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Volume VIII, Issue 2, February 2012

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Choosing the best path

Global to national coordinate transformations

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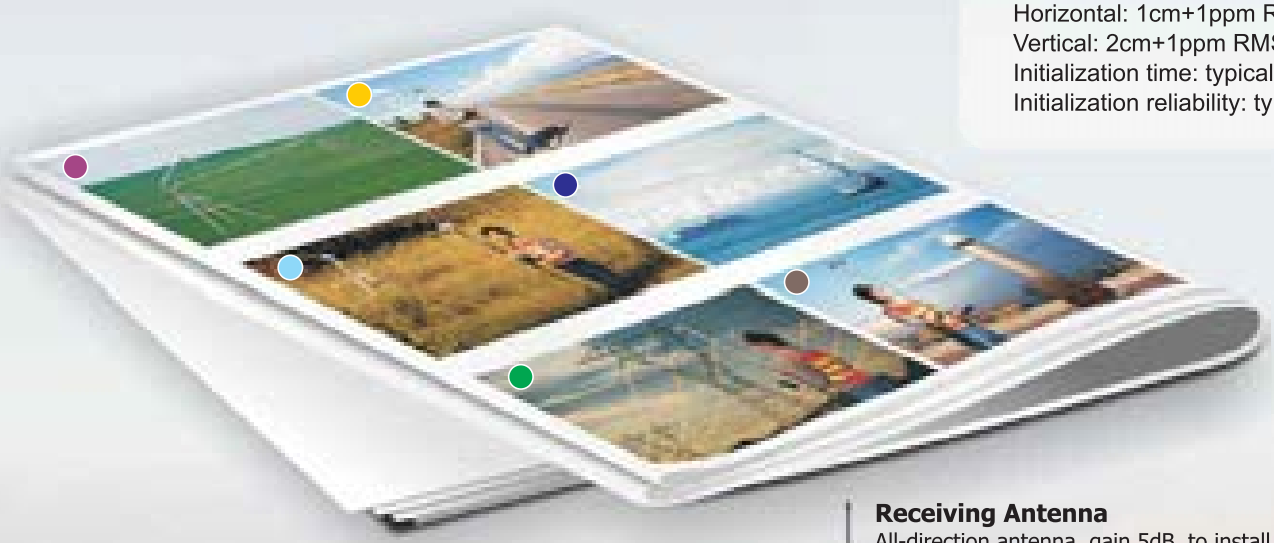

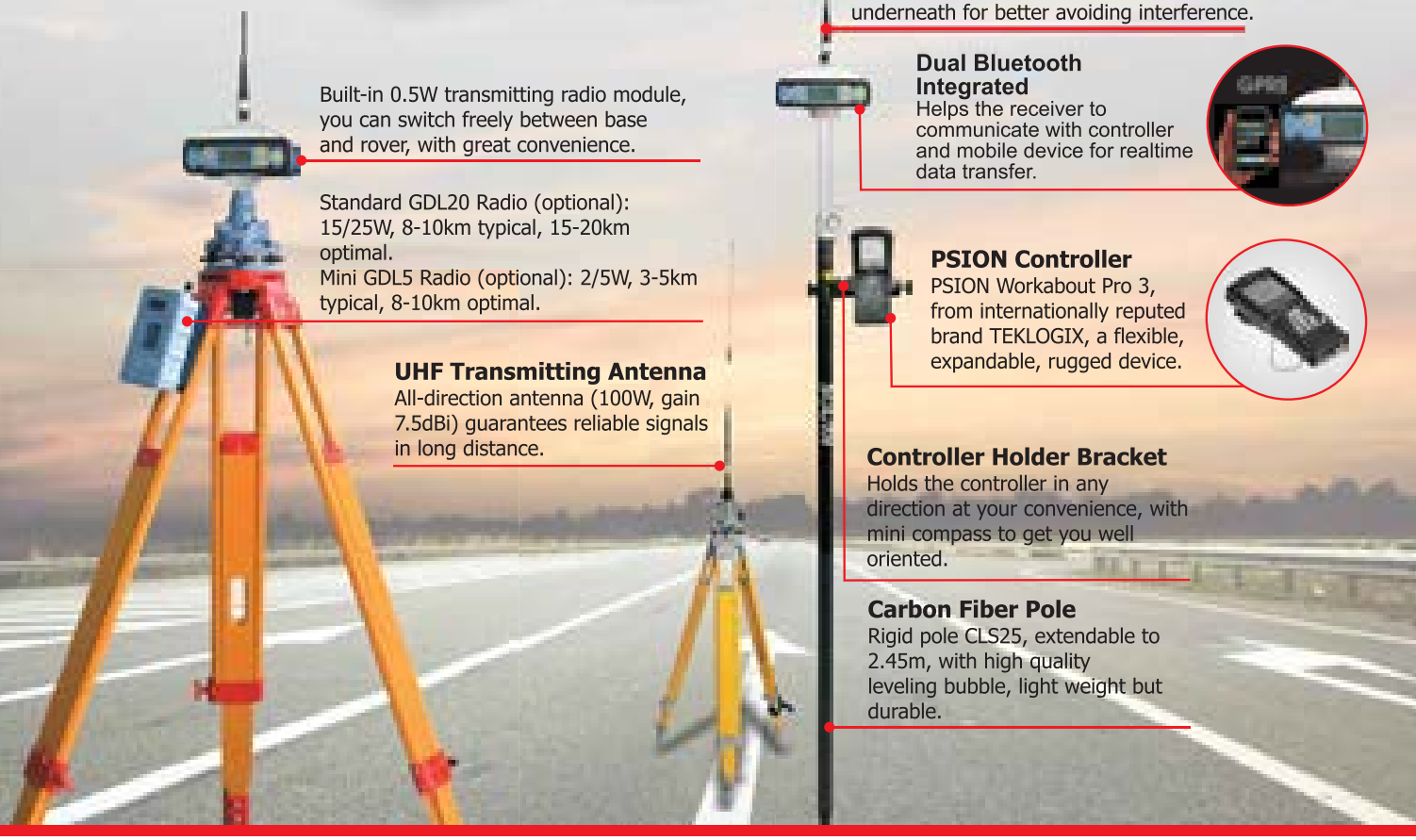

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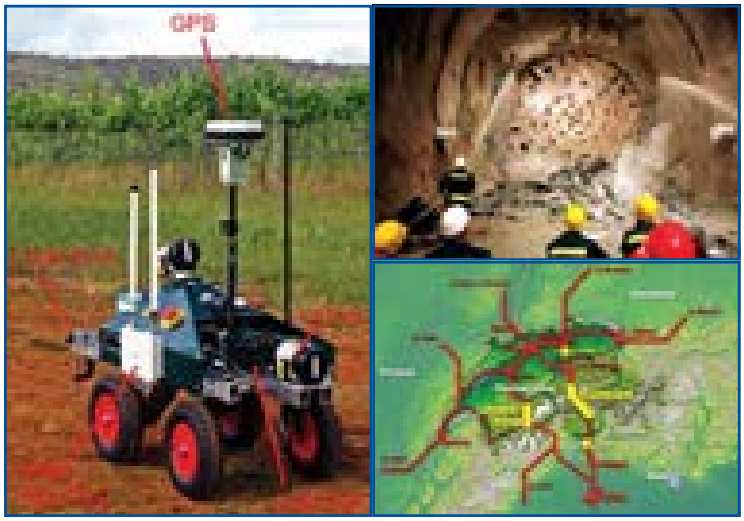

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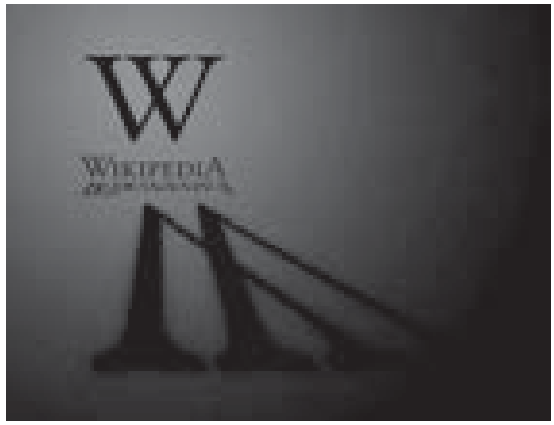

SOPA, PIPA, …

The proposed anti-piracy bills in the U.S.

Stop Online Piracy Act (SOPA), Protect IP Act (PIPA)…

Has been put on hold due to wide protests

Led by Google, Yahoo!, Wikipedia facebook, Twitter, Mozilla…

The opponents felt that the proposed bills,

May damage the free and open Internet and its growth.

The issues of piracy and intellectual property rights are very serious.

However, to deal with them,

An approach is required,

That is not only effective but is also acceptable.

Else, it may be perceived as an attack on ‘freedom’,

That is more fundamental and precious,

Than what these bills project to protect.

Bal Krishna, Editor
bal@mycoordinates.org

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"The surveying equipment industry continues to be highly dynamic"

Says François Erceau, General Manager
Spectra Precision / Nikon / Ashtech

"Our innovative GNSS portfolio and expertise complements Spectra Precision's powerful brand and global reach," was your statement after Trimble's acquisition of Ashtech. Would you like elaborate on this?

The Spectra Precision business within Trimble had very rapidly assembled a portfolio of optical and GNSS surveying products. While Spectra Precision had in-house engineering, design and manufacturing capabilities on the optical side, the GNSS products had been sourced from a variety of external suppliers. Acquisition of the Ashtech GNSS portfolio and the full suite of Ashtech in-house GNSS expertise has allowed us to instantly create a fully balanced surveying business. The combination of our reseller channels has also expanded the reach of both product portfolios.

How will you be positioning your products in the market after Spectra and Ashtech merger? What will be the new branding?

Our primary product brand is Spectra Precision. Where GNSS products contain Ashtech technology, we are using "Ashtech" as a supporting Technology Brand (e.g. "Powered by Ashtech"). The Ashtech product brands (e.g. ProMark, ProFlex) will continue, as these are well-respected and carry a long history of GNSS innovation.

As a business, we also continue with the respected Nikon brand for a portion of our optical product portfolio.

How is this acquisition going to help your existing users?

Our customers benefit in several ways:

- We are now able to offer them a wider portfolio of interoperable products and services, from a single source. Customers needing a mix of optical, GNSS, laser and software products can now purchase those all from a single manufacturer, guaranteeing compatibility and productivity.
- These products can now also be bought from a single reseller, making for one-stop shopping and a single point of contact for technical support or product training if that's required.
- By leveraging the wider Trimble portfolio and the Trimble supply chain, we can now offer customers even greater value for money and access to a much more diverse ecosystem of accessories and 3rd party products.

Do you think there will be any overlap with the traditional 'yellow' Trimble products?

Trimble created the Spectra Precision brand to address a difference set of customer needs from those targeted by the 'yellow' Trimble-branded Surveying solutions. In general, Spectra Precision products are intended to address the needs of mainstream surveying customers, for whom factors like cost-effectiveness, simplicity and reliability are highly valued. In contrast, Trimble surveying products are more often sold in the form of comprehensive market solutions, with greater emphasis on the latest technologies, vertical market capabilities and peak performance.

A given survey or engineering customer might well be able to select discrete products from either the Spectra Precision or Trimble portfolios. But in general one or other of these portfolio offerings is going to be a better fit to that customer's needs, because of the way that portfolio has been tailored to a different segment of the market. Is there overlap? Probably a bit. But that helps to ensure that the customer's needs are always covered fully, whichever product they choose to purchase.

Nikon is also a part of Spectra Precision. How are its products going to add value to the Spectra Nikon Ashtech portfolio?

Nikon is a highly respected optical surveying brand, and the fact that our field and office software now interoperates with Nikon optics and Ashtech-sourced GNSS ensures that loyal Nikon customers can use the best of both technologies with confidence. Similarly, Ashtech surveying customers can now more easily incorporate Nikon optical instruments into their daily workflow where necessary.

What are your plans to cater to the needs of the conventional surveying market?

The Surveying equipment industry continues to be highly innovative, with new technologies and capabilities continually redefining the state of the art. Some technology companies focus on adding new features and their products become more and more complex as a result. This is fine for technophiles and early adopters, who are willing to deal with complexity in exchange for (potentially) a competitive advantage and a gain in productivity. But for mainstream customers the bleeding edge of technology is not a comfortable place to be; they prefer the reliability of mature technologies, refined products and simple workflows.

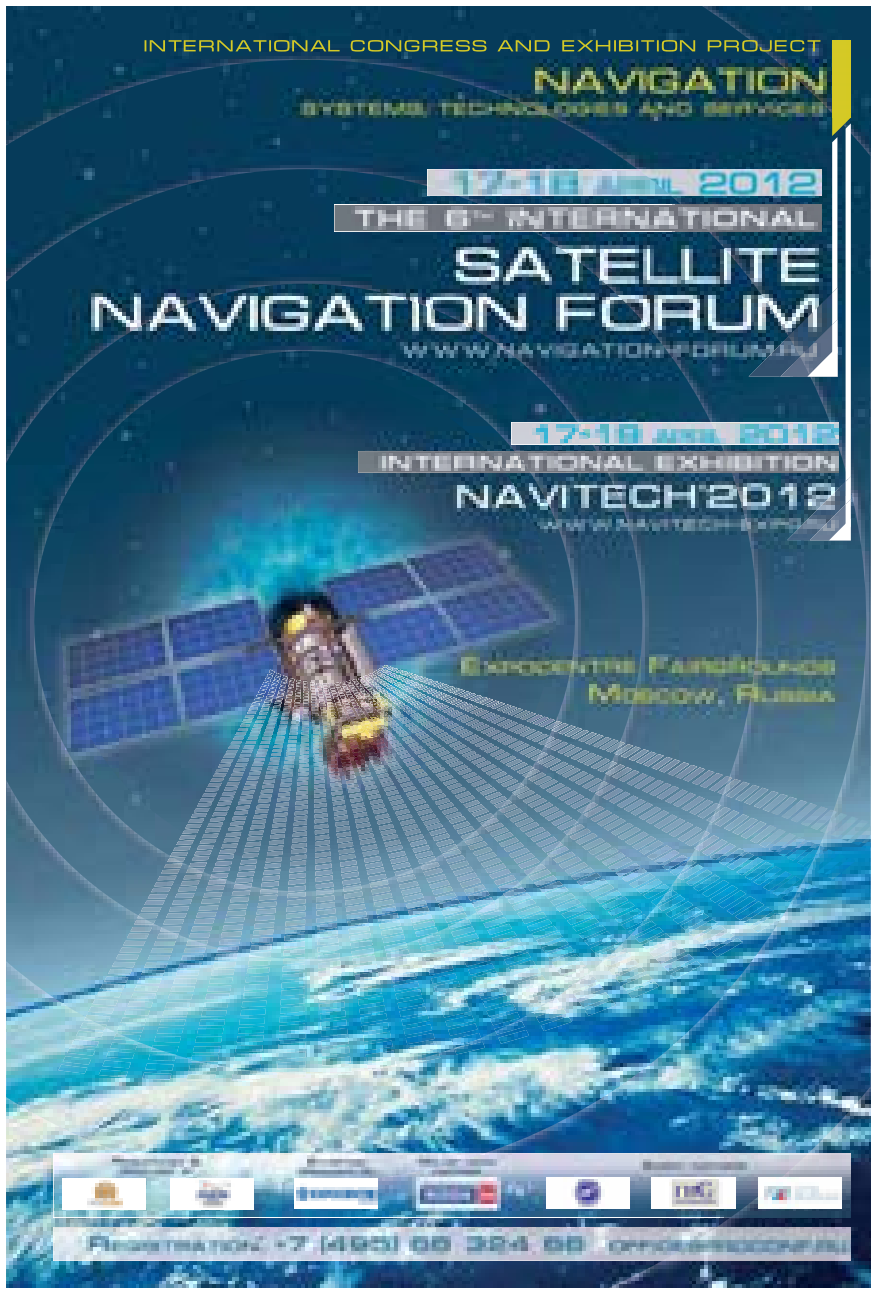
Given our target customer profile, our investment in R&D innovation is focused on making both GNSS and optical instruments more cost-effective, more simple to operate and more reliable over the longer term, while still delivering high performance and high productivity at all times.

What according to you are the emerging application segments offering promising market opportunities? Is there any rethinking on strategy to reach these segments after the acquisition?

Spectra Precision has built a strong position in many emerging markets; Ashtech has done likewise. In most cases the reach of our strongest sales channels are complementary, and the expanded product portfolio enables us to deliver increased capabilities to those channels and their growing customer bases.

In the changing world economic situation, what according to you holds the highest potential for growth?

Emerging markets are of particular interest given the “mainstream” nature of the Spectra Precision target customer, and our strong emphasis on value for money and simplicity. That bodes well for our future growth as a business, given that most emerging markets are expanding much more rapidly than the fully developed markets, who are struggling to shake off the recent recession and return to growth.



