutions meet the needs of the Indian customer. Where the solutions do not meet their needs or requirements we must adapt them so they can provide our customers maximum productivity advantages. We can accomplish this by adding resources in our Delhi and Chennai offices in marketing, R&D and sales. Where we find it necessary to create or integrate new solutions to address the unique needs of the Indian market, we may pursue opportunities with Indian organizations that can help us execute our strategy better and faster. Our emphasis will be to find partners who have the same customer value system and technology leadership as Trimble. We will also continue to demonstrate our solutions and capabilities through events such as Converge India so customers can get to know Trimble and we can gain a better understanding of the Indian market.

How do you see India as a market? What are the key segments which you would lay more emphasis on?

The Indian market is fascinating because it offers significant opportunities with its increased economic development and modernization efforts. Infrastructure projects, especially in the areas of transportation—roads, highway and airport construction—as well as telecommunications, water conservation, utilities, energy, environmental protection and mining are all on the rise. Recognizing this growth, Trimble has strengthened its commitment to the region.

Some companies will simply address the market opportunistically. This type of strategy can provide an influx of technologies into the market for a small percentage of industries very rapidly. However, seldom is there a training, service, and support network developed to sustain future growth and support the customer long term. Trimble's philosophy is to develop the necessary infrastructure and hire employees to meet the market segment requirements, not only for today but for the future. Trimble has over 200 employees in our Chennai and Delhi offices to support the needs of the Indian customer. The key market segments we are addressing today are the Utilities, Construction, Survey, Mobile Resource Management, Geospatial, and Public Safety markets and we believe we have a host of solutions—from hardware and software to services—that provide the customer improved productivity and reduced rework. These solutions can provide significant cost savings to private, public and government organizations. These solutions when inter-connected through Trimble Connected Site can provide unparalleled productivity advantages and reduce rework by as much as 50% in some market segments. Connected Site solutions consist of mapping or identifying the workflow of a specific industry segment and then ensuring that there is software and hardware integration between each segment or process of the workflow. This enables each step in the process to seamlessly handoff, rather than throw over the wall, data and deliverables from one work process to the other. As India, modernizes its railway, airport, and highway systems throughout the country Trimble solutions will be there to support and assist in the design, survey, construction, and maintenance of these public and private assets.

We also understand that each market segment is different. While we address our targeted market segments through a suite of solutions, we also believe that we may find new segments that have more critical needs to apply Trimble's core technologies such location, communication, image processing and workflow automation. We will use events such as Converge_India to identify these segments and create new solutions appropriate for these markets.

Would you like to explain your statement "Localisation is key part in Trimble fabric?"

Localization is more than translating product manuals or a Website from English into a local language. Localization requires us to understand the challenges and problems that the customer is trying to solve and the work flow they currently utilize for a particular application. With a variety of experienced resources in India, Trimble can work with customers to determine the way they work, and then develop or adapt solutions to improve their job and make them more productive and efficient. Also, localization is much more than just knowing industry, but also the language, culture, history, and philosophy of the region. Trimble can never be wholly Indian. However, Trimble can learn more about India both professionally and personally; our belief is that once you have learned both the needs of the profession and the history of the culture you can build better solutions for Indian customers. If you look at the Taj Mahal you see one of the most beautiful and historical structures of our time that used innovative building methods. Its construction did not compromise form, beauty, usefulness, or culture. As we focus on India, our goal is to provide solutions that will make their workflow more efficient without requiring them to completely transform the way they do their work. For surveyors, we will provide survey solutions. For mapping or geospatial professionals we will provide industry-specific solutions. For contractors or civil engineers we will do the same for their markets. We intend to provide specialized solutions adapted to the region, culture, and market segment; not horizontal, generic solutions that only meet part of their requirements.

Does it mean to build a 'connect' to history and culture of the region or will it lead to the emergence of "customized solutions"?

Cultures evolve and adapt over time. Companies, products, and solutions follow a similar evolution. Trimble has been in India since the early 1990's, but during that time we only put our foot into the water and looked at the market in more of an opportunistic manner. Today, we have made a corporate commitment to India and we are continually focusing on ways to improve our solutions and offerings from Trimble. India is a large opportunity for many industries. However, to know India you must learn about the people, culture, and the philosophy. Look at the beauty of the Taj Mahal, the brilliance of the Gateway of India, the absolute awe of Goa. India is a large market but it is also a much greater culture. At Trimble we ask our people to become knowledgeable, enjoy and respect a country and its business, economic and cultural traditions. Once you do this then you will understand the needs. Converge India brought many people together, not only from the country but also Trimble personnel from across the world. This experience was the first step for Trimble through the gateway of India.

Connecting to a region is important to understanding the historical needs for a particular market segment. For example in survey, Trimble acquired Ingenieurbüro Breining GmbH and HHK Datentechnik GmbH in Germany. Both provide customized field data collection and office software solutions for the German and European cadastral survey market. The addition of two company's resources, expertise and products enabled Trimble to further address local application requirements and provide customized survey solutions for the market. Today's solutions for the German surveyors provide complete data and workflow integration starting with intelligent data collection in the field and productive use of appropriate sensor technologies for the job conditions, through creation of the final product and customer deliverables. The surveyor can focus on the job and count on the integrated workflow to assist in efficiently delivering the needed results while the software manages the different data structures, models, and formats requirement for the region.

You mentioned that Trimble would build solutions that India needs. Will the localized products for India will be produced in India?

As I have mentioned before, we have a growing R&D and support center in Chennai that is building solutions for the worldwide market and for India. We believe it is important to have localized development because it enables us to respond in a timely manner to customer needs. However, products are just one part of localization. Trimble employees in India are involved in all facets of our business such as sales, support, finance, HR, and engineering. In addition, we have a respected, world-class distribution network that provides excellent services and support to our customers.

If you look worldwide, we have successfully demonstrated our ability to execute in diverse markets. For example, Trimble has established a sizable presence in the last four years in China by providing localized solutions. We have a software development center and a factory in Shanghai. In addition, we have established two joint ventures to address the local market needs.

Could you explain the shift of focus from 'technology' to 'product' to 'solutions' to 'applications' to 'localization of applications'?

Trimble began as a technology company where our vision was to make positioning, Global Positioning System (GPS), ubiquitous in all markets. We built single products or product families to address vertical markets. With each step of our evolution we learned more about different market segments, geographies and their specific requirements. Trimble began integrating a wide range of positioning technologies including GNSS, laser, optical and inertial technologies with application software, wireless communications, and services to provide complete commercial solutions; not just products. The integrated solutions provided customers the ability to collect, manage and analyze complex information faster and easier. Today, Trimble provides solutions across an entire market workflow.

What according to you could help accelerate the adoption of advanced technologies in the infrastructure development?

Events such as Converge_India, is one of many ways we can demonstrate how our technology and solutions that can be used to support their industries. In addition, supporting academia is essential. The students of today are the engineers, scientists, and managers of tomorrow. Trimble supports educational institutions worldwide through grants, training and equipment donations. In addition, industry publications such as Coordinates are an important medium to educate readers and industry professional on technology and new applications. Government agencies can play a significant role in this acceleration by mandating higher quality metrics of work, tighter project timelines with incentives/disincentives, demanding less rework, and reducing carbon footprints with the application of greener technologies. All of us in the industry from manufacturers and media to academia and government have a responsibility to educate. We should all work together because in the end the customer will have a better experience.

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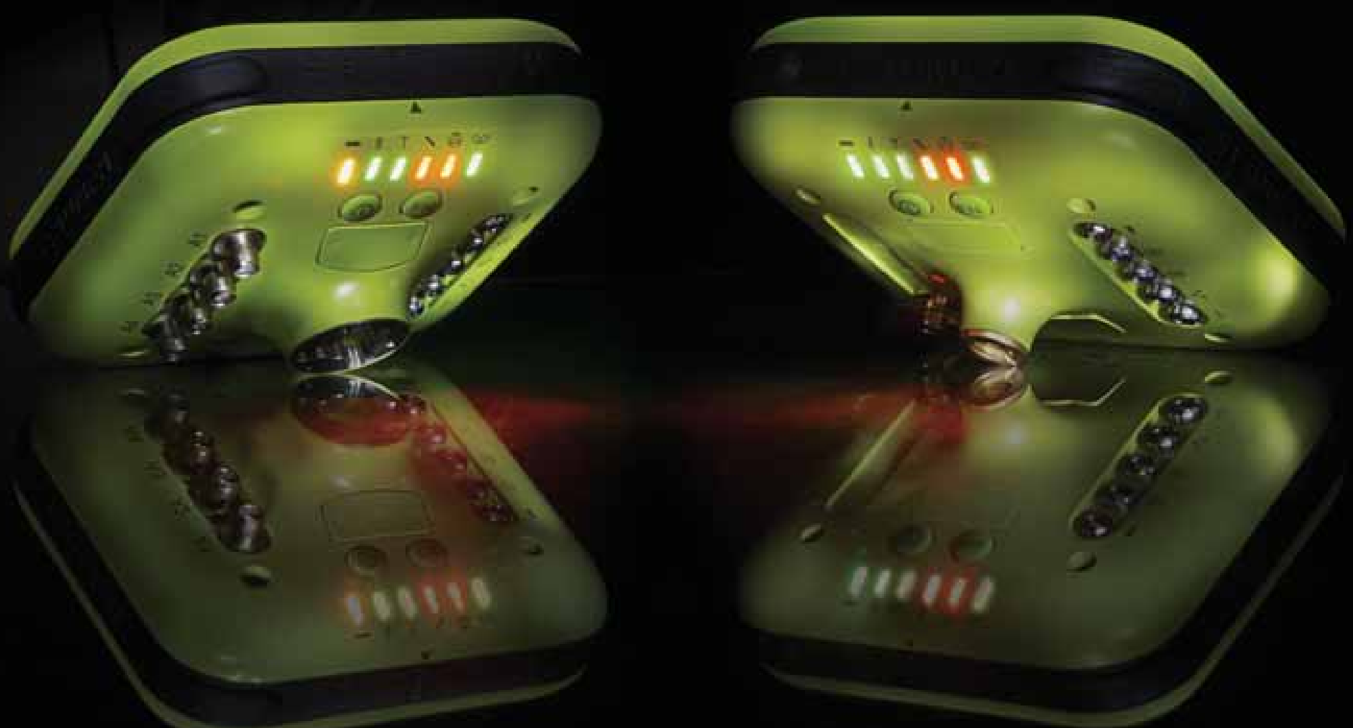
JAVAD ArcPad Extension
in focus