Choosing the best path: *Global to national coordinate transformations*

The paper demonstrates that differences of up to a few centimetres in each coordinate component can occur depending on the choice of the transformation method applied between GDA94 and ITRF2005

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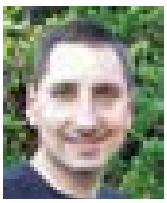
Bathurst, Australia



Dr Volker Janssen
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NSW Land and
Property Information,
Bathurst, Australia

If you've ever had to put together a jigsaw puzzle of spatial data obtained from different jobs, by different methods, from different eras or from different organisations, then you know the importance of making sure all the jigsaw pieces come from the same box. That is, you're working with all apples or all oranges. Stories abound of the errors that occur from mixing (i.e. ignoring) the datums in which data were observed, processed, archived or supplied to the next user. A lesser known issue of growing importance for users trying to squeeze all they can from new positioning techniques is how the transformation between datums was actually done. This applies to many users, whether they are using GNSS, LiDAR or imagery data to name just a few. Whilst national transformation parameters, endorsed software or the way you did it last time may appear the easiest and most obvious solution, there are many paths for data to travel between datums. Which one should you follow?

Now consider today's spatial environment, with data gathering tools operating on a global scale, employing global datums. Couple that with a drive for new and improved datums that are being developed faster and faster, as more accurate tools make older datums obsolete or at least stale. There is no longer a 20-year gap between the release of improved datums, but rather a 5-year, 2-year or even faster (e.g. continuous for scientific users) re-definition. In addition, the position changes between datums are becoming smaller and are therefore harder to indentify. In the past, a 200-metre, 1-metre or 50-centimetre blunder was easy to detect. Now you're trying to correct those last mismatches at the few-centimetre level that plague your data. Are these caused by ground movement, instrument error or simply by the 'transformation path' and the parameters chosen?

Obviously, before any datasets can be compared or combined, they must be brought together onto the same datum (Janssen, 2009). The practice of *transforming* from one datum to another is not difficult and the necessary parameters are available in many different software packages. However, with the increased number of datums comes an increased number of ways to transform between datums.

This paper demonstrates that differences of up to several centimetres in both horizontal and vertical coordinates can result from following different transformation paths. We suggest that some (but not all) users need to be careful of the methods employed. Additionally, the effect of the formal uncertainty in the transformation procedure on the estimated uncertainty of the output coordinates is often ignored, at the user's own risk. If included, formal uncertainty could help solve any discrepancies right away. Using some Australian scenarios, we discuss these issues to give spatial professionals a better understanding of the effect transformations have on the quality of their data.

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Datums commonly used in Australia

The current national horizontal coordinate datum in Australia is the Geocentric Datum of Australia 1994 (GDA94). Positions in GDA94 can be expressed in Cartesian coordinates (*X*,*Y*,*Z*), geographic coordinates (φ,λ,*h*), or projected (Map Grid of Australia, MGA94) coordinates as Easting, Northing and Height. *Converting* between coordinate systems (e.g. Cartesian to geographic) is mathematically exact and introduces no error. However, any organisation which has been gathering data for a prolonged period, or which makes use of data from other sources, will likely hold data in many different datums such as the Australian Geodetic Datum (AGD66 and AGD84), GDA94, the World Geodetic System (WGS84), various incarnations of the International Terrestrial Reference Frame (e.g. ITRF2000, ITRF2005, ITRF2008), and even historical datums superseded several decades ago.

Recall that different datums adopt different ellipsoidal coordinates for official 'datum' stations and may be based on ellipsoids of different size, shape or orientation. In contrast to *conversion*, *transforming* between datums requires a model, which is not exact and subject to any uncertainty in the transformation parameters. Directly comparing coordinates without accounting for this change in datum can cause significant errors. Similar effects can be caused by the transformation path selected and the transformation parameters chosen.

Complications arise because today's datum of choice may well be a global (and therefore dynamic) datum such as the ITRF (Altamimi et al., 2011). In a dynamic datum, where coordinates change due to tectonic motion and/or ground distortions, it is important to note the instant in time (i.e. epoch) at which the position is valid. The latest scientific-quality ITRF datums are not restricted to scientific users. Popular online GNSS processing services and commercial products commonly used in precision agriculture and GIS applications often provide positions in the latest ITRF. These positions are only valid at the epoch in which the data were gathered.

Since GDA94 was introduced in Australia, there have been several refinements of the ITRF, each including the publication of new transformation parameters. As a result, there are many different combinations of transformation routines by which data can travel from GDA94 to a particular ITRF and vice versa. The assumption that the GDA94, ITRF and WGS84 datums are identical for most practical purposes is no longer valid. Modern positioning techniques can detect the small discrepancies between these common datums. Similarly, newer datums generally represent 'only' centimetre-level refinements in datum definitions. However, ignoring these differences would introduce errors that may exceed the accuracy specifications required for a given application.

Static vs. dynamic datums

Australia (much unlike its neighbours New Zealand, Papua New Guinea and Indonesia) sits on a tectonic plate that has a high internal stability. Historically, we have therefore only employed (and enjoyed) a static datum where the coordinates of a ground mark do *not* change over time. As a result, the epoch at which the position or observation is determined is generally not recorded.

In a dynamic datum, the coordinates of a point continuously change as the underlying tectonic plate moves or deforms. The same ground mark will have continuously changing coordinates, but only one unique position per epoch. Therefore, both the datum and the epoch must be defined for all coordinates reported in a dynamic datum. The epoch should always be declared in decimal years in parentheses. For example, ITRF2005(2012.135) indicates a position in ITRF2005 valid at 12:00 UT on 19 February 2012. The decimal is calculated by day of year (50) minus one, plus time in the day (0.5 days), divided by the number of days in the year (366, remembering that 2012 is a leap year).

Transformation paths

In addition to having several valid datums to choose from, there are many different paths to take between these datums. Figure 1 illustrates the 'landscape' of current transformations relevant in the Australian context, showing possible paths between GDA94 (static national datum) and the three most recent realisations of ITRF (dynamic global datums). Here we only mention three distinct epochs because of their common usage, but any other epoch is equally valid. 1994.0 represents the epoch of the definition of GDA94. 2000.0 represents an epoch in which coordinates are often reported to allow direct comparisons at a common epoch. Finally, 'current' represents the date at which the data were observed.

Readily available online or downloadable tools can assist with current and historical transformations, as well as conversions between coordinate systems. However, without vigilance, it is easily possible that different software will employ different transformation paths or parameters to report the 'same' transformation (say,

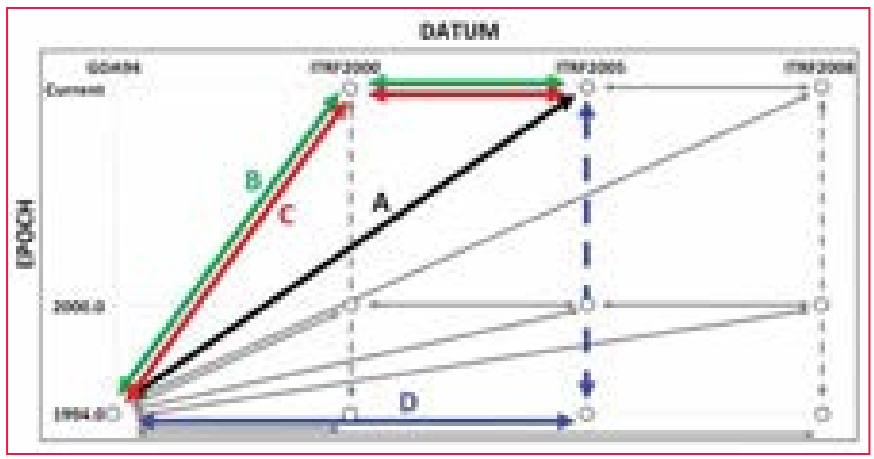

Figure 1: Landscape of current transformations available in the Australian context. Four different paths to travel from GDA94 to ITRF2005 (current) are highlighted and discussed later.

from GDA94 to ITRF2005). Current metadata records of existing data may be insufficient to make this distinction.

Transformation vs. propagation

Three distinct types of coordinate manipulation are demonstrated in Figure 1. In particular, the distinction is made between *transformation* and *propagation*. Transformation means coordinate values change due to a change in the datum origin, orientation and/or scale employed. Propagation means that coordinate values change over time due to some velocity (e.g. tectonic motion) of the mark within the same datum.

Moving from Left to Right (or vice versa) within Figure 1 represents a transformation, from datum to datum. Input and output coordinates are valid at the same epoch. For example, a position valid at 12:00 UT on 19 February 2012 in ITRF2005, i.e. ITRF2005(2012.135), can be transformed to one valid at 12:00 UT on 19 February 2012 in ITRF2008, i.e. ITRF2008(2012.135).

Moving from Top to Bottom (or vice versa) within Figure 1 represents the change in coordinates over time in the same dynamic datum. Here, the velocity of the mark is used to propagate the coordinates through time, within the same datum.

Diagonal movements within Figure 1 represent the special case of the transformation between a static datum (e.g. GDA94) and a dynamic datum (e.g. ITRF2005). This can be considered as transformation and propagation combined into the same set of parameters.

Transformation parameters

Transformation parameters that allow data to be transferred between datums are commonly supplied by national or international agencies. As new datums are defined (or refined) based on increased amounts of input data and improved processing techniques, new and better transformation parameters are published. However, there may be a significant delay between their initial availability and eventual adoption in software via updates or patches.

The two most common transformation models are the 7- and 14-parameter similarity transformations. These are based on Cartesian coordinates (X,Y,Z). A similarity transformation retains the shape of the network during the transformation. Seven parameters define the relationship between the two datums at a certain point in time known as the reference epoch: three translations, three rotations, and one scale change. The additional seven parameters define the rate of change of these parameters. These extra parameters are required to modify the transformation parameters for use at epochs different to the reference epoch.

Comparison of transformation methods in Australia

As shown in Figure 1, there are many different paths that can be followed to transform data between GDA94 and the various realisations of ITRF. However, not all transformations have the same precision or accuracy. The most recently published transformations are assumed to be of greater quality, due to improved processing techniques and the larger number of observations used to compute the parameters.

We explored the differences between four of these potential paths (Table 1). Each one is a reasonable method to transform between GDA94 and ITRF2005, and may satisfy a contractor's requirements for coordinates in a local datum using national parameters. Method A represents current best practice, following the most direct path using the most recently published parameters. Therefore we used Method A as 'ground truth'. Until recently, no direct transformation was available between GDA94 and ITRF2005. Instead, a 2-step transformation was required (Method B). Method C also uses this 2-step transformation, but replaces the parameters for the GDA94-to-ITRF2000 transformation with those most recently published. Method D uses only the most recently published parameters, but shows an explicit combination of transformation and propagation.

Methods A and D use only regional transformations determined specifically for Australia (GDA94-to-ITRF). On the other hand, Methods B and C also use global (ITRF-to-ITRF) transformations. Transformations between global datums require generalisations (at a global scale) of complex tectonic motion and can be less certain, especially when comparing data from different epochs.

The current datums used in Australia are expected to be in operation for at least another five years. So we investigated the behaviour of the four transformation paths for epochs ranging from 1994.0 (reference epoch of GDA94) to 2020.0. For a given position in Sydney, we revealed significant differences for those transformations that proceed in two steps via the now outdated ITRF2000 (Methods B and C). These differences exceed 20 millimetres in height (by 2010.0) and 30 millimetres in Northing (by 2020.0). Moreover, Methods B and C diverge from each other by several *centimetres* in height (Figure 2). Any software not updated recently may still be using these paths.

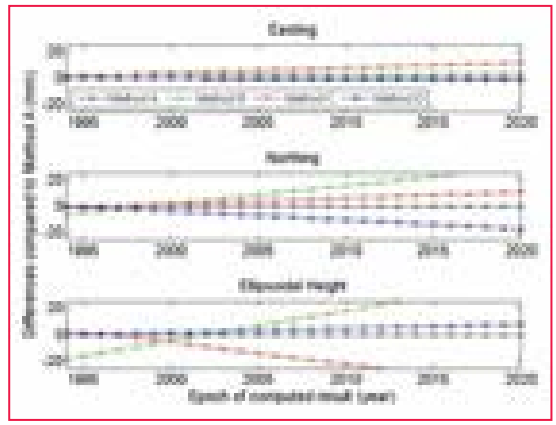

Figure 2: Difference in output coordinates after transformation of a point in Sydney by several methods (compared to Method A) from GDA94 to ITRF2005 at various epochs between 1994.0 and 2020.0.

Methods A and D represent different techniques (transformation only vs. transformation and explicit propagation). Both employ only regional transformation parameters (GDA94-to-ITRF2005), in contrast to Methods B and C which also employ global (ITRF2000-to-ITRF2005) transformation parameters. Method D yields results that are most similar to Method A with differences in all coordinate components limited to less than 20 millimetres, even up to epoch 2020.0.

When performing the same comparison at locations across Australia, it quickly became clear that the differences between the methods are spatially dependent. This occurs because of the complex combination of translation, rotation, scaling and tectonic plate models. As an example, Figure 3 illustrates these differences between the most similar methods (A and D) across Australia, computed on a 1-degree grid of latitude and longitude over the area shown.

Error propagation during the transformation

Obviously the quality of the input coordinates will have a major effect on the quality of the output coordinates after the transformation (rubbish-in-rubbish-out principle). However, the effect of the transformation procedure itself on the estimated uncertainty of the output coordinates is often not considered, nor output and rarely archived. Although an estimate of the quality of transformation parameters is usually published, transformation software generally

Table 1: Four different paths of transformation from GDA94 to ITRF 2005. These paths are also visualised in Figure 1.

Path	Transformation	Propagation
Method A	GDA94 (1994.0) - ➤ ITRF2005 (various) (Dawson and Woods, 2010)	implicit
Method B	GDA94 (1994.0) - - ➤ ITRF2000 (various) - - - - ➤ ITRF2005 (unchanged) (Dawson and Steed, 2004) (Altamimi et al., 2007)	implicit
Method C	GDA94 (1994.0) - - ➤ ITRF2000 (various) - - - - ➤ ITRF2005 (unchanged) (Dawson and Woods, 2010) (Altamimi et al., 2007)	implicit
Method D	GDA94(1994.0) - ➤ ITRF2005(1994.0) (Dawson and Woods, 2010)	ITRF2005 (1994.0) to ITRF2005 (various) (Altamimi et al., 2007)

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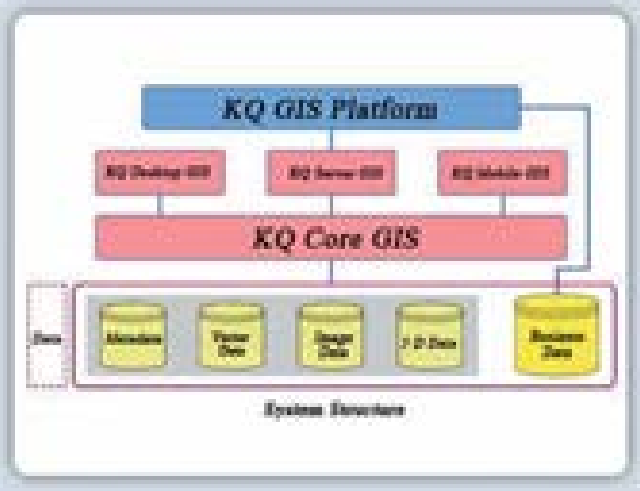

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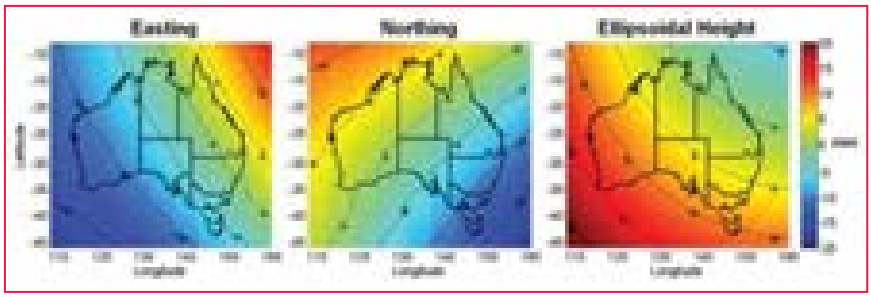

Figure 3: Easting, Northing and Ellipsoidal Height differences in millimetres (Method D minus Method A) at epoch 2010.0 across Australia.

supplies only coordinate values (and not their quality) as output. This leads to the following question: What is the contribution of the transformation on the uncertainty of the output coordinates? Assuming a perfectly known input position, we can compute an example of how much formal uncertainty is inherent in a modern transformation.

We found that the most recent GDA94-to-ITRF2005 transformation (Method A) nominally contributes about 5-10 millimetres to the uncertainty of each coordinate component for an epoch between 2010.0 and 2020.0. Understandably this contribution steadily increases when the specified epoch is further away from the reference epoch (in this case 1994.0), due to the extra uncertainty of the seven rate parameters. In contrast, the transformation between GDA94 and the most recent ITRF2008 is known with more certainty (due to improvements in ITRF2008 over ITRF2005) and only contributes about 2-4 millimetres in the same time span (Haasdyk and Janssen, 2011).

Importance of transformation metadata

Data previously transformed may have metadata giving details of the datum in which the dataset was collected, and of datum(s) to which it has been transformed. However, the method or path of transformation may well be lost or disregarded. In order to clearly identify what has happened to a particular dataset and help avoid the issues outlined in this paper, metadata should include the following information in regards to transformations:

- Complete transformation path (including propagation if employed) from Datum 1 to Datum 2.
- Transformation parameters used and how they were computed, or citation of reference document.
- Epoch(s) at which the transformation parameters are valid.
- Sign convention used for the parameters (e.g. positive for anti-clockwise rotation of the coordinate axis).
- If an explicit propagation is applied, site velocities used and their source.
- If possible, quality (uncertainty) of the transformed coordinates and of the transformation parameters.

Conclusion

Recently a number of new transformation parameters have been published, allowing users to transform data between the current (static) national Australian datum (GDA94) and the latest global (dynamic) ITRF datums. This has created a problem of choice because there are many different paths of transformation by which data can travel between these datums.

We have demonstrated that differences of up to a few centimetres in each coordinate component can occur depending on the choice of the transformation method applied between GDA94 and ITRF2005. For all transformations, the expected quality of output coordinates degrades with greater time separation from the transformation's reference epoch. These differences can be disregarded for many navigation, mapping and GIS purposes. However, users requiring coordinate qualities at the centimetre-level need to be aware of the transformation methods employed by their software. This includes the transformation paths previously followed for existing data and is particularly important when mixing data from different periods and sources.

All users need to be increasingly careful when using multiple datums and transforming between them. The highest and most consistent coordinate quality is obtained by following the most direct transformation path and applying the latest transformation parameters to the original untransformed data (i.e. Method A). Metadata for transformed data should include information on the specific transformation path followed with reference to the transformation parameters, their source, and the epoch(s) used in the transformation.

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GAGAN is expected to replace the GPS receivers and provide data integrity

Says A S Ganeshan, Project Director, Navigation Systems, ISRO Satellite Centre in an interview with Coordinates

What is the origin of the name 'GAGAN'?

As you are aware GPS meets most of the navigation requirements of users. However, to improve the performance and integrity of the GPS system and to meet civil aviation requirements, the basic GPS system is to be augmented by GEO satellite with corrections and confidences. Hence, the name GAGAN which is an acronym for GPS Aided Geo Augmented Navigation System was chosen. *Gagan* is a Hindi word of Sanskrit origin for the sky and aptly suits the project.

We are expected to have a certified GAGAN by 2013. How close are we to this?

With the completion of installation, integration and testing of all ground elements, the major requirements of facility certification has been completed. The integration of GEO satellites with the ground elements and other aspects related to certifications have been taken up. The system is expected to be certified by the 3rd quarter of 2013. The GAGAN will be certified by DGCA to provide NPA (Non Precision Approach) services of RNP-0.1over Indian FIR (Flight Information Region) and PA (Precision Approach) service of APV-1.0/APV-1.5 over Indian landmass.

What are the user segments going to be benefitted by GAGAN?

Even though GAGAN is being developed primarily for civil aviation applications over Indian region, it is expected to provide enhanced service level to the user segments like, Agriculture, Emergency response, Business solutions, Geographical data collection, Natural resources, Land management, Scientific research, Geodynamics ,Urban Mapping, Unmanned vehicles, Vehicle tracking, Air navigation, Car navigation, Maritime applications, Search And Rescue Operations, GIS, Timing applications, Canal Transit Management, etc

In short, it is expected to replace the GPS receivers and provide data integrity. Also, GAGAN will aid the DGPS users with minimum change, risk and cost.

As the GAGAN GEO foot print extends from Middle East Asia to Australia, the augmentation can be provided over this region using GAGAN system. GAGAN will bridge the gap between Europe (served by EGNOS) and Japan (served by MSAS).

What is the reach of GAGAN going to be and how other countries will be able to utilize its services?

The GAGAN system intends to deploy and certify an operational Satellite Based Augmentation System (SBAS) for the Indian Flight Information Region (FIR), with expansion capability to neighboring FIRs. When commissioned for service, GAGAN will provide a civil aeronautical navigation signal consistent with International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARP) as established by the Global Navigation Satellite System (GNSS) Panel. The neighboring countries can utilize GAGAN system by having reference stations within their country. As the GAGAN GEO foot print extends from Middle East Asia to Australia, the augmentation can be provided over this region using GAGAN system. GAGAN will bridge the gap between Europe (served by EGNOS) and Japan (served by MSAS).

What is the role of private sector in the development of GAGAN?

Navigation projects have created awareness among the Public Sector Undertaking and Indian industries and they have been contributing to GAGAN projects. To name a few, ECIL (Electronics Corporation of India

Limited) was responsible for designing and development of 11 meter antennae installed at INLUS (Indian Land Uplink Station). Accord Software is developing GAGAN and IRNSS receivers. Software development of INLUS RFU (Radio Frequency Unit) systems will require the participation of software companies capable of developing DO-178B compliant software. Many other industries are involved in various subsystems of Navigation projects. Even though the Indian private sector participation is limited in the development of GAGAN, there is tremendous scope for the industry to develop user segment equipments for the GAGAN system. The industries need to come up innovative solution to meet diverse user positioning and timing requirements. Also, hand in hand there is a need to develop applications suiting Indian conditions and requirements using GAGAN signals especially in the areas of survey, intelligent transportation systems, location based systems, disaster management, maritime etc.

What are your plans to create awareness among prospective users of GAGAN?

GNSS user meet is planned to be jointly organized by ISRO and AAI on February 23rd 2012 at ISRO Satellite Centre, Bangalore. This will be a platform where all the parties involved in Navigation will interact and prospective users will greatly benefit. The plan is to conduct such meets at regular intervals to ensure that the benefit of GAGAN utilization is maximized.

How interoperable is GAGAN going to be with other SBAS systems?

The functional performance of GAGAN will meet the accuracy, integrity, continuity and availability requirements specified for aviation by ICAO. The system will be inter-operable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc and provide seamless air navigation across regional boundaries utilizing same signal frequency.

There is a tremendous scope for the industry to develop user segment equipment for the GAGAN

Interference and jamming with satellite signals are becoming major threats. How serious such threats are in the context of GAGAN?

The threat to GAGAN signals is similar in nature to any other GNSS system.

Building national capacity through spatial standards policies

Such policies have a "capacity multiplier" effect, because open standards facilitate data sharing and promote geospatial technology market development

Steven Ramage
Executive Director, Marketing and Communications
The Open Geospatial Consortium (OGC)

National capacity building is about building new capabilities and resources on a nation's platform of existing capabilities and resources – human, scientific, economic, technological, educational, cultural, organizational, institutional, agricultural, industrial and so on. In both developed and developing nations, policy makers see information and communications technology (ICT) as a key element in their capacity building plans, because ICT connects people and expedites information flows and workflows in all of those domains.

Geospatial information flows are a particularly important factor in capacity building across those domains. This article focuses on how capacity building in the geospatial sector of the ICT domain depends on National Spatial Data Infrastructure (NSDI) policies that encourage the use of open geospatial standards. OGC standards (*www.opengeospatial.org*) and complementary standards from the International Organization for Standardization (ISO) Technical Committee 211 (ISO/TC 211 Geographic information/ Geomatics (*www.isotc211.org*)) have become part of SDI "best practices" around the world. The Global Spatial Data Infrastructure SDI Cookbook defines SDI as the "…collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data." This definition (which predates the cookbook) is more than fifteen years old, and over the course of fifteen years much progress has been made toward the SDI vision of abundant, easily shared, easily used geospatial information.

Arguably the most progress has been made in the area of open technology standards that facilitate the practical availability of and access to spatial data. Policy and institutional arrangements are absolutely essential, but they are unworkable if technical obstacles to interoperability cannot be overcome. When a significant number of systems implement open standards so that users can use the Internet to easily publish, discover, access, assess and use diverse sources of data and services, then government policy makers can establish policies that reinforce the purchase and use of these standards-based systems. The resultant widespread use of interoperable systems makes it easier for public and private sector institutions to reach agreements about data sharing that are based on institutional needs rather than technical limitations. Widespread interoperability also opens up the market for geospatial data, software and services, which results in economic progress and increased capacity in the ICT sector and also in all the other sectors that benefit from ICT innovations.

Producers and users of geospatial resources are all part of a vast network of producers and users, and the value of their resources depends to a significant extent on how much of that network they can connect to. Some of these stakeholders eagerly implement open standards and even participate in standards development because the benefits are obvious to them. Most stakeholders, however, are not particularly aware of standards because their attention is focused on immediate tasks and a narrow circle of data sharing partners. Responsible policy makers have a broader view. They serve everyone well when they provide incentives for diverse stakeholders to upgrade to systems that implement open standards that expand the geospatial network.

SDI best practices – Enabling communities of interest

SDIs built on open standards "work together," enabling information networks that benefit multiple communities of interest, each of which has special information requirements. Creating spatial information for specific purposes often depends on having access to more basic spatial information about such things as survey points, elevation, political boundaries and water bodies. Open access to such basic data is one of the critical economic enablers of an SDI. In December 2011, in its most recent call for freely available public sector data, the European Commission announced an "Open Data Strategy for Europe which is expected to deliver a €40 billion boost to the EU's economy each year. Europe's public administrations are sitting on a goldmine of unrealized economic potential: the large volumes of information collected by numerous public authorities and services." (European Commission press release. *http://ec.europa.eu/information_society/policy/psi/index_en.htm*)

Figure 1 outlines a spatial data value chain. Each link in the chain represents ICT business creation and new jobs. The efficiencies that result from the value delivered – generally in the area of improved information flow – result in improvements in the production and delivery of many other public and private sector goods and services. This is capacity building. Having open access, and in many cases free access, to public data is one part of an SDI, but much of this data's economic value lies in its ability to support businesses that sell

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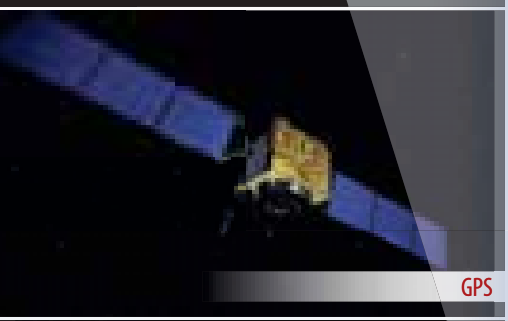

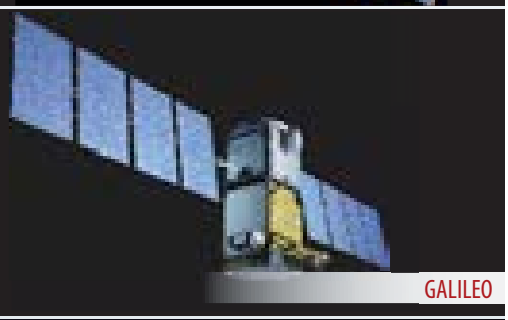

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N° of GNSS Signals	Number of channels	13	17	21	26	30	34	38	42
1	GPS L1 (including SBAS)	✓	✓	✓	-	-	-	-	-
	GLONASS G1	✓	✓	✓	-	-	-	-	-
	Galileo E1	✓	✓	✓	-	-	-	-	-
2	GPS L1 (incl. SBAS)+ QZSS L1	✓	✓	✓	-	-	-	-	-
	GLONASS G1 + QZSS L1	✓	✓	✓	-	-	-	-	-
	Galileo E1 + QZSS L1	✓	✓	✓	-	-	-	-	-
	GPS L1 (SBAS) + GLONASS G1	✓	✓	✓	✓	✓	✓	✓	✓
	GPS L1 (SBAS) + Galileo E1	✓	✓	✓	✓	✓	✓	✓	✓
	Galileo E1 + GLONASS G1	✓	✓	✓	✓	✓	✓	✓	✓
3	GPS L1 (SBAS) + GLONASS G1 + QZSS L1	✓	✓	✓	✓	✓	✓	✓	✓
	GPS L1 (SBAS) + Galileo E1 + QZSS L1	✓	✓	✓	✓	✓	✓	✓	✓
	Galileo E1 + GLONASS G1 + QZSS L1	✓	✓	✓	✓	✓	✓	✓	✓
	GPS L1 (SBAS) + GLONASS G1 + Galileo E1	✓	✓	✓	✓	✓	✓	✓	✓
4	GPS L1 + GLONASS G1 + Galileo E1 + QZSS L1	✓	✓	✓	✓	✓	✓	✓	✓

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value-added data and services. Information flow among diverse stakeholders with diverse ICT systems depends on open standards for data and for interfaces and encodings. Speaking about the Open Data Strategy, Neelie Kroes, Vice President European Commission responsible for the Digital Agenda, explained that, "In all sectors, standards and standardisation drive competitiveness, promote innovation, and benefit consumers through competition. … In the ICT sector, having the right standard-setting procedures and interoperability rules creates the level playing field needed for all parts of the machine to fit together: devices, applications, data repositories, services and networks" (*http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/11/596&format=HTML&aged=0&language=EN&guiLanguage=en*).

Policy makers tasked with building national SDIs play an important role, because they are in a position to "nudge" stakeholders to purchase and deploy standards-based systems. Mandating open standards is almost always a better solution than mandating purchase from particular technology providers, because open standards encourage competition. Open standards also provide a way for users to extend the value of their legacy systems while choosing "best of breed" solutions for their current needs. At the same time, they are "future-proofing" their ITC assets because widely implemented open standards provide the best possible assurance that future products and technologies will interoperate with previously deployed products and technologies.

The Netherlands example

The Dutch Geo-Information and ICT Department of Rijkwaterstaat (the Ministry of Transport, Public Works and Water Management) has an SDI based on open standards. The Ministry's responsibilities include traffic via roads, waterways, railways, and by air, and they are also responsible for clean water in the rivers, lakes, sea, and water tables. The Dutch National Mapping Agency Kadaster uses a GML-based application schema for data sharing. The Dutch Kadaster Topographical Service has demonstrated interoperability involving their TOP 10 GML schemas (also known as TOP10NL) and a number of commercial products. In March 2011, geospatial standards were also added to the 'comply or explain' list of open standards of the Dutch Standardisation Board (College Standaardisatie, in Dutch). This means that all Dutch government organisations must now incorporate and implement these standards, where applicable. Dutch geo-standards are managed by Geonovum, the National Spatial Data Infrastructure (NSDI) executive committee in the Netherlands. Geonovum is an OGC member.

The 3D Pilot NL, a network of over 65 private, public and scientific organizations, has collaborated to push 3D developments in the Netherlands. The pilot project established the groundwork for one of the world's most comprehensive national 3D geo-information programs. The close integration between an existing information model for 2D geo-information and CityGML is a major step toward the practical use and re-use of 2D *and* 3D information. The objective of the 3D Pilot NL was to accelerate the use of 3D geo-information in the Netherlands. The pilot has demonstrated the added value of 3D geo-information compared to 2D geo-information in various use cases, including interactive airstream simulation, 3D cadaster, mutation detection and integrated planning and management of underground and aboveground municipal assets. Also, 3D information automatically generated from laser point data can serve many application domains. Such information about tree heights and sizes, new buildings, roofs, etc. can easily become part of an OGC CityGML model. Demonstrations of use cases can be found at *www.geonovum.nl/dossiers/3dpilot/bibliotheek/presentaties#films (on YouTube)*.

The next phase of the 3D Pilot NL started in October 2011. This phase focuses on the development of tools and instruments to support the implementation of the 3D standard. This includes generating data at various levels of detail; describing standard procedures to generate such data; describing standard procedures to update and maintain the 3D data as part of existing (2D) information processes; and developing a 3D validation tool. In addition, special attention is being paid to aligning standards from the construction domain (Building Information Models) and the spatial data domain, at both national and international levels. Almost 120 participants have subscribed to participate in this next phase (*www.geonovum.nl/dossiers/3d-pilot/deelnemersvervolg*).

Below is a brief overview of other national open standards initiatives.

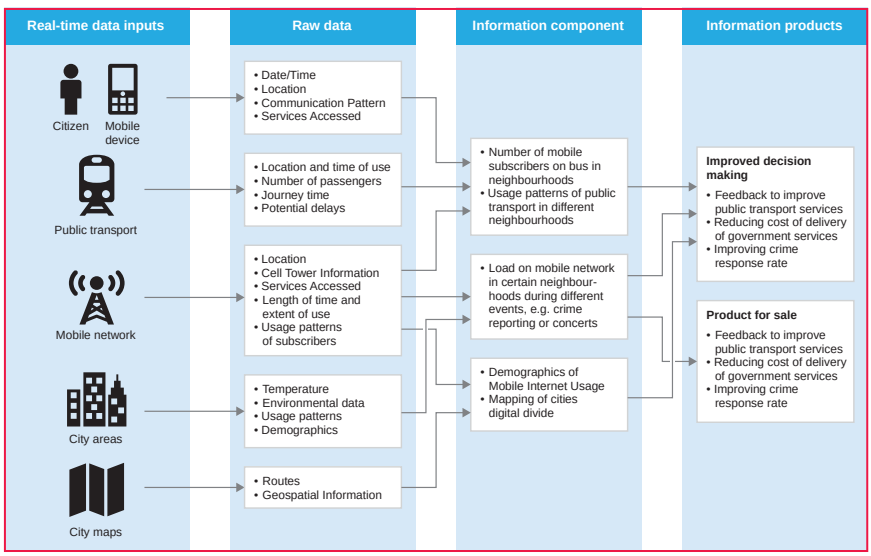


Figure 1: A spatial data value chain (From "Information Marketplaces – The New Economics of Cities,"(http://www.accenture.com/us-en/Pages/insight-cities-missing-smart-opportunity.aspx) by Accenture, December 2011.)