JAVAD ArcPad Extension

In response to a long-standing request from ESRI, JAVAD GNSS is pleased to announce that ArcPad users can now communicate directly with ESRI ArcGIS Server via our Triumph receiver so no additional devices (external radio) or settings are required. Real-time centimeter-level positioning is now possible in the field for ArcPad users.

- JAVAD ArcPad Extension enhances the spectrum of ArcPad's surveying capabilities by adding state of the art JAVAD GNSS solutions. JAVAD ArcPad Extension provides a full range of functions to control the GNSS receiver and manage the surveying process.
- JAVAD ArcPad Extension establishes a connection to the receiver via serial, USB, or Bluetooth and configures the base station parameters that govern the RTK and UHF radio setups, and GSM modem settings.

- Quality control of real-time positioning results are assured in the field. The JAVAD GNSS Victor PDA displays the status/process progress continuously via the Bluetooth connection to the receiver.
- Advanced RTK accuracy and ArcPad vector/raster map visualization capabilities deliver reliable object positioning and a new level of job control in the field.
- JAVAD ArcPad Extension is an optimal ESRI-compatible solution for a wide variety of civil engineering or cartography tasks where centimeter level accuracies are required. At the core of this solution lies highly integrated JAVAD GNSS technology optimized for use with ESRI's GIS software.

Please see www.javad.com for details.

Actual size

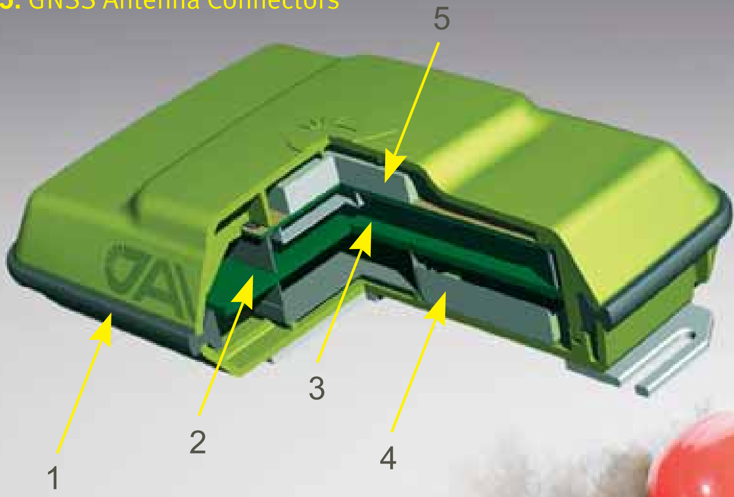
1. Guard Bumper

2. Bluetooth/GSM Antenna

3. GNSS Receiver, Power Board, GSM/Bluetooth and Memory

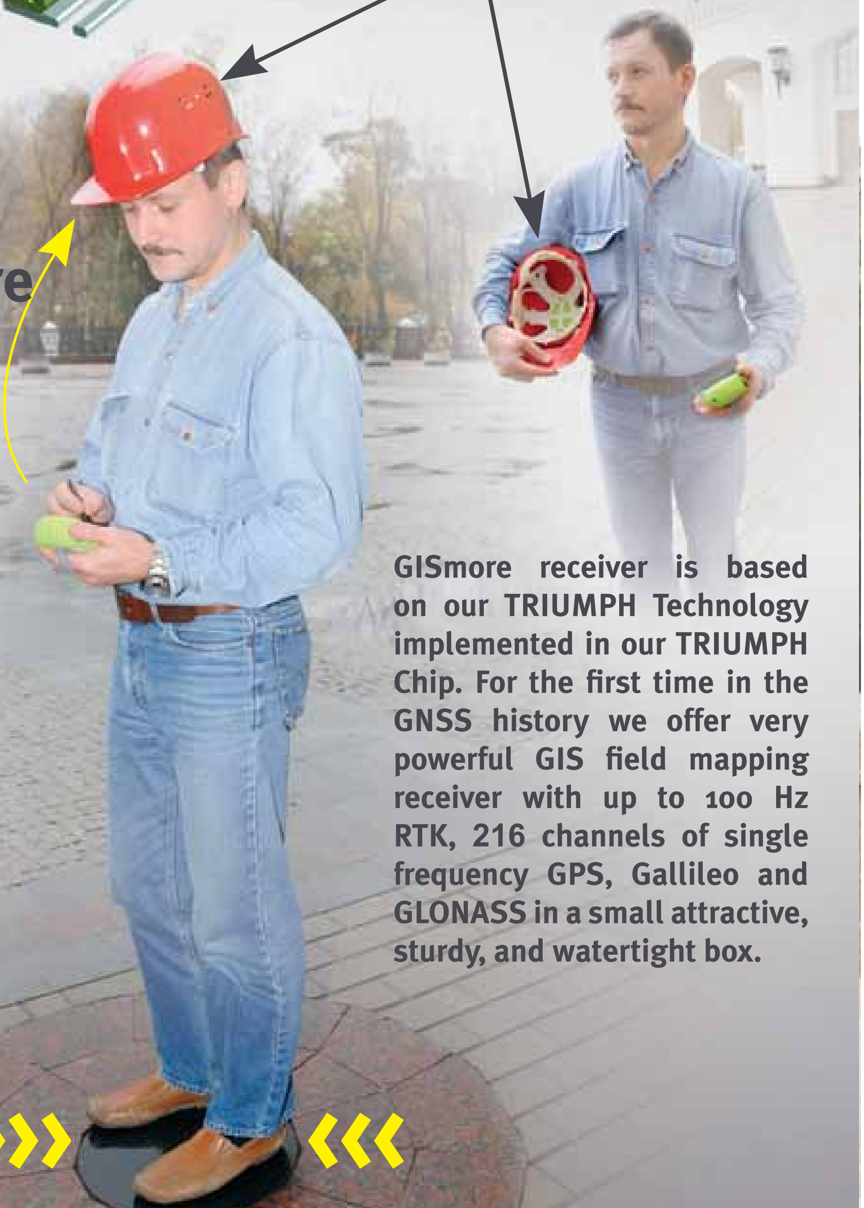
4. Rechargeable li-Ion Battery

5. GNSS Antenna Connectors



GISmore

stand-alone or inside the hat



Bluetooth wireless connection to GISmore

- GPS L1
- Galileo E1
- GLONASS L1
- 100 Hz update rate
- 100 Hz update rate
- RAIM
- WAAS/EGNOS
- Rechargeable Li-Ion Battery
- GNSS Antenna
- GSM Module
- Bluetooth® Interface
- Bluetooth/GSM Antenna

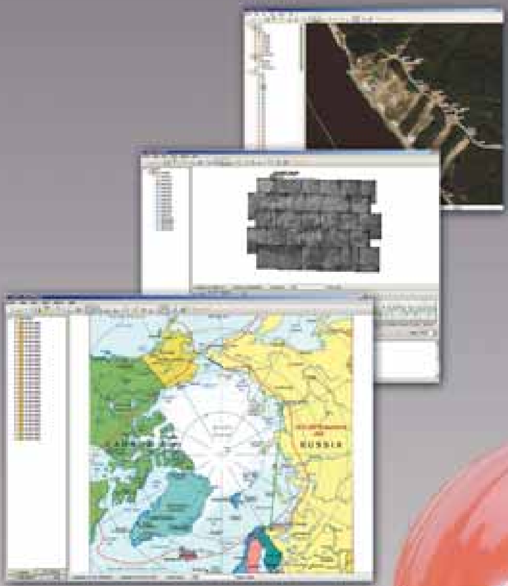
GISmore receiver is based on our TRIUMPH Technology implemented in our TRIUMPH Chip. For the first time in the GNSS history we offer very powerful GIS field mapping receiver with up to 100 Hz RTK, 216 channels of single frequency GPS, Gallileo and GLONASS in a small attractive, sturdy, and watertight box.

Many ways to use

GPS + GLONASS + Galileo

TRIUMPH 1

Software solutions for all tasks



Justin

A comprehensive Survey and GIS software

Justin has integrated native tools to use ESRI or MapInfo cartography windows.