Europe

Germany –The GDI-DE, the German SDI, is based on OGC standards, as are the SDIs of the German federal states. The spatial portal site GeoPortal.rlp enables federal state agencies, municipal authorities and private companies to present their data and

services. With more than 2000 layers from 70 OGC WMS services it is an excellent example of an implementation of the INSPIRE directive. CityGML began with urban modeling activities in Germany.

Great Britain – Ordnance Survey Great Britain initially became involved in OGC® standards about 10 years ago to structure and deliver their products more openly. In 2009 OS went live with a commercial service called 'OS OnDemand'. It delivers 10 Ordnance Survey products through WMS and includes the large scale OS MasterMap® Topography Layer, which is in a raster format generated from the vector data store.

Norway – "Norge Digitalt" or in English, Digital Norway, is the Norwegian government's initiative to build a national geographical infrastructure. Since 2005 more than 100 operational web map services, geoportal and other services have been in co-existence.

Spain – IDEC, the Geoportal of the Catalonia SDI, a project of the government of the autonomous region of Catalonia (Spain), offers services including the multilingual Catalog Server describing data available from over 80 providers. The viewer, a client that implements the OGC Web Map Server (WMS) Specification, allows users to access more than a dozen WMS servers from different providers who together provide about 200 layers of geodata. A 2007 study showed that the initial investment to set up the IDEC SDI was recovered in just 4 months.

North America

Canada – The Canadian Geospatial Data Infrastructure (CGDI) has been developed by the Canadian government in partnership with the provinces, territories and the private sector. The CGDI is a distributed network of spatial data and processing resources that gives decision-makers access to online location-based information, offering valuable benefits to decision-makers in priority areas such as public safety, public health, Aboriginal community planning and environmental management.

USA – The partner agencies of the Federal Geographic Data Committee (FGDC) are developing a Geospatial Platform to more effectively provide place-based products and services to the American public. Many federal agencies and US states have or are building Web-centric SDIs that rely on OGC standards. The recently released "National Geospatial Advisory Council's *Local Government GIS Best Practices* paper specifies areas in which OGC standards are essential.

South America

Brazil – Brazil created a National Spatial Data Infrastructure (INDE) and the Interoperability Program of e-Government (e-PING). The legal framework of INDE (Decreto 6.666) establishes that the production of data and geospatial information must follow standards and regulations accredited by the National Commission on Cartography (CONCAR).

Chile – The Government of Chile, through the National System of Territorial Information Coordination (SNIT), fosters the use of technologies enabling the integration of geospatial information through Web services. The computer tools generated by the SNIT ("Geoportal of Chile" and "Geonodo") and the diverse map services implemented in some public institutions support OGC Standards.

Middle East

Abu Dhabi – The Abu Dhabi Systems and Information Centre has engaged most of the emirate's government entities and federal entities within the Abu Dhabi NSDI (AD-SDI) to support sharing of geospatial information and services. ISO and OGC standards have been customized or profiled for use by the AD-SDI stakeholder community.

Asia and Asia-Pacific

Australia – The Australian SDI is based on a framework of guidelines and policies developed by ANZLIC - the Australian and New Zealand Land Information Council. These emphasize open standards. The Australian SDI also comprises capabilities at state and territory level such as the Western Australian (WA) Government's Shared Land Information Platform (SLIP), which forms the foundation of an information connection service that serves 19 WA government agencies and the New South Wales Government's Spatial Information eXchange (SIX).

China – The China Ministry of Land and Resources is using applications based on the OGC Web Feature Service Standard (WFS - now also ISO 19142:2010) to build a country-level and province-level data exchange system that satisfies update requirements for land use data.

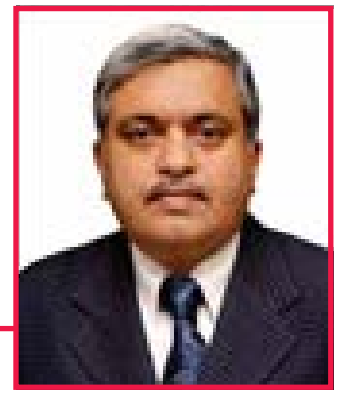
India – Through the India Geo-Portal, the NSDI program hosts ISO compliant metadata and web services that implement OGC standards for use in a variety of national development activities. The Geo-Portal uses OGC standards to help nodal agencies uplink their metadata, product-catalogue and other services through an SSO 128 bit encryption based secured communication. The state governments of India are also involved in SDI development. The OGC India Forum met in Kolkata on March 14th 2011. India's Executive Committee of the NSDI (EC NSDI) participated. There will be another meeting of the OGC India Forum on 9th February 2012 as part of the India Geospatial Forum being held at the in Gurgaon. This session will be held in conjunction with a special workshop on the business value of open standards.

Korea – In Korea's "U-Cities" initiative, a ubiquitous city is an urban region in which all major information systems (residential, medical, business, governmental and the like) share data, and computers are built into the houses, streets and office buildings. OGC and ISO standards play a major role.

Conclusion

SDIs are a key contributor to economic, social and institutional capacity building, and open standards that enable technical interoperability are a key component of SDIs. Government policies that mandate open geospatial standards from the OGC, ISO/TC 211 and other standards organisations play a critical role in the development of national capabilities in geospatial data, software and services. Such policies have a "capacity multiplier" effect, because open standards facilitate data sharing and promote geospatial technology market development, while also reducing the cost of geospatial solutions that can improve capacity in other market domains.

"Indian RS data products are very competitively priced"



Says Dr Vinay Kumar Dadhwal, Outstanding Scientist and Director, National Remote Sensing Centre, Indian Space Research Organization

What are the main services offered by National Remote Sensing Centre (NRSC)?

Historically National Remote Sensing Centre (NRSC) has offered to Indian users the standard and value-added satellite data, aerial services, maps and consultancy for EO application projects, disaster management information services and capacity building. While for foreign users, services are providing IRS satellite data, establishment and upgradation of ground stations for IRS data reception and RS data contributions from Indian Space Research Organization (ISRO) for disaster agreements such as International Charter and Sentinel Asia. Access to all historic EO data acquired at Shadnagar, about 1000 Terrabytes, is the other service offered by the NRSC. Recently, the NRSC has invested in significantly improving these services that enhance access to EO data and facilitate use in natural resource management and emergency services by

(a) realizing IMGEOS (Integrated Multi-mission Ground segment for Earth Observation Satellites) at Shadnagar Campus to reduce turnaround time (TAT) and increase capacity to deliver more products per day

(b) operating LFDC (Large Format Digital Camera) and ALTM (Airborne Laser Terrain Mapper) to provide all digital aerial services

(c) in addition to standard/ value added RS products, provide Geophysical Products from OCM and Scatterometer of Oceansat-2 and DEM from Cartosat-1, and

(d) provide visualization and selective free EO data access and WebGIS through Bhuvan (http://bhuvan.nrsc.gov.in).

> Remote Sensing Data Policy 2011 allows dissemination of RS data from Indian and foreign sensors of 1m and coarser spatial resolution to all users in India

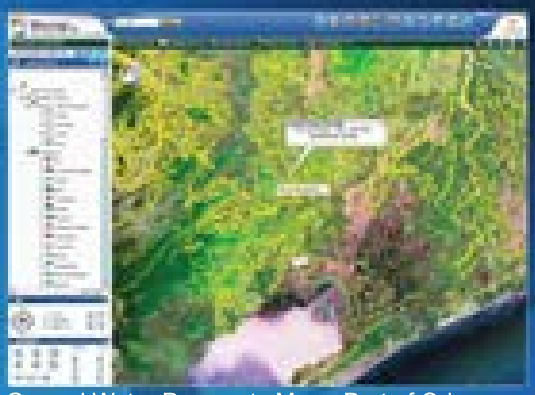
Would you like to highlight key points of Remote Sensing Data Policy (RSDP – 2011)?

The RSDP 2011 should be seen as next step over RSDP 2001 in facilitating wider access of RS data in the country. Its two key points are, first, that it allows dissemination of RS data from Indian and foreign sensors of 1m and coarser spatial resolution to all users in India (in contrast to earlier limit of 5.8m) and second, it assigns the NRSC the responsibility of data dissemination for this category as well as higher spatial resolutions after following the prescribed safeguards of user certification.

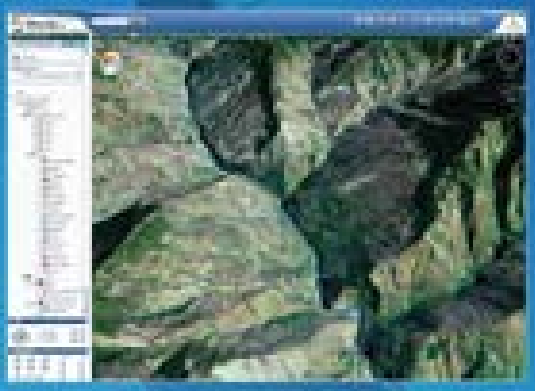
Would you like to share any recent experience where NRSC contribution in terms of importance and utilization of EO data was felt significantly especially in the field of disaster monitoring or management of natural resources?

The NRSC has been at forefront of providing national scale inputs for natural resource management to various Central Government Agencies. Recent completed projects appreciated for relevance and content are Wasteland Change Analysis (2005-06 to 2009-10) and Land Degradation Mapping of country (specifically enriched by integrating National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur field data on soil analysis) while hydro-geological mapping being carried out under Rajiv Gandhi National Drinking Water Mission (RGNDWM) provides information for locating well for providing water for domestic use. Last year all major flood events were mapped for extent and data provided in very short period to state and central agencies for their relief operations. Particularly during last year in September, Orissa flood inundation maps were used for relief operations and RS-derived Vegetation Indices for Mandal-wise drought assessment over Andhra Pradesh received commendations from user agencies. It is also acknowledged by the global weather forecasting community is the acquisition of Scatterometer

Bhuvan : Gateway to Indian Earth Observation



Ground Water Prospects Map - Part of Orissa



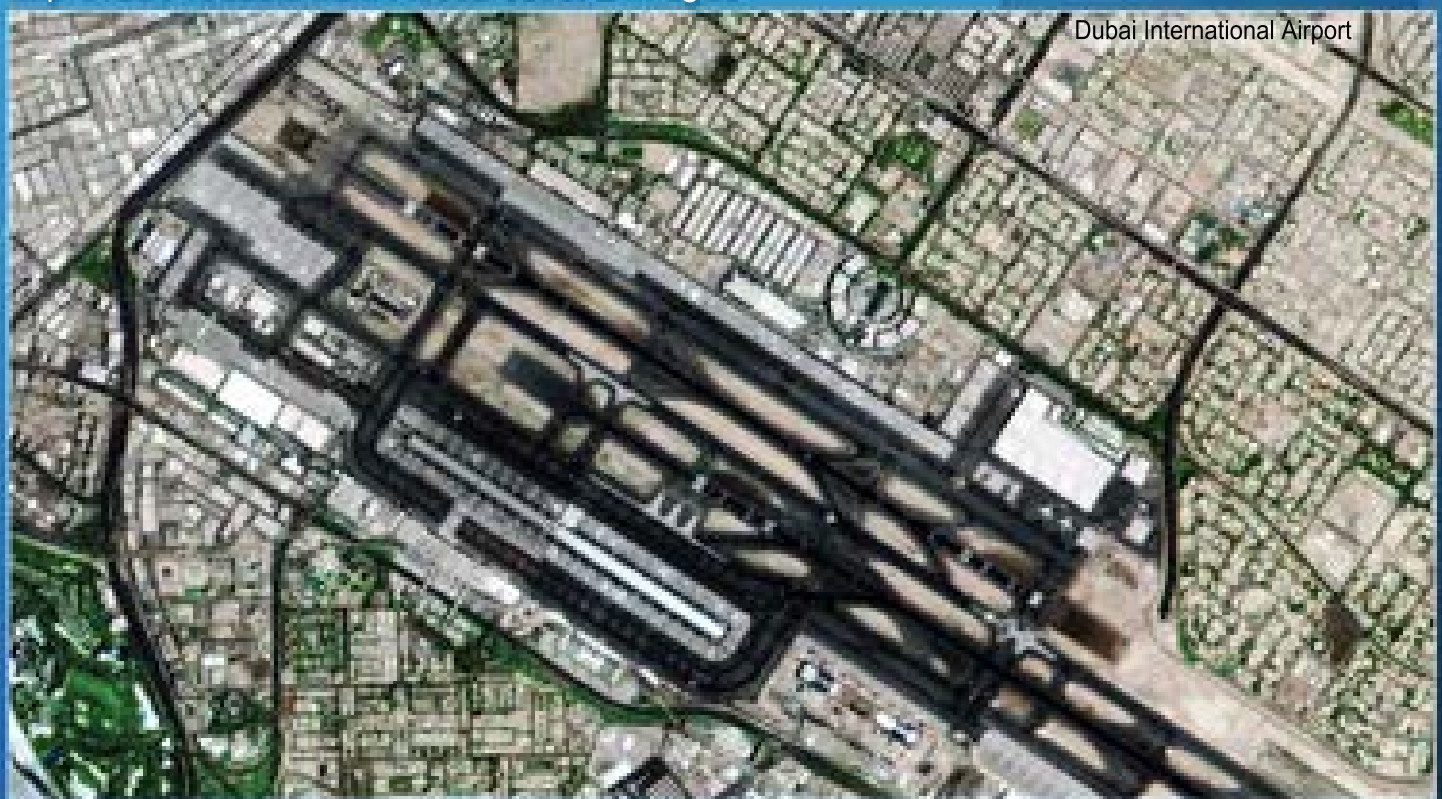
3D Visualisation

Features

- Time Series Visualisation
- Services - Land, Ocean, Weather, Disaster etc.,
- Pocket Bhuvan
- Multi-Lingual Bhuvan
- On-line Discussion Forum
- Free Downloads - Carto DEM, AWiFS

www.bhuvan.nrsc.gov.in

Improved Products from Resourcesat-2 Images



Dubai International Airport

National Remote Sensing Centre (NRSC), Balanagar, Hyderabad-500037 www.nrsc.gov.in sales@nrsc.gov.in

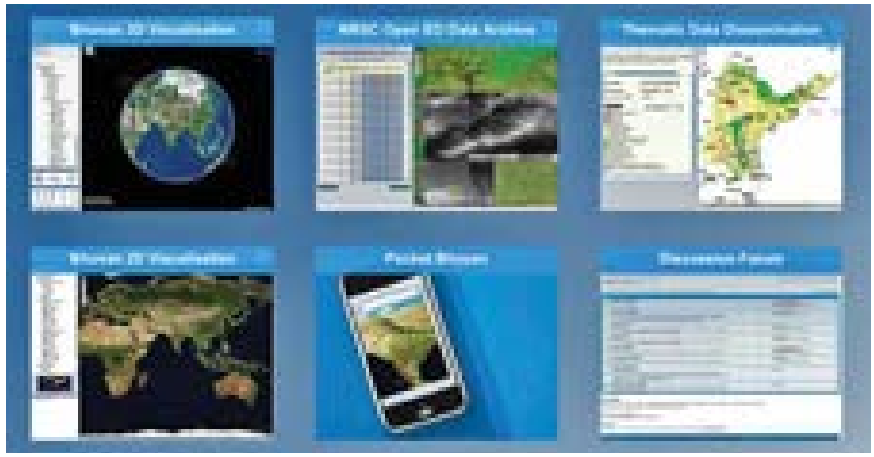
data globally using ground station at Svalbard (Norway) and within 150 minutes for making the geophysical product available for assimilation in weather forecast at Eumetsat.

What is new in Bhuvan? How has been the response of users to Bhuvan ?

Bhuvan is already in its third version after its launch on August 12, 2009 and has moved from only 3D Indian EO visualization to EO data products, information services and collaborative services in an open system architecture. New facilities are access from mobiles, multi-lingual content (English, Hindi, Tamil and Telugu), WebGIS WMS/ WMTS of thematic layers including map composition and user defined interactive AOI based statistics generation, data download from NRSC Open EO Data Archive (NOEDA) with visualization, metadata and user log and history. Also to support users who have not downloaded and installed the plugin (10 MB), a 2D OGC compliant visualization on the fly has been added. User response has been very positive and Bhuvan plugin downloads have crossed 5 lakhs, NOEDA download of free data has exceeded 8000 (since its launch on 28 Sep 2011) and monthly total of daily unique visitors is above 11000 in past six months. In order to further enhance its awareness amongst users, especially students and academia, 7 workshops have been held in past year (Bhubaneshwar, Chennai, Hyderabad, Kolkotta, New Delhi, Pune and Shillong)

Do you see a growth in satellite imagery market in India? How important is the role of pricing of satellite data in the overall growth of the imagery market?