It can import data files as well as whole folders. Justin employs special technique to process high rover data rates (up to 100 Hz) using low base data rates. Other features include single epoch static solution, manual postprocessing with time line chart, using vertical profile to filter out suspected data and scientific data analysis and viewer.

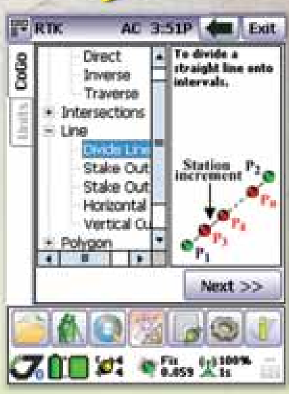
Victor

Victor is pre-loaded with our Tracy field software. When turned on, Victor automatically connects to TRIUMPH-1, TRIUMPH–4X or GISmore via its internal Bluetooth and guides you through field operations. It manages the GNSS receiver and modem operations automatically.

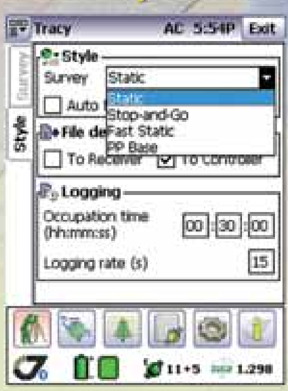
- **Lightweight** (17 ounces; 482 grams) magnesium case with easy-to-grip over-molding
- **Operating temperature** -22°F to 122°F (-30°C to 50°C)
- **Connectivity via built in Bluetooth, USB Host and Client, plus 9-pin RS-232 and optional WiFi and Modems**
- **Rechargeable, field replaceable, Li-Ion battery** It operates for more than 20 hours on one charge (3 to 5 hours of charging time)

Giodis

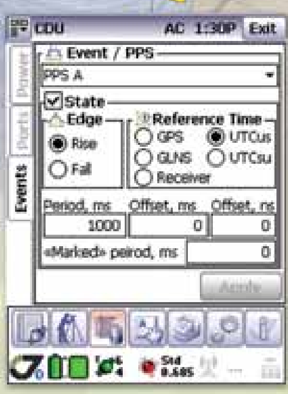
Full-featured office post-processing software



Support for survey and stakeout projects



Static, Fast Static and Stop&Go surveying



Configuration of all hardware

Tracy

A versatile and powerful field software

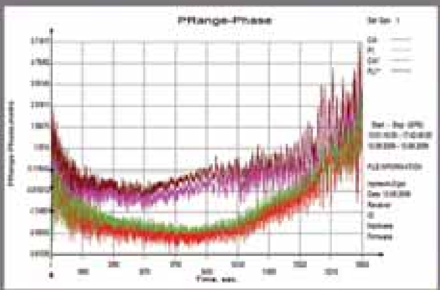
Software for Windows Mobile OS to control receivers, automated GNSS post processing surveying tasks (Static, Fast Static, Stop&Go, Data Acquisition), and to perform RTK survey and stakeout tasks.

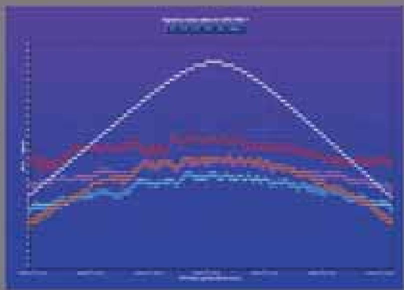
Javad eliminates GPS SVN 49 anomalies

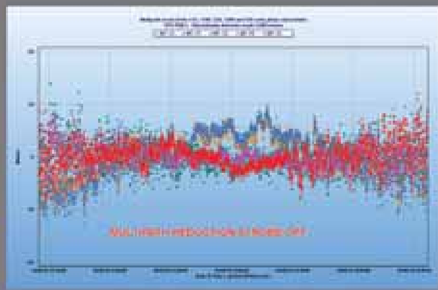
The anomalies in the recently launched SVN49(PRN1) was a chance to demonstrate the advanced multipath reduction capabilities of JAVAD GNSS Triumph technologies.

Figure below shows SNV49 (PRN1) code-minus-phase plot for usual correlator (magenta - C/A code, brown - P/L1 code) and for "mpnew" (red - C/A code, green - P/L1 code), which shows almost all anomalies and satellite multipath are removed.

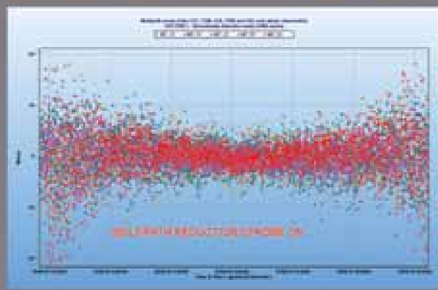
Figures below also describe the multipath performance of a pair of Triumph-1 receivers we ran in a zero baseline test. The left figure depicts the code multipath errors of the GPS PRN1 pseudoranges measured by the receiver with the 'normal' strobe enabled. The right figure shows the code multipath as estimated for the second receiver, where the optimized multipath reduction strobe was enabled. The center screenshot displays the signal-to-noise ratios and elevation angles of GPS SVN49 over the time interval analyzed.



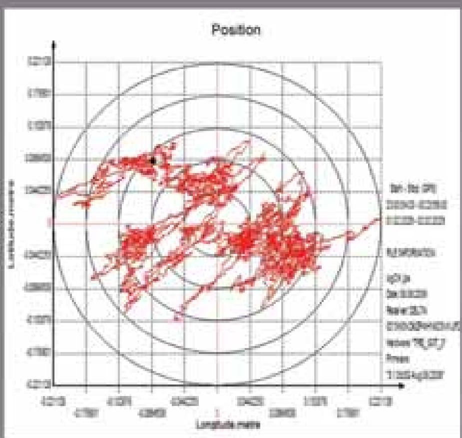




The optimized multipath mitigation technique implemented in our Triumph technology allows nearly complete compensation for the satellite-induced multipath anomalies that would otherwise badly affect GPS SVN49 measurements. The same multipath reduction capabilities which removed the SVN49 multipath anomalies can remove the multipath effects which are a major source of error in precision positioning.



JAVAD GNSS receivers tracked all current and future Galileo satellite signals



JAVAD GNSS receivers successfully tracked all Galileo satellites from Spirent simulator and produced Galileo-only and triple satellite (Gps+Glonass+Galileo) positions. Up to 27 satellites were tracked simultaneously.

The experiments were performed jointly by Spirent and JAVAD GNSS.

Sat	(Fn)	El	Az	C/A	P1	P2	TC	Count	F_C/A	F_P1	F_P2	Use
Gps	1	29	--	46	0	0	63	3818	0xA153	-------	-------	Y(0)
Gps	3	24	--	47	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	6	27	--	46	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	11	14	--	44	0	0	77	4622	0xA153	-------	-------	Y(0)
Gps	14	30	--	45	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	16	78	--	49	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	18	7	--	47	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	19	10	--	48	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	20	7	--	47	0	0	4	272	0xA153	-------	-------	Y(0)
Gps	22	38	--	47	0	0	86	4986	0xA153	-------	-------	Y(0)
Gps	31	23	--	46	0	0	86	4986	0xA153	-------	-------	Y(0)
Gln	6(-2)	24	--	51	0	0	87	4986	0xA153	-------	-------	Y(0)
Gln	7(-1)	28	--	51	0	0	87	4986	0xA153	-------	-------	Y(0)
Gln	9(1)	21	--	50	0	0	87	4986	0xA153	-------	-------	Y(0)
Gln	10(2)	76	--	52	0	0	87	4986	0xA153	-------	-------	Y(0)
Gln	11(3)	44	--	50	0	0	81	4911	0xA153	-------	-------	Y(0)
Gal	71	18	--	50	0	0	85	4986	0xA153	-------	-------	Y(0)
Gal	78	18	--	50	0	0	81	4892	0xA153	-------	-------	Y(0)
Gal	79	30	--	49	0	0	85	4986	0xA153	-------	-------	Y(0)
Gal	83	23	--	48	0	0	59	3572	0xA153	-------	-------	Y(0)
Gal	84	70	--	49	0	0	86	4986	0xA153	-------	-------	Y(0)
Gal	85	58	--	50	0	0	84	4986	0xA153	-------	-------	Y(0)
Gal	86	13	--	49	0	0	86	4986	0xA153	-------	-------	Y(0)
Gal	89	33	--	50	0	0	85	4986	0xA153	-------	-------	Y(0)
Gal	90	35	--	51	0	0	86	4986	0xA153	-------	-------	Y(0)
Gal	91	11	--	51	0	0	86	4986	0xA153	-------	-------	Y(0)
Gal	97	8	--	50	0	0	29	1742	0xA153	-------	-------	Y(0)

Other Receivers

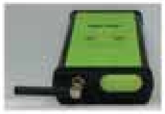
ALPHA

- Internal battery
- Charger
- GSM
- Bluetooth

FOR: TR-G3, TR-G2T, TR-G3T

Front panel connectors:

Power Input + serial port A + USB + Antenna



Back panel connectors:

Can have up to 3 connectors of 1-PPS • Event Marker • IRIG • GSM Antenna (without Bluetooth antenna).

When Bluetooth antenna is installed only one extra connector can be installed.

Example 1: BT Antenna + GSM Antenna
Example 2: 1-PPS output + Event Marker + GSM Antenna

DELTA

FOR: TRE-G2T, TRE-G3T, Duo-G2, Duo-G2D, Quattro-G3D

Front panel connectors:

Option 1: Power Input + Serial A + Serial B + Serial C + Antenna

Option 2: Power Input + USB + Serial A + Serial C + Antenna

Options 3: Power Input + USB + Serial A + Serial C + Ethernet

Back panel connectors:

Can have up to 4 connectors of 1-PPS A • 1-PPS B • Event A • Event B • Antenna • CAN • IRIG B

Example: 1-PPS A + 1-PPS B + Event A + Event B

SIGMA

- Internal battery
- Charger
- Modem
- GSM
- Bluetooth

FOR: TRE-G2T, TRE-G3T, Duo-G2, Duo-G2D, Quattro-G3D

Front panel connectors:

Can have Power Input • Second Power Input • USB • Serial A • Serial B or C • Ethernet

and up to 4 connectors of 1-PPS A • 1-PPS B • Event A • Event B • Antenna • CAN • IRIG • RS422

Back panel connectors:

Can have SIM door and GSM Antenna connector and up to 4 connectors of 1-PPS A • 1-PPS B • Event A • Event B • Antenna • IRIG • Modem Antenna • Bluetooth Antenna

Example: GSM Antenna + SIM door + 1-PPS A + 1-PPS B + Event A + Modem Antenna

Sustainable Land Governance

This paper provides the concept of land administration systems for dealing with rights, restrictions and responsibilities in future spatially enabled government. Readers may recall the first part of the paper in November 2009 issue. Here is the concluding part.

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Property restrictions

Ownership and long term leasehold are the most important rights in land. The actual content of these rights may vary between countries and jurisdictions, but in general the content is well understood. Rights to land also include the rights of use. This right may be limited through public land use regulations and restrictions, sectoral land use provisions, and also various kind of private land use regulations such as easements, covenants, etc. Many land-use rights are therefore in fact restrictions that control the possible future use of the land. Land-use planning and restrictions are becoming increasingly important as a means to ensure effective management of land-use, provide infrastructure and services, protect and improve the urban and rural environment, prevent pollution, and pursue sustainable development. Planning and regulation of land activities cross-cut tenures and the land rights they support. How these intersect is best explained by describing two conflicting points of view – the free market approach and the central planning approach.

The free market versus the central planning approach

The property rights activists, most of them influenced by private ownership viewpoints, argue that land owners should be obligated to no one and should have complete domain over their land. In this extreme position, the government opportunity to take land (eminent domain), or restrict its use (by planning systems), or even regulate how it is used (building controls) should be non-existent or highly limited. Proponents argue that planning restrictions should only be imposed after compensation for lost land development opportunities is paid (Jacobs 2007).

Throughout the European territory, another view appeared. In this, the role of a democratic government includes planning and regulating land systematically for public good purposes. Regulated planning is theoretically separated from taking private land with compensation and using it for public purposes. In these jurisdictions the historical assumption that a land owner could do anything than was not expressly forbidden by planning regulations changed into the different principle that land owners could do only what was expressly allowed, everything else being forbidden.The tension between these two points of view is especially felt by nations seeking economic security. The question however is how to balance owners' rights with the necessity and capacity of the government to regulate land use and development for the best of the society. The answer to this is found in a country's land policy which should set a reasonable balance between the ability of land owners to manage their land and the ability of the government to provide services and regulate growth for sustainable development.

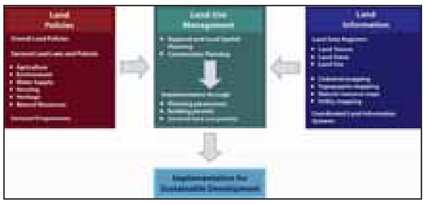

Fig. 5 Integrated land-use management for sustainable development (Enemark, 2004).

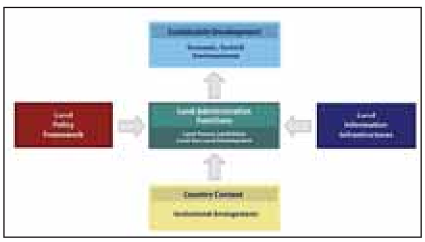

Fig. 6 The Land Management Paradigm (Enemark, 2004)

Environmental concerns

Environmental policies should emphasise that economic growth can be achieved simultaneously with improvements to the environment. Industries must be able to absorb - constructively and economically - environmental considerations into their development. Policies may be based on the "polluter pays principle" which is internationally recognized. Enterprises should be located at a site causing least possible pollution and should adopt the measures necessary to prevent pollution to the greatest possible extent. These principles are the basis of recent global/national carbon trading initiatives.

Informal development

Informal development may occur in various forms such as squatting where vacant state-owned or private land is occupied and used illegally for housing or any construction works without having formal permission from the planning or building authorities.

There is no simple solution to the problems of preventing and legalising informal development. The problems relate mainly to the national level of economic wealth in combination with the level of social and economic equity in society, while the solutions relate to the level of consistent land policies, good governance, and well established institutions. Guidance for solutions can be found in the concept of integrated land-use management as presented below with a focus on the means of decentralisation, comprehensive planning, and public participation. Although some occurrences of illegal development, such as in post conflict situations, may be difficult to stop, many other forms of illegal development could be significantly reduced through government interventions supported by the citizens. (Enemark and McLaren, 2008).

Integrated Land-Use Management

Integrated land-use management is based on land policies laid down in the overall land policy laws including the cadastral and land registration legislation and planning and building legislation. These laws identify the institutional principles and procedures for the areas of land and property registration, land-use panning, and land development. These laws identify the objectives within the various areas and the institutional arrangements to achieve these objectives through permit procedures, information policies, dispute handling, and so on.

Importantly, a mature system of comprehensive planning control needs to be based on appropriate and updated land use data systems, especially the cadastral register, the land book, the property valuation register, the building and dwelling register, etc. These registers need to be organized to form a network of integrated subsystems connected to the cadastral and topographic maps to form a national spatial data infrastructure for the natural and built environment.

Property responsibilities

Property responsibilities relate to a more social, ethical commitment or attitude to environmental sustainability and good husbandry. Individuals and other actors are supposed to treat land and property in a way that conform to cultural traditions and ways of good ethical behaviour. This relates to what is accepted both legally and socially. Therefore, the systems for managing the use of land vary throughout the world according to historical development and cultural traditions. More generally, the human kind to relationship is to some extent determined by the cultural and administrative development of the country or jurisdiction.

This relates to cultural dimensions as described by the Dutch scientist Gert Hofstede, especially the dimensions of: Uncertainty avoidance, that is the preference of structured situations over unstructured or flexible ones; and Power distance, that is the degree of inequality among people accepted by the population (Gert Hofstede, 2001). These cultural dimensions determine the social and ethical behaviour of people also in relation to the way land can be hold and used within a given culture. Systems of land tenure and land-use control therefore vary throughout the world according to such cultural differences.

Social responsibilities of land owners have a long heritage in Europe. In Germany, for example, the Constitution is insisting on the land owner´s social role. In general Europe is taking a comprehensive and holistic approach to land management by building integrated information and administration systems. Other regions in the world such as Australia creates separate commodities out of land, using the concept of "unbundling land rights", and is then adapting the land administration systems to accommodate this trading of rights without any national approach (Williamson and Wallace, 2007).

Land governance

Arguably sound land governance is the key to achieve sustainable development and to support the global agenda set by adoption of the Millennium Development Goals (MDGs). Land governance is about the policies, processes and institutions by which land, property and natural resources are managed. This includes decisions on access to land, land rights, land use, and land development. Land governance is basically about determining and implementing sustainable land policies.

Land governance underpins distribution and management of a key asset of any society namely its land. For western democracies, with their highly geared economies, land management is a key activity of both government and the private sector. Land management, and especially the central land administration component, aim to deliver efficient land markets and effective management of the use of land in support of economic, social, and environmental sustainability.

The land management paradigm as

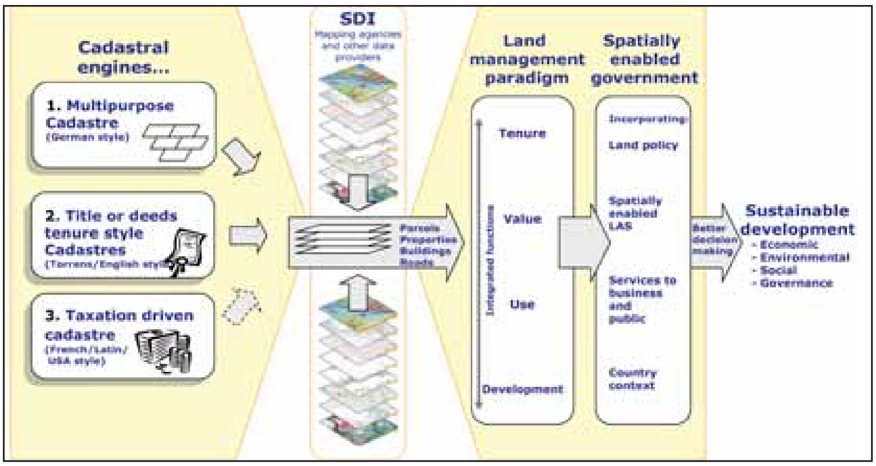

Fig. 7 Significance of the Cadastre (Williamson and Wallace, 2007)


Single data
Multiple use
Land, Water & Ocean Studies
23.5 m
LISS III Sensor
इसरो isro
NRSC Data Centre
National Remote Sensing Centre
Phone: +91(40)2388 4422, 4423, 4425
Fax: +91(40)2387 8158, 8664
Email: sales@nrsc.gov.in
Website: http://www.nrsc.gov.in

illustration in Figure 6 allows everyone to understand the role of the land administration functions (land tenure, land value, land use, and land development) and how land administration institutions relate to the historical circumstances of a country and its policy decisions. Importantly, the paradigm provides a framework to facilitate the processes of integrating new needs into traditionally organised systems without disturbing the fundamental security these systems provide. A Land Administration System designed in this way forms a backbone for society and is essential for good governance because it delivers detailed information and reliable administration of land from the basic foundational level of individual land parcels to the national level of policy implementation. And the system includes all rights, restrictions and responsibilities.