I definitely expect significant growth in the satellite imagery market in India which comprises (a) high resolution data for infrastructure, urban planning, cartography and



projects related demand by Government as well as commercial users,

(b) natural resource mapping for multispectral mid resolution data, mostly for Government users, and

(c) atmosphere ocean science related data segment. SAR data market will expand with launch of RISAT-1. Prices are important, however, Indian RS data products are very competitively priced. With recent introduction of free download of selected AWiFS and LISS-III archived data on Bhuvan, usability of RS data is expected to substantially increase.

What is your perception about availability and quality of human resources in the field of remote sensing? Is there any initiative at NRSC regarding this?

I understand that RS is being included in curricula at various levels of education and in parallel there has been a quantum jump in the number of University Departments, Institutes and Private organizations offering post-graduate degree and diploma in RS and Geomatics. With students from diverse backgrounds opting for this discipline, the availability of manpower is much higher. The quality may not be uniformly high, but is due to lack of adequate faculty and facility infrastructure at some places. NRSC, through Indian Institute of Remote Sensing at Dehradun, in last decade introduced post graduate degree programmes in Photogrammetry and Remote Sensing, Geoinformatics and Geohazards.

How has academia been engaged in NRSC programmes?

A multipronged engagement with academia is an important activity of NRSC. Academia is encouraged to directly work with NRSC as a collaborator in many research projects as well as programmes of national importance and when Academia on their own propose a project of relevance to NRSC, they are guided and encouraged to seek funding under the RESPOND programme of ISRO through coordination by NRSC. Limited facilities are also offered to Masters students to carry out their Masters project/dissertation at NRSC in advanced areas of RS data utilization.

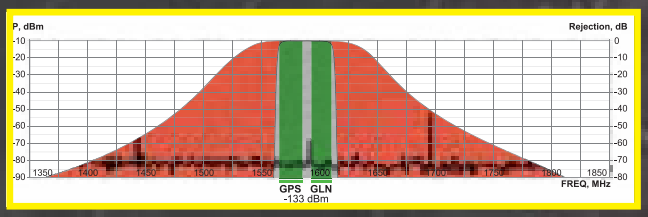
What is BHOOSAMPADA portal and what are its objectives?

BHOOSAMPADA is a WebGIS portal (http://applications.nrsc.gov.in) providing free access to land cover/land use layer annually generated by NRSC from multi-date AWiFS data. Users can visualize and understand inter-annual LULC changes in regional context, especially as they relate to net sown area and cropping intensity. In addition, year-wise seasonal snow cover and water bodies from 2004 to 2008 on 1: 250,000 scale and vegetation type map can also be accessed from this site.

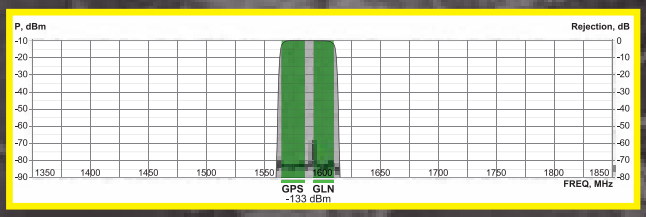
JAVAD

A technical story...

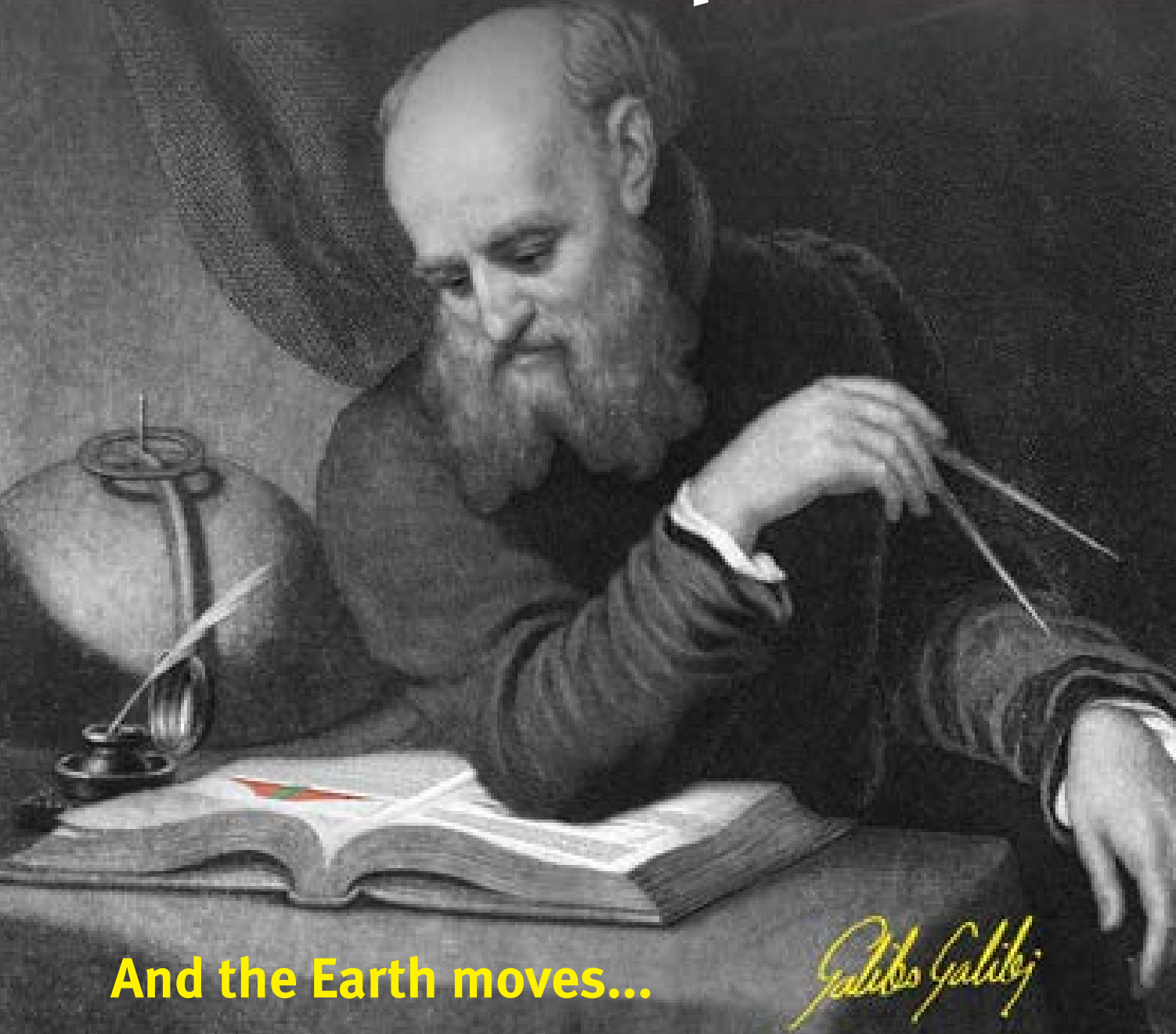
of a bad filter...



and a good filter...



which turned political!



And the Earth moves...

Galileo Galilei

The Real Interference Issue: Political Noise

I have been reflecting on events related to the GPS interference issue and LightSquared. What I discovered revealed the root of this problem, and as I will describe in this paper, it is entirely caused by poor design of GPS receivers The problem can be solved easily and with existing technology. In fact, it already has been solved.

Unfortunately, the GPS interference issue is a perfect example of how Washington is allowing politics to influence a technical debate. Opponents of LightSquared are trying to deal with the GPS interference issue by employing armies of lawyers and lobbyists who either don't understand the scientific facts or are lying about them. Instead, it would be much better for those who are making much of the noise about LightSquared, to spend money on research and development to help solve the problem.

This political approach to a technical issue demonstrates why the United States is currently ranked seventh in the world for the most scientific and engineering researchers per capita, following Finland, Sweden, Japan, Singapore and Norway. Why would high-caliber talent want to go into technology-related jobs when our system appears to be placing low value on scientific facts and high value on political influence?

How I Came to Understand the Real Issue

Around December 2010, when I received initial reports and letters regarding LightSquared interference with GPS, I joined the Coalition to Save GPS and signed a letter to the chairman of the Federal Communications Commission thinking I was doing my part to protect GPS. I wrote similar commentary on my website, www.javad.com.

Then I was invited to participate in the 2011 ESRI[1] conference in San Diego and join a panel to discuss the LightSquared-GPS issues. In order to defend the GPS system and provide technical data, I started my own investigation of the problem. I soon realized that my own company had a fundamental problem in the first stage of our antenna system. It was allowing other radio energies into the receiver in addition to the Global Navigation Satellite System (GNSS) signals. I recognized that the flaw in our filter system would degrade the performance of our GNSS receivers whether LightSquared's system is deployed or not.

As an engineer, I always strive to innovate my products and took it upon myself to see if we could develop a device that filters out as much noise as possible from the adjacent band without affecting the integrity of the GNSS signals. Unfortunately, this was never a priority in our industry – we always used filters that offered little protection against interference.

I soon drew the conclusion that the standard operating procedure resulted in degraded performance. **Figure 1**, below, shows the theoretical spectrum of the United States' GPS satellite system and Russia's similar system, GLONASS, the so-called L1 bands. This figure shows GPS and GLONASS spectrum allocations and assumes that all of the adjacent spectrum is completely clean and free of any radio signals. At least that's the theory. In practice this is not the case.

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[1]ESRI is a company based in Redlands, CA that creates Geographic Information Systems software and provides digital maps and other GIS data. They sponsor numerous conferences each year.

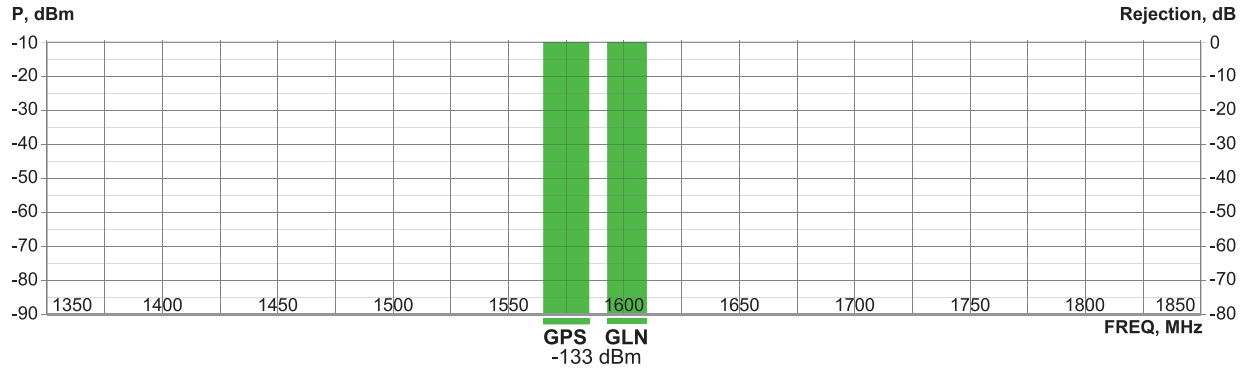


Figure 2, below, shows what the actual spectrum may look like. It has lots of “white noise” and harmonics of other existing transmitters. In the real world, the GPS system lives in a very noisy neighbourhood. The shape of interfering signals can change drastically as you drive around. To extract the best of GNSS signals, we should only allow these signals in and do not invite other outside noise.

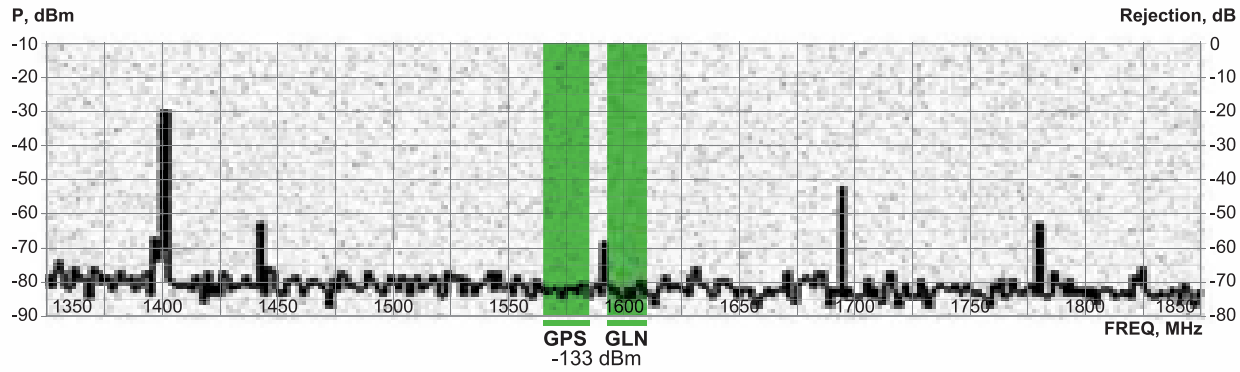
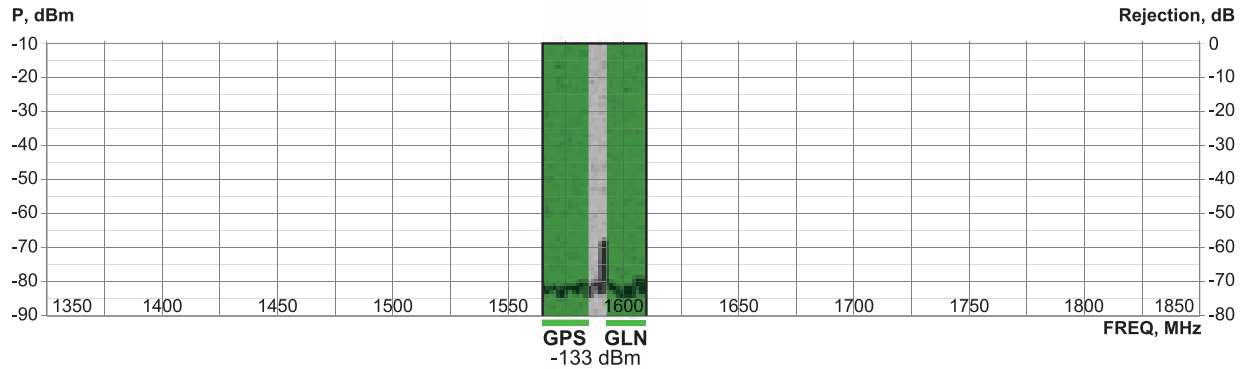
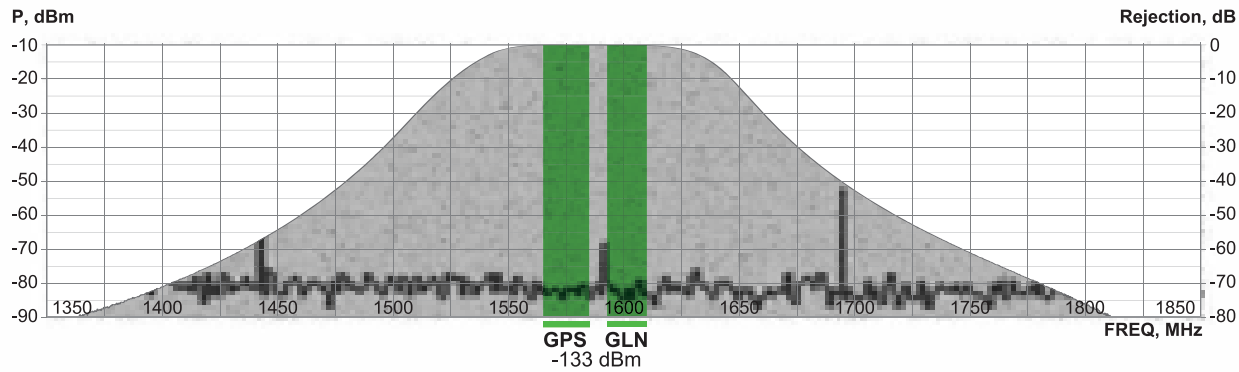


Figure 3, shows a perfect theoretical filter. It allows 100% of GNSS signals to pass from the antenna to the receiver, and it blocks 100% of all radio signals outside the spectrum allotted to GNSS. Such a filter would give us the best possible theoretical signal-to-noise ratio in a receiver and the best possible theoretical receiver performance. This theoretical filter would let in all signals in the GNSS spectrum pass, and completely blocks everything else.