Spatially enabled government

Spatially enabled government is achieved when governments use place as the key means of organising their activities in addition to information, and when location and spatial information are available to citizens and businesses to encourage creativity.

Google Earth is good example of providing user friendly information in a very accessible way. We should consider the option where spatial data from Google Earth are merged with built and natural environment data. This unleashes the power of both technologies in relation to emergency response, taxation assessment, environmental monitoring and conservation, economic planning and assessment, social services planning, infrastructure planning, etc. This is related to institutional challenges with a range of stakeholder interests. This includes Ministries/Departments such as: Justice; Taxation; Planning; Environment; Transport; Agriculture; Housing; Interior (regional and local authorities); Utilities; and civil society interests such as businesses and citizens. Creating awareness of the benefits of developing a shared platform for Integrated Land Information Management takes time and patience. The Mapping/Cadastral Agencies have a key role to play in this regard. The technical core of Spatially Enabling Government is the spatially enabled cadastre.

Significance of the Cadastre

The land management paradigm makes a national cadastre the engine of the entire LAS, underpinning the country's capacity to deliver sustainable development.
The role of the cadastre as the engine of LAS is neutral in terms of the historical development of any national system, though systems based on the German and Torrens approaches, are much more easily focused on land management than systems based on the French/Latin approach.

The cadastre as an engine of LAS is shown diagrammatically in Figure 7. The diagram highlights the usefulness of the large scale cadastral map as a tool by exposing its power as the representation of the human scale of land use and how people are connected to their land. The digital cadastral representation of the human scale of the built environment, and the cognitive understanding of land use patterns in peoples' farms, businesses, homes, and other developments, then form the core information sets that facilitate a country building an overall administrative framework to deliver sustainable development in a country. The diagram demonstrates that the cadastral information layer cannot be replaced by a different spatial information layer derived from geographic information systems (GIS). The unique cadastral capacity is to identify a parcel of land both on the ground and in the system in terms that all stakeholders can relate to, typically an address plus a systematically generated identifier (given addresses are often duplicated or are otherwise imprecise). The core cadastral information of parcels, properties and buildings, and in many cases legal roads, thus becomes the core of SDI information, feeding into utility infrastructure, hydrological, vegetation, topographical, images, and dozens of other datasets.

Good governance

Governance refers to the manner in which power is exercised by governments in managing a country's social, economic, and spatial recourses. It simply means: the process of decision-making and the process by which decisions are implemented. This indicates that government is just one of the actors in governance. The concept of governance includes formal as well as informal actors involved in decision-making and implementation of decisions made, and the formal and informal structures that have been set in place to arrive at and implement the decision.

Good governance is a qualitative term or an ideal which may be difficult to achieve. The term includes a number of characteristics e.g. as identified in the UN-Habitat Global Campai n Urban Governance. The characteristics or norms are as follows (adapted from FAO, 2007):

- Sustainable and locally responsive: It balances the economic, social, and environmental needs of present and future generations, and locates its service provision at the closest level to citizens.

- Legitimate and equitable: It has been endorsed by society through democratic processes and deals fairly and impartially with individuals and groups providing non-discriminatory access to services.

- Efficient, effective and competent: It formulates policy and mplements it efficiently by delivering services of high quality

- Transparent, accountable and predictable: It is open and demonstrates stewardship by responding to questioning and providing decisions in accordance with rules and regulations.

- Participatory and providing security and stability: It enables citizens to participate in government and provides security of livelihoods, freedom from crime and intolerance.

- Dedicated to integrity: Officials perform their duties without bribe and give independent advice and judgements, and respects confidentiality. There is a clear separation between private interests of officials and politicians and the affairs of government.

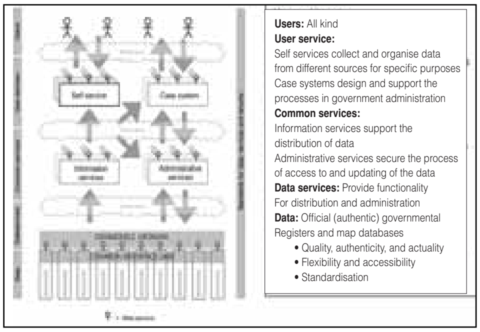

Fig. 8 The Danish concept for service-oriented IT-architecture

Once the adjective "good" is added, a normative debate begins. In any case, almost all kind of government includes a spatial component. In other words: Good governance and sustainable development is not attainable without sound land administration or - more broadly – sound land management.

Good e-Government

"E-Government" refers to the use by government agencies of information technologies (such as Wide Area Networks, the Internet, and mobile computing) that have the ability to transform relations with citizens, businesses, and other arms of government (World Bank website). These technologies can serve a variety of different ends: better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management. The resulting benefits can be less corruption, increased transparency, greater convenience, revenue growth, and/or cost reductions.

E-government is about changing how governments work, share information, and deliver services to external and internal clients. It harnesses information and communications technology to transform relationships with citizens and businesses, and between arms of government. Benefits can include reduced corruption, increased transparency, greater convenience, higher revenues, and lower costs. But these benefits do not result solely from the use of information and communications technology. Instead, e-government initiatives should be part of broader reforms to improve public sector performance in:

Delivering services to citizens. E-government can benefit citizens by reducing delays, consolidating multiple services under one roof, eliminating the need for frequent visits to government offices, and containing corruption. In addition, publishing rules and procedures online can increase transparency.

Delivering services to businesses. Businesses often face significant administrative roadblocks when interacting with government. Rules can be made transparent and consistent across departments. Transaction costs for both businesses and government can be reduced. And government can benefit from more efficient revenue collection.

Increasing efficiency. E-government can lead to higher productivity. Governments can cut staff or redeploy workers in more productive tasks. Da ta captured by an electronic system often enables more frequent and accurate data sharing across departments, closer monitoring of employee productivity, easier identification of pressure points for delay and corruption, and improved compilation of historical data that can be mined for policy analysis (World Bank, 2004) .

Knowledge management in e-Government

The concept of Knowledge Management is about optimising the use of the basic asset of any organisation namely knowledge. Knowledge Management is basically an integrated approach to managing the information assets of an organisation/ enterprise. These information assets may include databases, documents, policies, procedures, or just knowledge stored in the individual's heads. Knowledge Management, this way, is just common sense. However, in reality, the state of knowing or having access to the right knowledge at the right time is a real and important business advantage.

However, in relation to e-Government knowledge management is then basically about designing and implementing suitable spatial data infrastructures or, more particularly, it is about designing and implementing a suitable IT-architecture for organising spatial information that can improve the communication between administrative systems and also establish more reliable data due to the use the original data instead of copies. In Denmark, such governmental guidelines for service-oriented architecture e-government are recently adopted.

The key elements are: (i) Flexibility and accessibility which facilitates decision-making at all levels, (ii) Quality, authenticity and actuality due to direct access for reading and updating in the basic databases, and (iii) Standardisation through homogeneously selection of communications and exchange standards such as XML etc. This is currently being applied in the area of land administration through close cooperation between the agencies and stakeholders involved.

Final remarks

No nation can build land management institutions without thinking about integration of activities, policies, and approaches. Technology opportunities provide additional motivation. Careful management of land related activities on the ground are crucial for delivery of sustainability.

Land administration systems, in principle, reflect the social relationship between people and land recognized by any particular jurisdiction or state. Such a system is not just a GIS. On the other hand, Land Administration Systems are not an end in itself but facilitate the implementation of the land policies within the context of a wider national land management framework.

Land administration activities are, not just about technical or administrative processes. The activities are basically political and reflect the accepted social concepts concerning people, rights, and land objects with regard to land tenure, land markets, land taxation, land-use control, land development, and environmental management. Land administration systems therefore need high-level political support and recognition.

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GPS equipment accuracy testing

It is essential that all GPS equipment be tested not only initially but periodically also

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In general, measurements are only "legal" if they are "traceable" to primary standards of measurement. A GPS measurement is "legally traceable" if: (i) it is carried out using the various test/calibration procedures as required by the Guidelines, and; (ii) the survey has followed the "recommended practices for field and office procedures" as described in the Guidelines.

A GPS system testing/calibration program is considered a prerequisite for demonstrating "competence" and for assuring that GPS-derived coordinates are of a uniformly high quality. We recommend three tests: (a) a zero-baseline test, (b) calibration of the GPS equipment on an existing first order EDM/Total station baseline, and (c) connections to several existing first order geodetic control stations. It is essential that all GPS equipment be tested not only initially but periodically depending upon volume of usage of particular GPS equipment in case of surveys of first and second order accuracy. Details of these tests have been described in this paper.

A pair of dual frequency or single frequency geodetic GPS receivers or used mostly in relative positioning mode and also in differential mode (DGPS) for all applications requiring first or second order control surveys. Whether the GPS equipment (GPS receivers, antenna, cables, processing software etc.) yield the required results, should be found by carrying out testing, on receipt of the equipment and before any significant project is taken up. The following tests are recommended for the testing of GPS equipment: -

Zero base line test

The two GPS receivers should be connected to single antenna using an antenna splitter appropriate for the particular brand of receiver and antenna. The slope distance on processing should be less than 3 mm. This test is very simple and should be performed at regular intervals and also before any control survey project is undertaken.

Known base line test

The pair of GPS receivers should be tested by measurement against a known base line of first order accuracy. In India Survey of India has a 13 km base line of first order accuracy near Dehra Dun. Most of the GPS equipment purchased by SOI is tested against this base line. Such test sites can be prepared by number of zero order observations between two inter visible points/stations anywhere by Geodimeters/ Precise EDM instruments. GPS equipment should be checked against such base line periodically. The resulting difference between slope distances should yield accuracy of better than 1 in 50000.

Network test

India has a geodetic control network of first order accuracy in which control points are available nearly every 50 km apart. GPS receivers to be tested should be used for observations at such points and processed coordinates can be checked against these. Indian control points known as GTS stations are in Indian system whereas GPS gives coordinates in WGS 84. Therefore a network of at least a braced quadrilateral can be observed, data processed, and adjustment done by least squares. Processing shall yield accuracy also which should be of the first order. This test is most comprehensive and considered the best but it takes considerable time.

Conclusion

It is essential that at least two tests preferably all the three tests should be performed on receipt of the instruments and periodically say every year and before any large control survey project is taken up.

References

Guidelines for GPS Cadastral urveys in Malaysia

TurboGPS wireless service in S Korea

u-blox and FINEDIGITAL Inc. has launched a wireless accelerated-GPS service "TurboGPS". It provides GPS aiding data to vehicle and PNDs throughout South Korea and is available to 3rd party manufacturers of GPS products. *www.u-blox.com*

Vehicle Tracking in Papua New Guinea

MapData Sciences (MDS) and Data Nets Limited shall be providing current digital mapping and live fleet tracking services in Papua New Guinea (PNG). One of the first applications shall be to protect the fuel tankers and their cargo for a major energy provider in the region, by allowing them to utilise GPS tracking devices and real time monitoring of the vehicles. *www.mapds.com.au*

3-D maps help at difficult intersections

Navteq plans to help drivers navigate the most difficult intersections by rendering them in 3-D. The image appears as animation but mimics what the driver sees through the windshield, including roads signs, overhead passes and other real-world objects. The software will switch from a flat map to 3-D and highlight the correct lane. Its named as "Motorway Junction Objects." *http://corporate.navteq.com*

Nokia gets a new Maps Booster application

A new application by Skyhook will speed up the time taken by Nokia handsets running the Symbian S60 OS to locate their position on mapping software. www.top10.co.uk

Telogis, MapIT partner for fleet management

Telogis collaborated with MapIT to offer new technology and map data for enterprise-focussed companies in the Sub-Saharan region. It offers MapIT`s clients the latest in mapping, routing and navigation technologies, and white label tracking and route optimization as a hosted service. *www.reuters.com*

OS data to keep track on workers

Data collected by Ordnance Survey is to be used to keep track on vulnerable workers and young children. Locatorz will be the first commercial company to get its hands on such data. Users will have to have a GPS-enabled handset for the service to work. It can only be activated with the consent of the mobile owner and can locate people to within 10 metres. *http://news.bbc.co.uk*

GPS on Panchkula ambulances

All government-owned ambulances in the Panchkula, India will have GPS on board. Red Cross and health department intend to do this for providing prompt assistance to accident victims and others needing emergency medical services. *http://timesofindia.indiatimes.com*

Netherlands distance-driven taxi service

A distance-driven taxi service, with the distance calculated by onboard GPS receivers, to replace the annual road tax on cars has been initiated by the Dutch government. Dutch drivers will pay per kilometre driven, in a move to ease chronic traffic jams and cut carbon emissions. GPS receivers will track the time, hour, and place each car moves and send the data to a billing agency. There was no specification as to whether the measure will require carmakers to install the receivers and antennas, or whether it must be done by car dealers, or others, prior to sale. *www.verkeerenwaterstaat.nl*

Improving Air Navigation Planning

Using ArcGIS Server, International Civil Aviation Organization (ICAO) is creating a Web-based portal containing various global air navigation charts that can be viewed and accessed over the Internet. Providing access to the data is beneficial for the planning, monitoring, and analysis of newly planned facilities and services in regional air navigation plans. *www.esri.com*

Free GPS navigation on mobile phones

Google unveiled a free navigation system for mobile phones in USA. Verizon Wireless and Motorola announced that a smartphone going on sale in the US, the Droid, would be the first to feature Google Maps Navigation. It is powered by Android 2.0 software, mobile phone operating system by Google. *http://tech.yahoo.com*

Telmap brings navigation to iPhone

Telmap has used its navigation technology and NAVTEQ's global map data to bring a comprehensive mobile search, mapping and navigation solution for the iPhone. *www.telmap.com*

Navigon PND uses NASA Terrain Data

Navigon has launched 8100T, with a 4.8-inch display and NASA terrain data with free traffic data service for life. It includes routing around congestion by including traffic flow, incidents, and alternate routes; it covers some 95 markets across the US and Canada. *www.navigonusa.com*

iPhone app for managing UPS shipments

UPS announced a new application for iPhone and iPod touch users that not only ships and tracks packages but also uses built-in GPS features to find the nearest UPS location. The users can use their devices to access their My UPS Address Book and Preferences and create shipping labels, which can be e-mailed in a PDF file for printout. *www.ups.com*

LBS for Indonesian subscribers

Indosat is bringing advanced LBS to its 29 million subscribers using Ericsson's technology. Subscribers will get location tailored content, enabling real-time traffic information. *www.ericsson.com*

Galileo update

Inauguration of Galileo station at Kourou

The site of a ground station for Galileo inside the Guiana Space Centre (CSG), near Kourou in French Guiana, has been inaugurated. The site, which was made available by France's Centre national d'études spatiales (CNES), will play an essential role in the setting up of the Galileo system, since it will accommodate the most comprehensive of the Galileo ground segment stations. The Kourou station will consist of a telemetry, tracking and command (TT&C) station to monitor and control the Galileo constellation satellites, a sensor station (GSS) for acquisition of the satellite navigation signals, and two uplink stations (ULS) for transmission of navigation and integrity messages to the satellites. In all, the Galileo ground segment for the in-orbit validation phase (IOV) will comprise 18 sensor stations, 5 uplink stations, 2 telemetry, tracking and command stations, and 2 Galileo Control Centres (GCCs). The Control Centres will be situated at Fucino in Italy and Oberpfaffenhofen in Germany. The site was inaugurated in the presence of René Oosterlinck, Director of the Galileo programme and navigation-related activities at ESA, and of Joël Barre, Director of CNES/CSG. *www.esa.int*

SE Asian Centre on GNSS

The Galileo Space Advisory Council has asked the Asian Institute of Technology in Bangkok to prepare a sustainability strategy for the next five years for the Southeast Asia Centre on GNSS. The centre is being established under the SEAGAL (the South-East Asia centre on European GNSS for international cooperation And Local development) project. SEAGAL is funded by the European Union under the European Commission's Seventh Research Framework program. The main objective of the project is the definition of an implementation plan for a Galileo collaboration centre to support the educational, commercial and technical needs of South-East Asia. The partners in the project are AIT, Istituto Superior Mario Boella and Politcno Di Torino, both in Italy, the Spanish Universitat Politècnica de Catalunya and the French Universite, Franche-Comte as well as Hanoi University of Technology. *http://galileosystem.blogspot.com*

Galileo concert promotes satellite navigation programmes

A 'Galileo Concert' held in Austria harmoniously blended information about Europe's space navigation programmes with a classical piano recital. With wine tasting and food as part of the mix, the event attracted 330 people to the Austrian Academy of Sciences building in Vienna. It provides an example of an alternative way of promoting the benefits of EGNOS and Galileo to the general public. Connecting technology with the arts and culture draws a broader range of people to information events about Europe's two satellite navigation programmes, says Elisabeth Klaffenböck, a technical expert with the Austrian Research Promotion Agency and the country's Aeronautics and Space Agency. Each year the two organisations hold four to five events to inform people about the EGNOS and Galileo programmes. The event in Vienna was the first to feature music, food and drink. *www.gsa.europa.eu*

New Satellite Positioning Station in Central Vietnam

The Ministry of Natural Resources and Environment has launched a DGPS to receive round the clock positioning signals from the US satellite system in Vietnam's central province of Quang Nam. It will be useful for the development of the sea-borne economy and the management of natural resources and environment. *http://newswire.bernama.com*

Satellite Test Software for GPS III

L-3 Telemetry-West has signed a contract with Lockheed Martin Space Systems Company to supply a Command, Control, Communications, and Monitor (C3M) system used in factory testing on the GPS III Program. The C3M software is based on L-3 TW's InControl software product, which supports satellite test and on-orbit operations. *www.l-3com.com*

Mumbai Metro-II survey

The concessionaire of Mumbai's second metro corridor has undertaken the topography survey and alignment mapping with the help of DGPS. It is being used for the first time in Metro rail construction in India. Reliance Infrastructure teamed up with Canada-based SNC Lavlin and bagged the Rs 8,250-crore contract. Fugro has been roped in to carry out the topography survey for the Charkop-Bandra-Mankhurd corridor. *www.indianexpress.com*

Video sync capability for LabSat GPS Simulator

Using a Racelogic Video VBOX, a GPS data logger used by automotive and motorsports professionals, it is now possible to record live video and then replay it, synchronised with the LabSat data. This gives a unique visual element to testing, and is ideal for companies developing LBS applications. *www.labsat.co.uk*

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www.southinstrument.com
http://us.southinstrument.com

Dual Axis Compensation
High automation in eliminating errors and compensation.