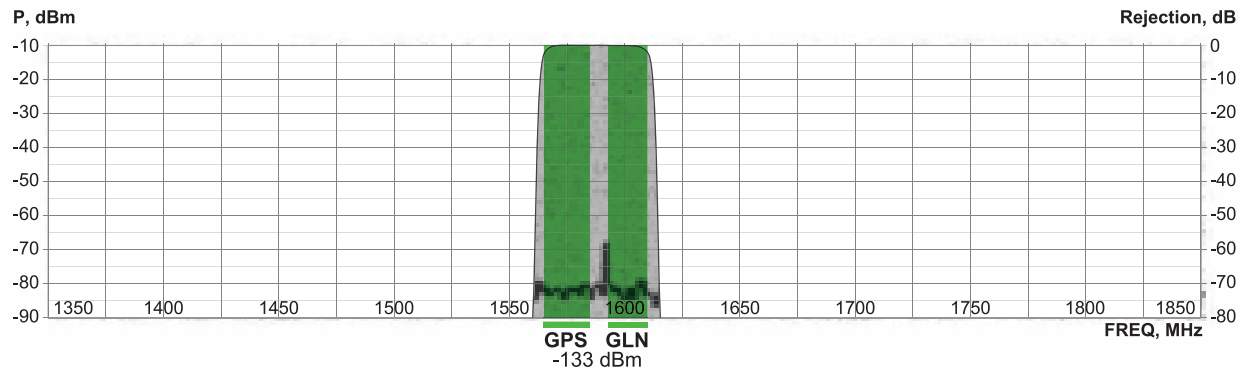


Unfortunately, it is not technically possible to build such a perfect filter. Our challenge is to build the best filter that keeps the GNSS signals intact and blocks unwanted signals as much as possible. In other words, make the side slopes, or skirts, of a filter as steep as possible. How difficult it is to build such a filter? How much would it cost?

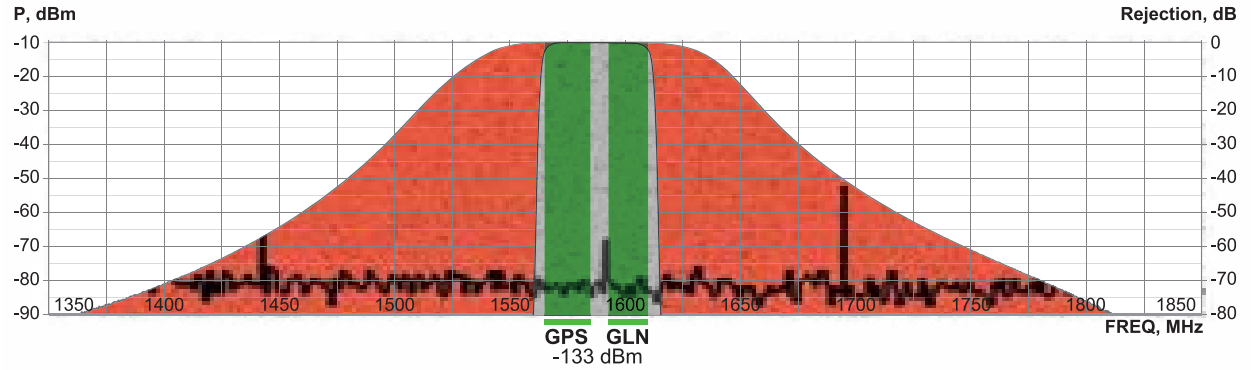
First let us look at the filter that we were using in my own company's GPS receiver products (see **Figure 4**). Those long, gently sloping skirts are not good. Filters with this shape allow a lot of white noise and strong signal spikes into the receiver that a GNSS device doesn't need, and doesn't want (the overall grey area). I knew we could do better, and this is why I set out to find a solution that filters out as much as possible.



As an innovator, I always want to improve our filter designs and enhance overall performance. **Figure 5** shows the performance curve and shape of a filter that we built and tested that met these criteria. And as you see below, the skirts on this filter are nearly vertical, indicating that we were able to block out almost all the noise. In technical terms, the slope of the filter on each side is about 10dB per MHz. In the future we may be able to do even better, but today, I think this the state-of-the-art design. To my delight, there is considerable benefit to this new filter because it is simpler, it performs better and it costs less than our old filter design.



The performance difference between the old filter of **Figure 4** and new filter of **Figure 5** is enormous. The red section in **Figure 6**, below, illustrates the extra noise and undesirable signals that our old filter was allowing to pass from the antenna into the receiver. All of that extra noise degrades the performance of GNSS receivers.



To think in laymen's terms about such performance degradation, consider having a conversation with a friend in a quiet room. Now consider trying to have the same conversation in a crowded restaurant with waiters shouting to each other (noise spikes) and all the restaurant customers talking loudly to overcome all the background noise. All that extra noise makes it a lot harder to understand what your friend is trying to say to you. The same is true for radio receivers: the more background noise they hear, the harder it is for them to detect and understand the signal that they are supposed to be listening to.

As **Figure 6** shows, we had a lot of extra noise coming into our GNSS receivers. Note again that we are not discussing LightSquared here. Our focus is to improve the performance of GNSS receivers by eliminating as much noise as possible from the red zone – whether coming from a LightSquared transmitter or any other source.

If you are out in the countryside in an electronically quiet environment, you may see only small amount of improvement with our new filter, but in cities, where there are lots of other transmitters, the improvement will be significant. With the new filter, you probably will be able to get a Real Time Kinematic[2] (RTK) solution faster and with greater accuracy. With the old, broad-skirted filter, you will need to stay longer in one position to get a position fix, and your solution may not be as accurate. Indeed, your receiver might stop functioning completely if there's too much radio noise. All practicing surveyors will say that there have been times when their receivers were not functioning properly. They usually blame it on foliage, rain, and other physical environmental conditions, when the real problem often is a noisy radio spectrum environment that does not allow enough margin for operation under foliage and where GNSS signal reception is weaker.

In scientific terms, the filter of **Figure 4** can allow enough noise to get into the receiver to create the equivalent of several dB of additional "noise figure"[3]. To put this in perspective, a good receiver has a noise figure of less than 2 dB. Most engineers would agree that an effective noise figure of more than 3 dB means poor receiver performance. Allowing extra noise into the receiver can make the effective noise figure much more than 3 dB.

It's important to distinguish between "noise figure" and "signal-to-noise" ratios that are determined at the end of the signal processing. Even 1 dB of additional "noise figure" will degrade performance, but several dB change in signal to noise ratio might not be noticeable at all in a GNSS receiver. Please note that the discussion so far has nothing to do with LightSquared. Everything I've outlined thus is meant to improve receiver design overall.

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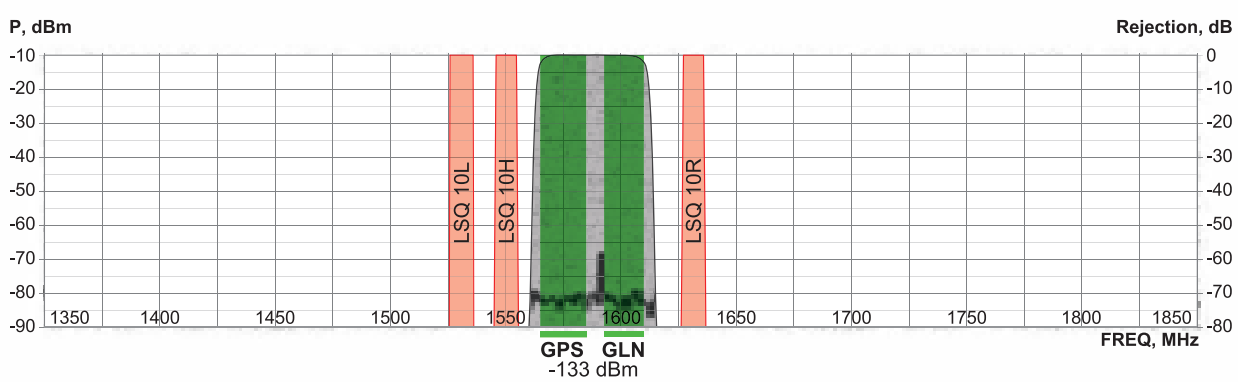
[2]RTK devices are high-precision receivers that use information from terrestrial transmitters to provide additional information, allowing more precise positional solutions.

[3]Noise figure is defined as the difference (in decibels) between a theoretically perfect receiver that does not generate any noise internally, and a real-world receiver.

Better Filters Provide Multiple Benefits

I think this discussion shows that other GNSS manufacturers are not showing a desire to innovate and improve their designs. Either they don't want to block out noise, or they don't have the technical competency to do so. The filter in **Figure 5** is much better than the one in **Figure 4** because it provides superior performance for GNSS receivers, with or without LightSquared. If they thought they couldn't build such filters without negative side effects, they were wrong – we have demonstrated that it can be done.

If we build better filters and better GNSS receivers, both general purpose users and high-precision users of GNSS will get improved results. In addition, the **Figure 5** filter will protect the receiver from hearing LightSquared signals. This is shown in **Figure 7**, below. The GPS and GLONASS signals are shown in green. Our new steep-skirt filter is shown in grey, and the LightSquared signals are pink. Note that this new filter completely blocks out the LightSquared signals without reducing the signal strength of GNSS signals.



This improved filter design should make it clear that LightSquared can coexist with GNSS. Once we understand that, we can also understand that high-precision GNSS receivers can benefit from LightSquared. We can use LightSquared for RTK communication (the land-based signals that augment signals from GPS satellites and provide more precise positional data). We desperately need better RTK communication, and LightSquared's network can provide it.

My desire to innovate filter design was evident in my presentation at the 2011 ESRI conference, where a representative from LightSquared spoke with me on a panel. He was intrigued by the challenge I wanted to tackle offered to support my efforts to build a new and improved filter.

The GPS Community's Response (or Non-Response) to Scientific Facts

Since the ESRI conference, the community's response has been a mix of good, bad, and even ugly. The good part is that our cooperation with LightSquared led to effective and cost-effective solutions to the technical problem. The bad part was that most of the GNSS receiver community stuck fingers in their ears and said, in effect: "I'm not listening! I can't hear you!" The ugly part came in the form of numerous hostile responses I received when I presented my solution at the 2011 PNT[4] meeting, published my findings, and partici-

[4]The National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT) is a U.S. Government organization established by Presidential directive to advise and coordinate federal departments and agencies on matters concerning the Global Positioning System (GPS) and related systems.

pated in the GPS World webinar.

Proving that it was possible to design and build a filter that would improve GNSS receiver performance, and do away with the possibility of interference from LightSquared, made me a villain to the status quo. But I ignored their hostility because my objective is to build better receivers, not please the establishment.

I soon took the designs out of the theoretical realm and successfully built a number of prototypes to test in the laboratory and in the field. The results were successful, and within just a few months from the point when I decided to tackle this problem, we were in full production – not only were my new devices more accurate because they filtered out unnecessary noise, they were cheaper to produce and they were compatible with LightSquared.

The PNT Advisory Board's letter to the FCC Chairman on August 3, 2011 blamed LightSquared for the interference and asserted that the only solution was to shut down the company. Rather than innovate and develop a technical solution to the interference problem, those on the PNT Advisory Board, several of whom represent the major GPS companies with a financial interest in the outcome of this debate, chose to use their political might.

The Sound of Silence

I chose to let the science inform my opinion. We developed a theoretical solution, created an experiment to test it, and proved that the theory was correct. The last step in the scientific process is that experimental results must be replicable. To assist others in replicating my findings, I took 40 units of the new system to the November PNT Advisory Board Meeting and offered our new filter design to those who wished to test them. Some people took up my offer, but nobody has come out in public and announced the results of their own tests. Did anyone conduct any tests? If so, what were the results?

All I heard was silence! I have to assume that any tests that were actually conducted in fact replicated our results. If the new filters didn't work, opponents of LightSquared would have been shouting their test results from the rooftops.

The reaction from many of my industry peers to my scientific analysis was decidedly unscientific. My pure technical findings were tagged as hostile, harsh, disrespectful, political, self-serving and betraying. I ask my critics: How in the world could I possibly want to cause harm to GNSS systems that I have worked so hard in the past 30 years to improve? If GNSS system receives any harm, my company and I are among the first to feel the damage!

I'm not a stranger to controversy, so I chose to ignore them. I received similar personal attacks for ten years when I was working on GLONASS. Déjà vu!

Despite my findings that proved the August 3rd letter technically wrong, the PNT did not correct the record, nor did they offer an apology to the FCC chairman for making false claims. In the scientific community, an organization that puts out such blatantly wrong information loses its credibility and goes silent for a while.

So recently, others inside the government created a new smoke screen: low precision (C/A code only) receivers. The government tests reported that 75% of low-precision re-

ceivers “failed” a compatibility test with LightSquared, but what they neglect to explain is that their definition of “failure” is 1-dB loss in signal-to-noise!

There are two points to note: First, most receivers have up to 20-dB of margin on signal-to-noise and users most likely will not even notice a 1-dB loss. Second, if you take any one of the so called “failed” receivers near many existing transmitting systems (like AM and FM radio and TV towers) you will see that they will lose some dB’s of signal-to-noise or they may completely stop functioning. Should we force all such transmitters off the air? Or better yet, should we demand that GPS receivers that are being used in critical applications have protection against existing systems? I wrote a letter regarding this issue to the FCC Chairman recently outlining my point-of-view on this false rationale.

Next came the issue that LightSquared interferes with avionic systems that warn pilots about approaching terrain and mountains. This was tested in a laboratory. In addition to all I mentioned earlier, the test also ignored that LightSquared towers are aimed six degrees below the horizon and transmit 20-dB (100 times) less power in directions above the horizon. Those conducting the testing and analysis of the data clearly chose to ignore some facts.

It Would Be Funny If It Weren’t So Tragic

The story does not end here. According to the official test results, 300 million inexpensive GPS receivers built into cellular telephones are not affected by LightSquared. However, the very expensive encrypted military GPS receivers that are supposed to be battle hardened are affected!

Why is no one asking the Pentagon why they procured equipment that’s vulnerable to wireless signals of all things?

One may argue that the reason military receivers did worse than cell phones is that military receivers use wide band P-code. This is exactly my point; the military receivers which use wide band un-encrypted P-code for the main purpose of getting better protection against interferences, end up performing worse than even a cell phone in the presence of interference. This also applies to the FAA. Everyone in Washington ignores these facts!

This technical matter has a lot of lawyers, lobbyists and spin doctors involved, but it’s the engineers who have the ability to solve this problem.

No matter what happens to LightSquared, I am determined to build a better filter system for our GNSS receivers and offer better products to surveyors worldwide, and if we can accomplish this while facilitating a better RTK network, all the more reason.

Locating dangerous zones prior to drilling the 57 km long Gotthard Tunnel in Switzerland

Georadar (or Ground Penetrating Radar) was one of the tools used to locate the most critical zone "Piora Mulde"

Edi Meier
edi meier + partner AG
Switzerland

Ulrich Sambeth
Stump Foratec AG
Switzerland

The Gotthard Base Tunnel with its 57 km is the world's longest railway tunnel (Figure 1). It is located beneath the Swiss Alps and consists of two single track tunnels, several cross-cuts and shafts with a total length of 153.5 km.

The constructions started in 1996. The eastern tunnel was completed on 15 October 2010 and celebrated with a cut-through ceremony (Figure 2). The constructions are planned to end by 2016 and the opening to the traffic by 2017 [1].

The tunnel leads through largely disturbed granite and gneiss massifs interrupted by weak and instable rock formations (Figure 3, top). The maximum overburden is up to 2500 m, the hydrological situations are highly variable. The most dreaded geological formation was the so-called "Piora Mulde" (Figure 3, yellow marked). The material of this formation has the consistancy of sugar and is therefore called sugar grained dolomite. It has no mechanical stability at all. At the beginning in 1995 nobody knew whether this formation would reach down to the planned tunnel level. In order to gain more detailed information a sounding tunnel was built prior to the construction of the base tunnels.The sounding tunnel was built 300 m above the planned base tunnel [2].

For safety reasons it is important to identify a problematic rock formation before the Tunnel Boring Machine (TBM) reaches it. To prevent unexpected hazards a Georadar or Ground Penetrating Radar (GPR) measurement in front of the drilling face was used for prognostic purposes.

Georadar principle

GPR is a geophysical investigation method. Its principle is similar to that of Seismics but instead of emitting elastic

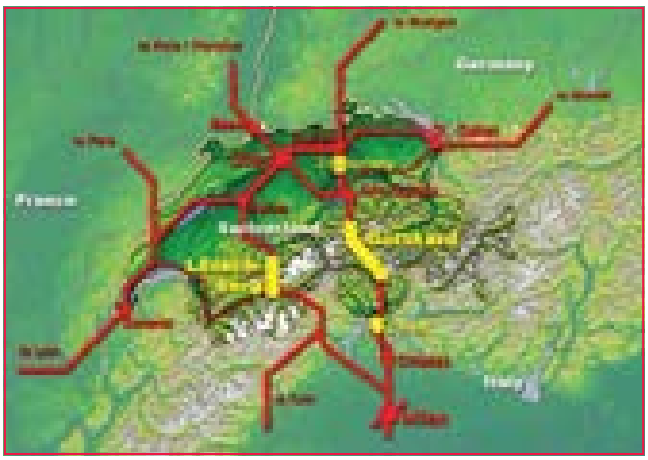


Figure 1: Location of the Gotthard tunnel transect (by Cooper.ch).

Figure 2: Cut-through of the TBM on 15 October 2010.