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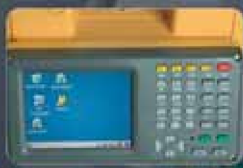
Easy to use, operate by direct touch or press the key board according to your habit.



Win-CE System
Windows® CE.Net™ is installed.

Convenient Data Communication
The SD huge extended memory is incredibly flexibility and reliable safety, while USB interface help you build a close communication between TS and PC.

Dual sides with graph

Built-in Software
With various outstanding surveying programs, Mapping Genius and Engineering Genius evolved your TS into a more powerful product.

NTS-960R SERIES TOTAL STATION
Win-CE System
Touch Screen
Water & Dust Proof
Stability Greatly Improve

2" or 5"
Measuring range without prism :300m
Accuracy: 5+3ppm
Measuring range with single prism: 5Km
Accuracy:2+2ppm

USGS seeks proposals to build NSDI

USGS and the Federal Geographic Data Committee of USA formally announced their request for proposals to support the 2010 National Spatial Data Infrastructure (NSDI) Cooperative Agreements Program. The NSDI CAP will award an estimated 31 innovative projects in the geospatial data community. *www.fgdc.gov*

Delhi gets new geo-portal

Delhi State Spatial Data Infrastructure Project has been unveiled recently by the Chief Minister of Delhi state in India. The geo-portal with geo-spatial data of the Capital has been developed by the IT department of the Delhi Government. The CM said the project would set new benchmarks in urban management in the country. It will make underground and overground utilities in digital form

accessible to over 30 departments. The whole range of spatial and attribute data will be accessible through a geo-portal that will function as a single window through which associated bodies can access information and decision-support systems. The portal will provide access to the line departments like the New Delhi Municipal Council, Municipal Corporation of Delhi, Delhi Development Authority and Delhi Police besides Union and State government bodies. *www.thehindu.com*

Ireland project by RMSI

RMSI has successfully completed a large scale "Text Data Capture from Image Folios Project" for the Property Registration Authority of Ireland that involved the conversion of more than 807,000 individual folios held in scanned image format into a fully digitized format. *www.rmsi.com*

Kerala State SDI established

The Kerala Government in India has taken the lead to create, maintain and deliver geospatial data and metadata for their external clients, in real time. It has announced setting up of a SDI called Kerala State Spatial Data Infrastructure (KSSDI). *www.itmission.kerala.gov.in*

Satellite mapping for slum free Mumbai

Mumbai would soon have satellite mapping and land audit to avoid encroachments on open spaces, as per the Maharashtra government's mission to make the financial capital slum-free. *www.ptinews.com*

Land cover map of Antartica

Chinese scientists from the country's 26th Antarctic expedition are expected to complete the world's first land cover map of the Antarctica by the end of 2009. It will conduct wide range of field spectral collection to provide data for the map. It will show the distribution of key features on the continent, including sea ice, snow, blue ice, rocks, soil marshes, lakes and ice crevasse. The map will provide more accurate ground parameters for scientists to forecast global change or global warming with climate system models and also important data for detection on the change of Antarctica land cover in a long run. *http://news.xinhuanet.com*

Legal battle over web based mapping patent

Google, Microsoft, Yahoo and a dozen more US based companies that offer web based mapping applications are being sued by WebMap Technologies for infringement of a US patent called Method and Apparatus for Collecting and Expressing Geographically Referenced Data. The patent from 2004 was originally assigned to Cornell Research Foundation and National Audubon Society. WebMap Technologies claims to be the only licensee of the patent and alleges in the complaint that Google has known about the potential infringement for some time before the suit was filed. *www.tgdaily.com*

New global digital topographic map

NASA and Japan have released a new digital topographic map covering more of the globe and in more detail than any previous global digital elevation map. Nearly 1.3 million individual stereo-pair images collected by the Japanese Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) provided the bases for the global DEM of Earth. *www.nasa.gov*

World Ocean Database 2009

NOAA released the World Ocean Database 2009, the largest and the most comprehensive collection of scientific information about the oceans with records dating as far back as 1800. *www.noaanews.noaa.gov*

Lawsuit against Google

Swiss Organisation for the protection of privacy intends to file a lawsuit against Google's Street View serviceas it is not hiding the faces of people in their photographs of Swiss cities. *http://it-chuiko.com*

Free online OS map data

Ordnance Survey (OS) map data will be available online free of cost to everybody from 2010. It will allow people to interpret public statistics about crime, health and education by postcode, local authority or electoral boundary. *www.ordnancesurvey.co.uk*

Call for Participation the OGC

OGC has issued a RFQ/CFP for the OGC Web Services, Phase 7 (OWS-7) Interoperability Initiative, a testbed to advance OGC's open interoperability framework for geospatial capabilities. *www.opengeospatial.org.*

DigitalGlobe signs agreement with Microsoft

DigitalGlobe has signed an agreement with Microsoft to launch the Clear30 program, an initiative to distribute high-resolution, 30-cm aerial imagery of contiguous landscapes, initially in the U.S. and Western Europe. *http://media.digitalglobe.com*

China to build satellite launch center

A new satellite launch center is now under construction near Wenchang in China's Hainan province. It will be the country's fourth satellite launch centre and replace the Xichang Satellite Launch Centre. *www.spacedaily.com*

GeoEye-1 Multi-Site option available

AAMHatch's Multi-Site product is now available for 50cm GeoEye-1 satellite imagery. Multi-Site, already available for 80cm IKONOS imagery, allows clients interested in multiple captures over small areas to acquire the higher resolution GeoEye-1 satellite imagery. *www.aamhatch.com*

Indian students design satellite

A team of engineering students from southern India have been designing a small light-weight satellite supported by Indian Space Research Organisation (ISRO). All the 40 students from seven colleges in Bangalore and Hyderabad are working together at Nitte Meenakshi Institute of Technology in Bangalore. The satellite will be used for remote-sensing applications and will orbit the earth at an altitude of 700 kilometers and will send 30 minutes of data everyday. The students have already built a master-control ground station to track the location of the satellite in space. *http://english.cctv.com*

SPOT satellite data of North America

USGS in partnership with Spot Image Corporation, has begun to distribute, over the Internet, SPOT satellite data collected over parts of North America between 1986 and 1998. The USGS is distributing this data at no charge through the USGS Earth Explorer search and order tool. *www.usgs.gov*

NRSC to monitor irrigation projects

Government of India has decided to assign the National Remote Sensing Center (NRSC) to monitor 50 irrigation projects using satellite imagery. The satellite imagery will be used to confirm the progress made by states in carrying out irrigation projects under the Accelerated Irrigation Benefit Programme (AIBP). *www.ptinews.com*

Satellite Bush Fire site for Indonesia

Indonesia's latest weapon in the fight against damaging forest fires is a website called Indofire - a collaborative project between two Indonesian government departments: Ministry of Forestry, and the Institute of Aeronautics and Space (LAPAN). It was developed by the Western Australian state government agency Landgate, and funded by Ausaid. The system uses the MODIS sensor on NASA's Aqua and Tera satellites to map the position of hot spots, and a web interface to get the information out to a user community. *www.antara.co.id*

Eurockot launches SMOS and Proba-2

The second satellite in ESA's Earth Explorer series-the Soil Moisture and Ocean Salinity (SMOS) mission-and the second demonstration satellite under ESA's Project for Onboard Autonomy (Proba-2) have been launched. SMOS will play a key role in the monitoring of climate change on a global scale. It is the first ever satellite designed both to map sea surface salinity and to monitor soil moisture on a global scale. It features a unique interferometric radiometer that will enable passive surveying of the water cycle between oceans, the atmosphere and land. *www.eurockot.com*

At a Glance

Mergers, Acquisitions and Partnerships

- EVC to distribute LandScan Global Population Database.
- DLT, Tele Atlas contract to serve government sector.
- Appello Systems and Sony Ericsson strategic partnership.
- Rediff has announced an investment in Imere, Bangalore.
- 90 additional GPS ref stations by Topcon for the Japanese CORS GEONET.
- NASA agreement with ISRO for Oceansat-II.
- Samsung to use Tele Atlas maps for its GPS-enabled devices.
- TeleNav files for $75 million IPO.
- Hemisphere GPS receives Cleantech 10 award.
- Bentley announces winners of 2009 Be Inspired awards.
- 88% of PNDs sold in 2015 will have integrated cellular connectivity - Berg Insight.
- ISRO to outsource high-end work to private companies.
- IDBS opens new centres in China and Australia.
- AAMHatch increases GIS capabilities in Malaysia.
- ARCO-TT launches GPS navigation in Jordan.
- "Bhuvan should be accessed by organisations" says Indian minister.
- TomTom launches PND's in South Africa.
- PND shipments grow despite competition from GPS Handsets - Research and Markets Ltd.

Point Cloud CAD 2010 and FieldGenius 2010 by MicroSurvey

The Point Cloud CAD 2010 allows the individual to work with Point Cloud and LIDAR data with ease. It works with hundreds of millions of points with ease and the ability to create line work very quickly, surface models and contours directly from the Point Cloud. Built on MicroSurvey CAD 2010 platform it uses the same rendering program used in products like MicroStation and 3DStudio and uses the Leica PCE engine.

FieldGenius 2010 has many new features added to improve the work flow which include several new improved Stakeout routines ,new blue tooth manager for improved instrument communication, powerful new offset tools, point patterns etc. It can be loaded onto many data collectors.

Nottingham Geospatial Building open for business

GRACE has taken occupancy of the Nottingham Geospatial Building on the University of Nottingham Innovation Park on the Jubilee Campus. It brings the IESSG (Institute of Engineering Surveying and Space Geodesy), the CGS (Centre for Geospatial Science) and GRACE (GNSS Research Applications Centre of Excellence) together in one location. GRACE has also launched new Training Services. *www.grace.ac.uk*

Leica adds new software and updates Leica XPro 4.2

Leica Geosystems announced three new laser scanning software products for scan data import, forensic scene mapping, and modelling complex 3D surfaces. These products will increase the breadth and depth of laser scanning software solutions.

Leica XPro has been updated with several enhancements. It covers the entire line sensor workflow - from data download to image generation. It can take advantage of on-the-fly generated images in triangulation and many other improvements to increase productivity and efficiency. *www.leica-geosystems.com*

Advanced Positioning features for OEMs

Magellan® Professional released a major firmware release for its MB 500 OEM GNSS board. They are available in a variety of configurations from L1 GPS+GLONASS up to L1/L2 GPS+GLONASS+SBAS. It is designed to allow OEMs and system integrators to easily add real-time sub-meter up to centimetre-level positioning to specialized or custom hardware solutions. *www.promagellangps.com*

Outback S-Lite™ in Punjabi

Hemisphere GPS has launched a new version of the Outback S-Lite GPS guidance system in India. It carries over all the proven features of the existing versions and now supports the Punjabi language. Its compact size, expandable features and sub-meter accuracy make it an ideal entry-level GPS guidance solution for farming applications. *www.hemispheregps.com*

SuperGeo obtains patent

SuperGeo has obtained the Taiwanese patent on the Internet Map Cache Technology. The name of the patent is "Geographic Information System", No. 316671. *www.supergeotek.com*

Geomatica 10.3 released

PCI Geomatics have released of Geomatica 10.3. It includes support for ESRI ArcGIS Server Image Extension, as well as multi-sensor support through OrthoEngine for ArcGIS users. *www.pcigeomatics.com*

Bentley 2010 Student Design Competition

The call for nominations for Bentley's 2010 Student Design Competition is now open. Bentley will award a $1,500 scholarship to the winner in each of the categories at the university/college level and a $1,000 scholarship to the winner at the middle school/high school level. *www.bentley.com*

OnPoint ™ 6.3.1 released

Rolta Canada Limited released Rolta OnPoint™ which continues to enhance the power of Rolta's Geospatial Fusion™ solutions by providing support for ArcGIS Server 9.3.1. *www.rolta.com*

LIDAR-based mapping by Aerotec

Aerotec introduced its second-generation airborne LIDAR-based mapping product for identifying and locating vegetation in the vicinity of electric power transmission. A featured component of the vegetation management product is a handheld unit that provides the utility forester with the capability to measure, locate, analyse, and report the vegetation violation on-the-spot. *www.aerotecusa.com*

Trimble Placer Gold GPS receivers

Trimble released Placer Gold receiver, a 12-channel GPS receiver, designed to provide reliable, fully-configurable vehicle location and reporting for mission-critical automatic vehicle location applications. *www.trimble.com*

MapInfo embraces SaaS

Pitney Bowes Business Insights has begun making a major investment in Software as a Service. This has now reached a level where many, if not most, of its offerings are available in a SaaS environment. In PBBI's world, it seems the most likely business model is one where a client organisation has a particular business process. *www.mapinfo.com*

NATURE-SDIplus selects Intergraph(R)

NATURE-SDIplus has selected Intergraph® to build a geoportal to harmonize and improve access to national datasets. It supports the INSPIRE directive launched by the European Commission in 2002 to make geographic information available for developing community policies and initiatives. It aims to improve the harmonization of national datasets on nature conservation, making them accessible and exploitable at all levels of government and others. *www.nature-sdi.eu*

SSTL European Lunar Mission

Surrey Satellite Technology Ltd (SSTL) has been selected by the ESA to manage a pan-European student-built mission to the Moon. The European Student Moon Orbiter (ESMO) programme will place a spacecraft into a lunar orbit to map the lunar surface, acquiring images and other scientific data. *www.sstl.co.uk*

Sokkia releases enhancements

Sokkia has announced four enhancements to the NET05 and the NET1 Automated 3D Stations. The NET05 features 0.5-sec angle accuracy and sub-millimeter EDM for maximum precision, while the NET1, a 1-sec model, incorporates longer range EDM and a new laser option designed for precise measurement in tunnel and general construction applications. *www.sokkia.com*

Micro-Ant GPS/GLONASS antenna

Micro-Ant Inc. is offering a high-performance GPS L1/L2/L5 plus GLONASS antenna for the Machine Control and Agriculture market. The antenna has a horizontal phase-center accuracy of ±4 millimeters and vertical accuracy of ±14 millimeters. Its broad frequency-tracking band includes GPS (L1, L2, L5), GLONASS (L1, L2, L3), and Galileo (E1, E2, E5, E6). The antenna is also SBAS-capable (WAAS/EGNOS/MSAS). *www.micro-ant.com*

Pioneer sues Garmin in ITC court

Japan's Pioneer has filed a complaint with the U.S. International Trade Commission against Garmin, alleging some of its products infringe on Pioneer patents related to navigation. *www.pioneer.jp*

GeoTranslate 5.1 released

Blue Marble Geographics released the beta version of GeoTranslate 5.1 with Spatial Connect along with GeoTransform 6.1. GeoTranslate and GeoTransform are incorporated into the Blue Marble's GeoCore SDK an all-in-one geospatial data translation developer toolkit. *www.bluemarblegeo.com*

Garmin next generation navigators

Garmin International released the GPSMAP 6000 and GPSMAP 7000 series with Garmin G Motion technology. It represents a graphic breakthrough in speed, smoothness and clarity. *http://garmin.blogs.com*

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Asia Oceania Region Workshop on GNSS
25-26 January 2010
Bangkok,Thailand
www.multignss.asia/workshop.html

March 2010

Munich Satellite Navigation Summit
9-11 March
Munich, Germany
www.munich-satellite-navigation-summit.org

GEOFORM+'2010
30 March –2 April
Moscow, Russia
www.geoexpo.ru

Digital Preservation of Archaeological Heritage
10 - 12 March, 2010.
IIT Kanpur, Kanpur, India
arch3d@iitk.ac.in
www.iitk.ac.in/arch3d

CARIS 2010
22-25 March
Miami, Florida, USA
www.caris.com/caris2010

April 2010

XXIV FIG International Congress 2010
11 - 16 April 2010
Sydney, Australia
www.fig2010.com

Geo-Siberia 2010
27-29 April
Novosibirsk, Russia
www.geosiberia.sibfair.ru

ASPRS 2010
26-30 April
San Diego, CA, USA
www.asprs.org/SanDiego2010

May 2010

TIDES 2010
20-21 May
Taipei, Taiwan, R.O.C.
derc@mail.pccu.edu.tw

June 2010

Toulouse Space Show 2010
8 - 11 June
Toulouse, France
contact@toulousespaceshow.eu
www.toulousespaceshow.eu

July 2010

ISPRS Centenary celebrations
4 July
Vienna, Austria
www.isprs100vienna.org

ESRI International User Conference
12–16 July
San Diego, USA
www.esri.com

September 2010

IPIN 2010
September 15-17, 2010
ETH Zurich, Campus Science City
(Hoenggerberg), Switzerland
www.geometh.ethz.ch/ipin/

ION GNSS 2010
21-24 September
Portland, Oregon, USA
www.ion.org

October 2010

INTERGEO
5 - 7 October
Cologne, Germany
www.intergeo.de

GSDI-12 World Conference
19-22 October
Singapore
www.gsdi.org

GEOINT 2010
25-28 Oct
Nashville, Tennessee, USA
http://geoint2010.com

November 2010

Trimble Dimensions 2010
8 - 10 November
Las Vegas, USA
www.trimble-events.com


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