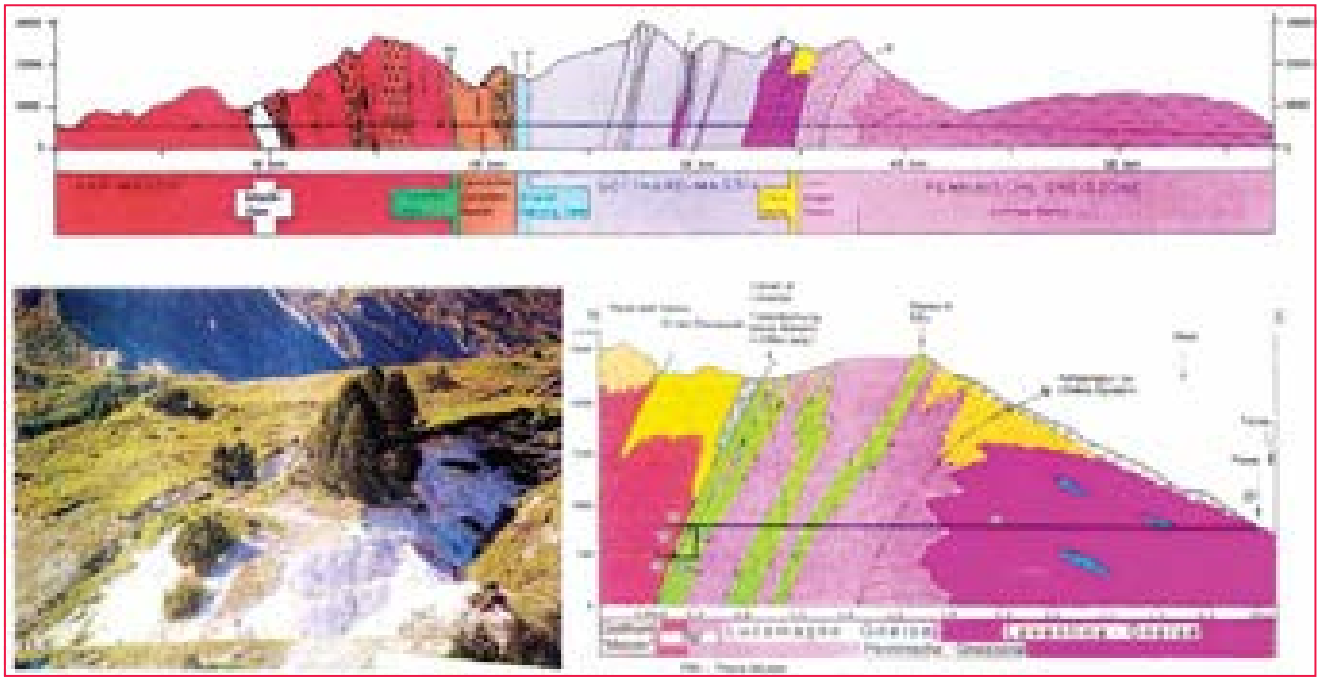


Figure 3: Geological cross-sections of the whole tunnel area published before 1995 (top, by Alptransit) and of the yellow marked critical section (right). Picture of the Piora region at the surface (left, by R. Steinegger, Lauener, 1997).

waves, it emits electromagnetic waves. They are much shorter, which leads to a much higher spatial resolution. GPR is sensitive to the electromagnetic properties of the material under investigation. Interfaces of rock formations, fissures and aquiferous areas are displayed.

The System consists of a transmitter antenna, a receiver antenna and a control unit. The GPR transmitter antenna produces high-frequency electromagnetic energy pulses. These pulses penetrate the ground and are reflected at interfaces of media with high contrasts in electrical conductivity. The reflected waves are captured by the receiver antenna and are displayed continuously on the control unit, producing a so-called radargram (Figure 4).

Depending on the required depth of penetration and spatial resolution, different antennas are used: The lower the antenna frequency, the deeper the penetration.

Prior to the measurements the antenna configuration was calculated in order to achieve the necessary depth of penetration. The excavation performance in the hard gneiss was about 14 m per day. The requirement was 20 m penetration depth, which is 1.5 times the excavation performance of the TBM. Whether a target is visible or not depends on the material in the expected fault zone. Calculations of the achievable penetration depth using 100 MHz antennas and a rock model ‘gneiss’ and target ‘water’ resulted in a value of 61 m for a specular and 37 m for a rough target.

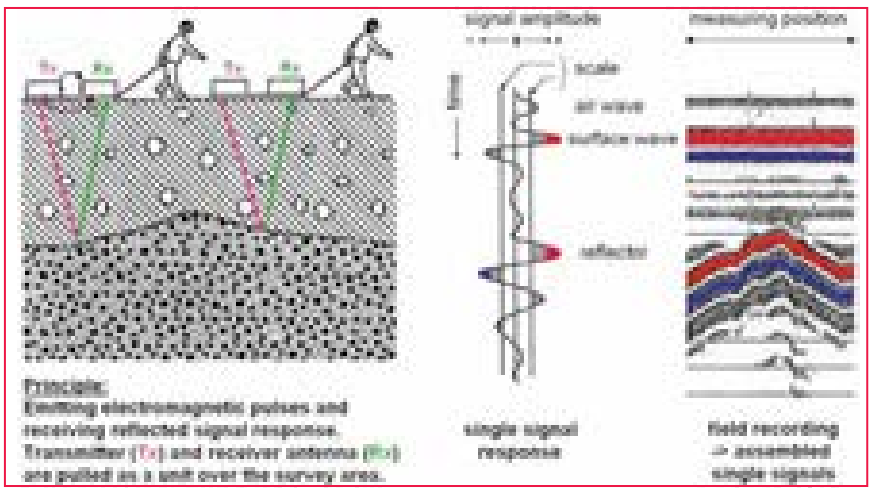


Figure 4: Georadar principle [3]

Survey

For the required penetration depth only unshielded antennas with frequencies of 100 MHz and 50 MHz could be used. We choosed the “pulseEKKO” system built by the canadian company Sensors&Software Inc. That Georadar equipment was small enough to fit through the narrow manhole of the TBM to get to the drilling face (Figure 5).

Prior to the measurement the TBM was pulled back 1.5 m at a time. Then the first man crawled through the several meters long manhole, while the second man pushed the equipment through the manhole and prepared the recording unit afterwards (Figure 6).

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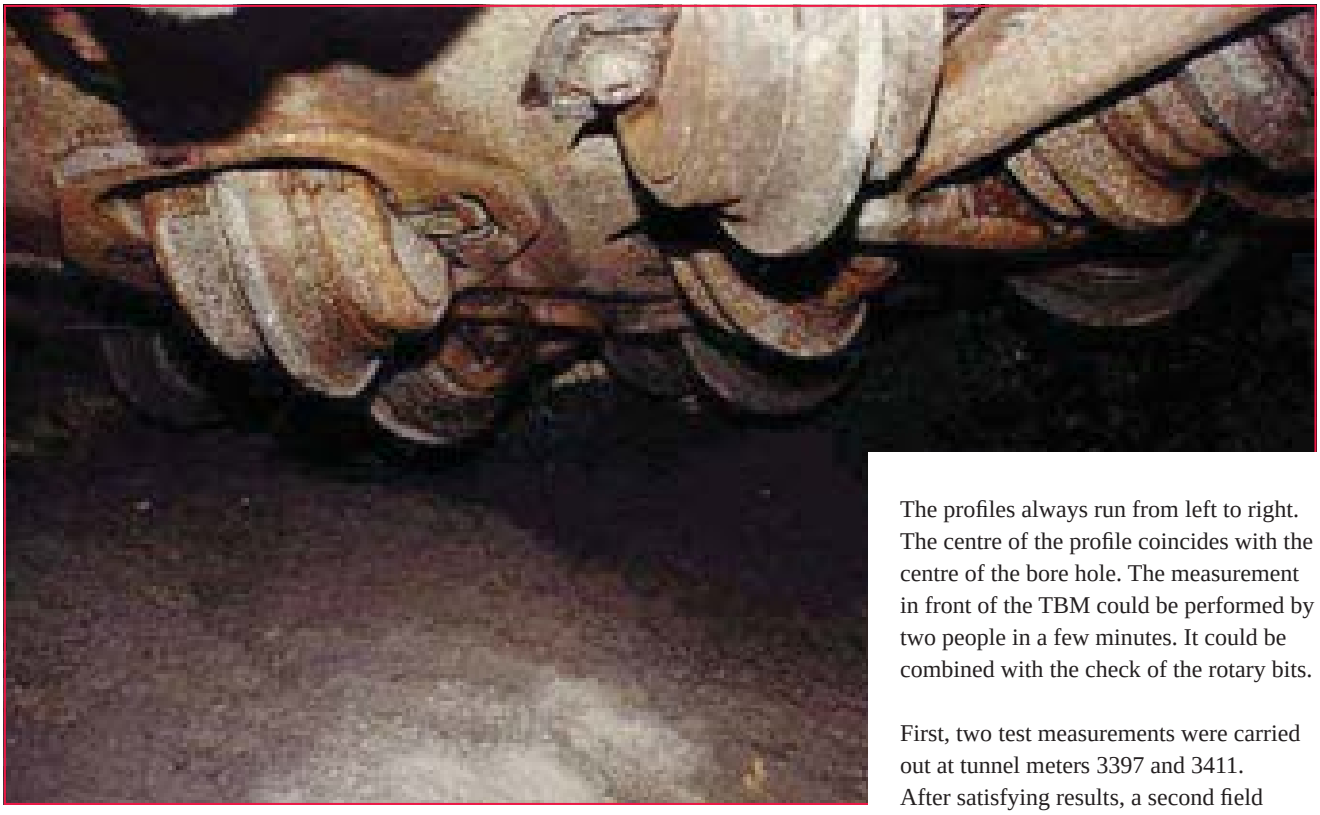

Figure 5: Close-up of the rotary bit. The borehole diameter is 5 m. Photo E. Meier.

Figure 6: GPR 100 MHz antennas (top left), Manhole with fibre optics (top right), engineers passing GPR equipment through a manhole (bottom left) and carrying protection tubes for the vulnerable fibre optics (bottom right). Photos: E Meier, U. Sambeth.

The profiles always run from left to right. The centre of the profile coincides with the centre of the bore hole. The measurement in front of the TBM could be performed by two people in a few minutes. It could be combined with the check of the rotary bits.

First, two test measurements were carried out at tunnel meters 3397 and 3411. After satisfying results, a second field campaign was conducted from tunnel meter 4840 to 5120 (Figure 7, 8).

Results

Unlike a normal GPR measurement the display of the radar signals in the radargrams is forward oriented, towards the progress of drilling.

Figure 7 displays a colour image of a radar section at tunnel position 3397 m and one at position 3411 m. At 24 m distance in the record at the left side a fault zone is clearly visible. In the figure on the right side this fault zone has approached, it is now at a distance of only 14 m from the drilling face.

The evaluation of the events is based on the radargram interpretation and the geological outcrop [4].

Figure 8 demonstrates different georadar images of different rock qualities. Images like the one on the left represent a high quality rock. In critical zones where water intrusions were present, already after a few meters no reflectors were visible any

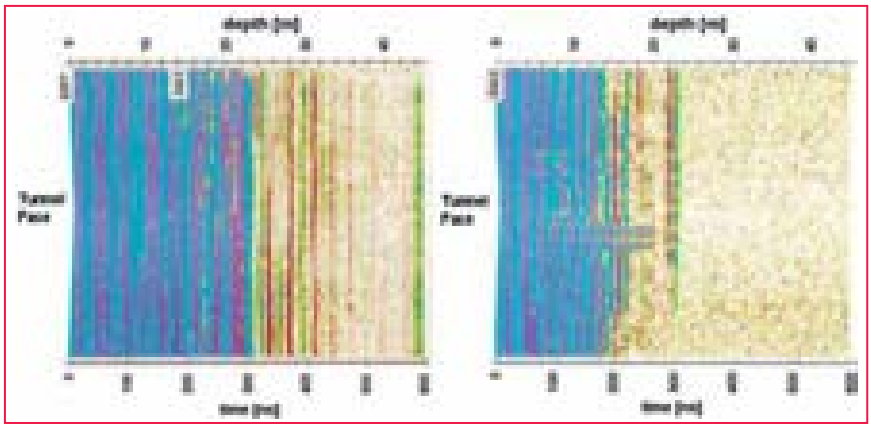

Figure 7: Coloured profiles of the two test measurements at tunnel meter 3397 m (left) and 3411 m (right). In the first record the blue range (reflections with big amplitudes) is reaching 24 m deep, in the second record 14 m deep.

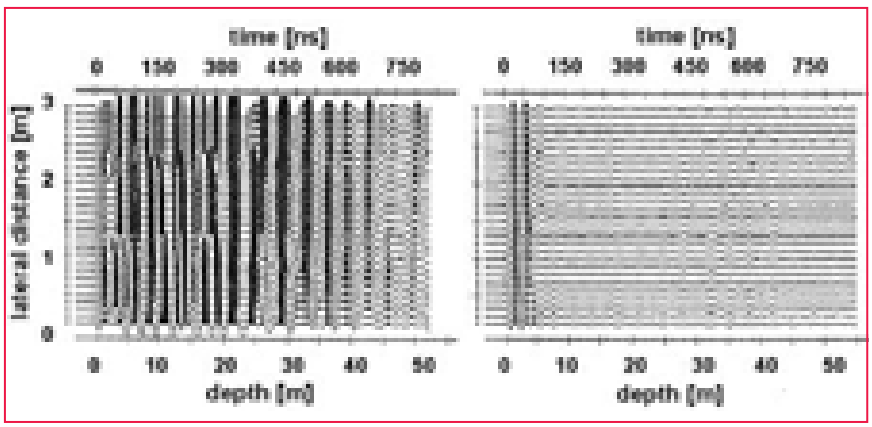

Figure 8: 50 MHz Georadaprofiles representing high quality solid rocks (left) and rock at a fault zone (right).

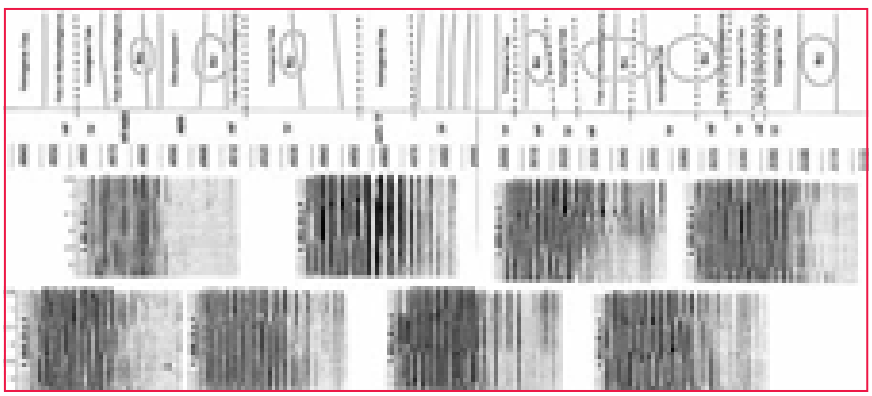

Figure 9: Overview of overlapping series of georadar profiles recorded between position 4840 m and 5120 m

more (Figure 8, right). An overview of overlapping georadar profiles is shown in Figure 9. At position 4875 a small fault zone was detected. The georadar image of that zone shows a clear signal absorption halfway in drilling direction. This was verified by the geological outcrop.

The last Georadar record was taken on 28 November 1995. On 31 March 1996, between 12:30 and 17:00, during the pilot hole drilling from position 5553 into the critical zone, an operating error ocurred and the tunnel was filled with 2000 tons of water and sugar grained dolomite [5].

Figure 10: Blow-out from borehole at 5553 m. A mixture of sugar grained dolomite and water with 1000 m overpressure filled the tunnel. Photo R.Volpers [6]

Conclusion

Georadar is a feasible tool for detecting dangerous waterfilled zones in granitic rocks. It is a very quick methode and can be carried out during the check of the drilling bits. Pilot holes are still necessary for safety reasons. However, the number of pilot holes can be reduced and limited to the critical zones, which also reduces the costs considerably.

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The paper was presented at FIG Working Week 2011, Marrakech, Morocco, 18-22 May 2011

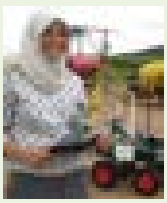
Spatially Smart Wine

Spatially Smart Wine was a project initiated by an enthusiastic group of Sydney Young Surveyors, with the support of the Institute of Surveyors New South Wales and the School of Surveying and Spatial Information Systems and the University of New South Wales. Readers may recall that we published the first and second part of the paper in December 2011 and January 2012 issue respectively. We present here the concluding part

Unmanned Ground Vehicle (UGV): Testing and applications

Here we present an Unmanned Ground Vehicle (UGV) which contains technologies for automated yield estimation which are readily applicable to many existing agricultural machines. The UGV was developed in the School of Mechanical and Manufacturing Engineering at the University of New South Wales under the direction of Associate Professor Jayantha Katupitiya and Dr Jose Guivant. As shown in Figure 4, it is a four wheeled vehicle equipped with sensors and actuators for tele-operation and full autonomous control. Weighing 50kg, it is a comprised of Commercial-Off-the-Shelf (COTS) sensors, a custom-made mechanical base and a low-cost onboard laptop with a wireless connection to a remote Base Station (BS). Of particular note is ready retrofitting capacity of the COTS sensors to existing farm machinery.

For the purposes of this paper, the vehicle was tele-operated from the nearby BS with the operator manoeuvring with the aid of three onboard video cameras and a display of the LiDAR data in real-time. Autonomous operation using the LiDAR data and was demonstrated in Whitty et al. (2010)(For videos, see our YouTube channel: www.youtube.com/UNSWMechatronics).



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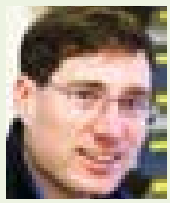

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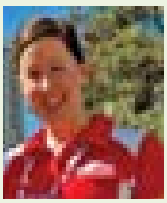

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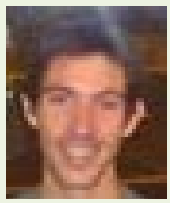

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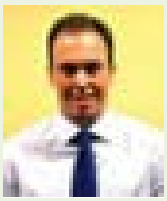

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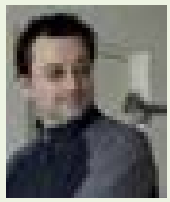

Jose Guivant
School of Mechanical and Manufacturing Engineering, University of New South Wales, Australia

Mitchell Leach
New South Wales Young Surveyors

Jayantha Katupitiya
School of Mechanical and Manufacturing Engineering, University of New South Wales, Australia

System overview

The equipment contained in the vehicle is shown in Table 4. Of this the relevant items are the rear 2D LiDAR sensor, the IMU, the CORS-corrected GPS receiver and the wheel encoders. Together with the onboard computer, these items allow accurate georeferenced point clouds to be generated which are accurate to 8cm. The output is not limited to point clouds, as any other appropriately sized sensors can be integrated to provide precise positioning of the sensed data, either in real-time or by post-processing.

Measurement estimation and accuracy

The following paragraphs show how the pose of the robot is accurately estimated and then how this pose is fused with the laser data to obtain 3D point clouds. Given the uncertainty of the robot pose, we also derive expressions for the resultant uncertainty of each point in the point cloud. Furthermore, the average case accuracy is compared with that obtained from aerial LiDAR and the advantages and disadvantages

Figure 4: UGV with relevant equipment labelled

Table 4: UGV Equipment

Device	Manufacturer	Purpose
LiDAR sensor	SICK	Measures range and bearing to a set of points
Inertial Measurement Unit (IMU)	Microstrain	Measures roll, pitch and yaw angles and rates
Wheel encoders	Maxon	Measures wheel position and velocity
GPS receiver	Leica Geosystems	Measures GPS position and accuracy
Laptop	MSI	Record and process data and communicate with BS
Wifi router	Meshlium	Communication with BS
Cameras	Logitech	Visual feedback to operator

of both methods of data gathering are discussed from the perspective of PV.

As discussed, the CORS-linked GPS sensor mounted o n the UGV provides both the position and position uncertainty of the vehicle in ECEF coordinates. In this case the MGA55 frame was used to combine all the sensor data for display in one visualisation package. The GPS position was provided at 1Hz and given the high frequency dynamics of the robot's motion, higher frequency position estimation was necessary. Hence an inertial measurement unit (IMU), containing accelerometers and gyroscopes, was mounted on the vehicle providing measurements at 200Hz. The output of this IMU was fused with the wheel velocities as described in (Whitty et al., 2010) to estimate the short term pose of the vehicle between GPS measurements. The IMU also provided pitch and roll angles, which were used in combination with the known physical offset of the GPS receiver to transform the GPS provided position to the coordinate system of the robot.

Given the time of each GPS measurement (synchronised with the IMU readings), the set of IMU derived poses between each pair of consecutive GPS measurements was extracted. Assuming the heading of the robot had been calculated from the IMU readings, the IMU derived poses were projected both forwards and backwards relatively from each GPS point. The position of the robot was then linearly interpolated between each pair of these poses, giving an accurate and smooth set of pose estimates at a rate of 200Hz. Since the GPS measurements were specified in MGA55 coordinates and the pose estimates calculated from these, the pose estimates were therefore also found in MGA55 coordinates.

The primary sensor used for mapping unknown environments was the SICK LMS151 2D laser rangefinder. Figure 6 pictures one of these lasers, which provided range readings up to a maximum of 50m with a 1σ statistical error of 1.2cm. Figure 5 shows the Field of View (FoV) as 270° with the 541 readings in each scan spaced at 0.5° intervals and recorded at a rate of 50Hz, giving about 27 000 points per second. Its position on the rear of the robot was selected to give

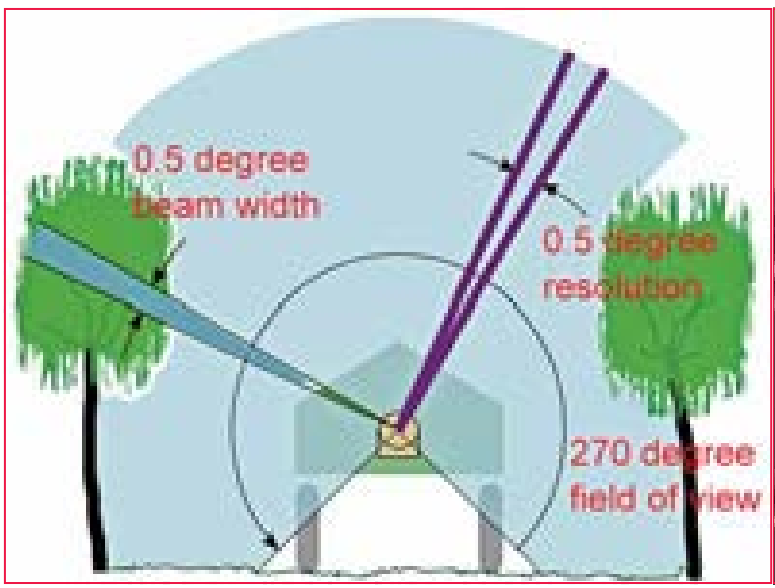

Figure 5: 2D Field of View (FoV), showing scan of vines

Figure 6: LiDAR sensor on the UGV

the best coverage of the vines on both sides as the robot moves along a row.

To accurately calculate the position of each scanned point, we needed to accurately determine the position and orientation of the laser at the time the range measurement was taken. All of the IMU data and laser measurements were accurately time stamped using Windows High Performance Counter so the exact pose could be interpolated for the known scan time. Given the known offset of the laser on the vehicle, simple geometrical transformations were then applied to project the points from range measurements into space in MGA55 coordinates. Complete details are available in Whitty et al., (2010) which was based on similar work in Katz et al. (2005) and Guivant (2008). This calculation was done in real-time, enabling the projected points – collectively termed a point cloud – to be displayed to the operator as the UGV moved.

Information representation to operator

The display of the point cloud was done using a custom built visualisation program which was also adapted to read in a LiDAR point cloud and georeferenced aerial imagery obtained from a flight over the vineyard. Since all these data sources were provided in MGA55 coordinates, it was a simple matter to overlay them to gain an estimate of the accuracy of the laser measurements. Figure 7 shows the terrestrial point cloud overlaid on the image data where the correspondence is clearly visible. Given that the point cloud is obtained in 3D, this provides the operator with a full picture of the vineyard which can be viewed from any angle.

Table 5: Comparison of aerial and terrestrial LiDAR systems (values are approximate)

	Units	Aerial LiDAR	Terrestrial LiDAR
Sensor		Leica ALS50-II	SICK LMS151
Data generation rate	Measurements / s	150 000	27 000
Area covered	m2 / s	37 500	80
Horizontal resolution	M	1	0.012
Horizontal accuracy	cm	±80cm	±7cm
Vertical resolution	M	0.5	0.012
Vertical accuracy	cm	±30cm	±4cm

Fusion of sensor data and calculation of accuracy

Although the above point cloud generation process has been described in a deterministic manner, in practice measurement of many of the robot parameters is usually not precise. By performing experiments, we were able to characterise these uncertainties individually and then combine them to estimate the uncertainty in position of every point we measured. In the field of robotics, these uncertainties are typically characterised as a covariance matrix based on the standard deviations of each quantity, assuming that they are normally distributed. The covariance matrix giving the uncertainty of the UGV's pose in MGA55 coordinates is a 6x6 matrix. The UGV's pose itself is given by a vector which concatenates the 3D position and the orientation given in Euler angles.

Since the GPS receiver was offset from the origin of the UGV's coordinate system, the GPS provided position was transformed to the UGV's coordinate system by rigid body transformation. However, the uncertainty of the angular elements of the pose meant that the GPS uncertainty must not only be shifted but be rotated and skewed to reflect this additional uncertainty. An analogy is that of drawing a straight line of fixed length with a ruler. If you don't know exactly where to start, then you have at least the same uncertainty in the endpoint of the line. But if you also aren't sure about the angle of the line, the uncertainty of the endpoint is increased.

A similar transformation of the UGV uncertainty to the position of the laser scanner on the rear of the UGV provided the uncertainty of the laser scanner's position. Then for every laser beam projected from the laser scanner itself, a further transformation gave the covariance of the projected point due to the angular uncertainty of the UGV's pose.

Additionally, we needed to take into account uncertainty in the measurement angle and range of individual laser beams. This followed a similar pattern and the uncertainty of the beam was calculated based on a standard deviation of 0.5 degrees in both directions due to spreading of the beam. Once the uncertainty in the beam, which was calculated relative to the individual beam, was found, it was rotated first to the laser coordinate frame and then to the world coordinate frame using the corresponding rotation matrices. Finally, the uncertainty of the laser position was added to give the uncertainty of the scanned point.

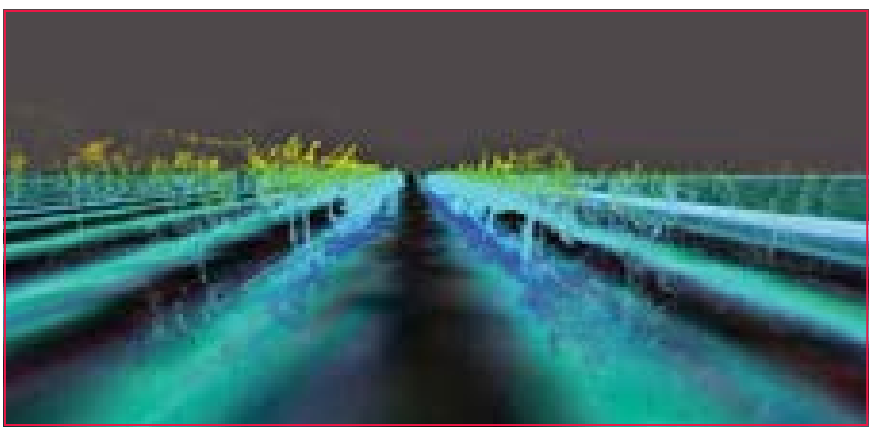

Figure 7: UGV generated point-cloud with overlay of aerial imagery

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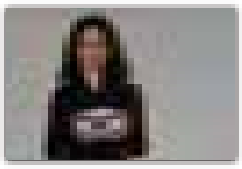

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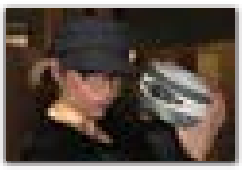

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Comparison of aerial and terrestrial LiDAR

An experiment was conducted at the location detailed in Section 1.2. The UGV was driven between the rows of vines to measure them in 3D at a speed of about 1m/s. The average uncertainty of all the points was calculated and found to be 8cm in 3D. Table 5 shows how this compares with about 1.2m for the aerial LiDAR but has the disadvantage of a much slower area coverage rate. The major advantages however are the increased density of points (~3000 / m3), ability to scan the underside of the vines and greatly improved resolution. Also, the terrestrial LiDAR can be retrofitted to many existing agricultural vehicles and used on a very wide range of crops. Limited vertical accuracy – a drawback of GPS – is a major restriction but this can be improved by calibrating the system at a set point with known altitude.

For PV, the terrestrial LiDAR system clearly offers a comprehensive package for precisely locating items of interest. Further developments in processing the point clouds will lead to estimation of yield throughout a block and thereby facilitating implementation of performance adjusting measures to standardise the yield and achieve higher returns. For example, a mulch delivery machine could have its outflow rate adjusted according to its GPS position, allowing the driver to concentrate on driving instead of controlling the mulch delivery rate. This not only reduces the amount of excess mulch used but reduces the operator's workload, with less likelihood of error such as collision with the vines due to fatigue.

Conclusion

In this paper we have evaluated several state-of-the-art geospatial technologies for precision viticulture including multi-layered information systems, GNSS receivers, Continuously Operating Reference Stations (CORS) and related hardware. These technologies were demonstrated to support sustainable farming practices including organic and biodynamic principles but require further work before their use can be widely adopted. Limitations of the current systems were identified in ease-of-use and more particularly in the lack of a unified data management system which combines field and office use. While individual technologies such as GIS, GNSS and handheld computers exist, their integration with existing geospatial information requires the expertise of geospatial professionals, and closer collaboration with end users.

In addition we demonstrated the application of an unmanned ground vehicle which produced centimetre-level feature position estimation through a combination of terrestrial LiDAR mapping and GNSS localisation. We compared the accuracy of this mapping approach with aerial LiDAR imagery of the vineyard and showed that apart from coverage rate the terrestrial approach was more suited in precision viticulture applications. Future work will focus in integrating this approach with precision viticulture machinery for estimating yield and controlling yield-dependent variables such as variable mulching, irrigation, spraying and harvesting. The end product? Spatially smart wine.

Acknowledgements

The authors wish to acknowledge the following bodies and individuals who provided equipment and support: Land and Property Management Authority (in particular Glenn Jones), CR Kennedy (in particular Nicole Fourez), ESRI Australia and the University of New South Wales. Particular thanks go to the vineyard owner and manager, Justin Jarrett and family.

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Galileo update

Second Galileo IOV Satellite transmitting signals

On 16 January, the second of the two Galileo In-Orbit Validation (IOV) satellites, FM2 (Flight Model 2) also known as GSAT0102, started transmitting navigation signals on the L1/E1 frequency using the E12 ranging code, according to tracking reports from the Cooperative Network for GIOVE Observation (CONGO). FM2 was launched together with PFM, the ProtoFlight Model (GSAT0101), on October 21, 2011. PFM started transmitting E1 signals on December 10, 2011, and E5 signals on December 14, according to CONGO network tracking reports. Subsequently, ESA confirmed that the E6 transmitter was powered up the weekend before Christmas. CONGO is a global network of 19 tracking stations established by the German Space Operations Center (DLR/GSOC) and the German Federal Agency for Cartography and Geodesy (BKG) in cooperation with several agencies including Technische Universitaet Muenchen.

Galileo sees success in early testing

The European Space Agency (ESA) staged a test of the Galileo in-orbit validation (IOV) spacecraft on December 17th, all signals that are to be used for Galileo activated simultaneously across the burgeoning GNSS system. When the network is established it will provide marked enhancements to the precision and measurements that current GNSS devices - including those used in machine control and surveying equipment - are capable of providing.

The signals were received by three of the network's current Test User Receivers - the two identical receivers in the ESA's Navigation Laboratory in Noordwijk, the Netherlands and the one located in Belgium's Ardennes Forest. The testing is being carried out on the Galileo-ProtoFlight Model (PFM) satellite, which was launched on October 21 last year. The testing will be moved on to the second satellite that was launched at the same time - Flight Model-2 - early in 2012. *www.surveyequipment.com*

First Galileo satellite GIOVE-A outlives design life to reach sixth anniversary

British satellite manufacturer Surrey Satellite Technology Ltd (SSTL) has announced that Galileo In Orbit Validation Element GIOVE-A has completed the sixth year of transmission of signals. Launched on 28th December 2005, GIOVE-A was one of two in-orbit testbeds for Galileo. Built with a design life of twenty-seven months, its mission was to secure the radio frequency filing for the Galileo satellite system with the International Telecommunications Union (ITU), test the critical Galileo payload equipment, and perform tests to characterize the radiation environment of Medium Earth Orbit (MEO) – the region of Earth's orbital space used by navigation satellites. *www.sstl.co.uk*

ESA outlines space plans for 2012

European Space Agency (ESA) revealed its plans for 2012. It includes Europe's Galileo satellite navigation system, which would see the launch of the second two In-Orbit Validation satellites in August/September 2012. With the first four satellites of the constellation and their ground network, the agency will be able to validate the overall Galileo concept. *www.esa.int*

At a Glance

- Trimble selected Mannai Corp. (software division) as a MGIS business partner in Qatar
- Hexagon to acquire all outstanding shares of MicroSurvey Software Inc.
- Johannes Riegl Jr. named the CMO for RIEGL
- Turkey's General Directorate of National Property purchase UltraCam Eagle
- Nigeria joins World Bank, Google mapping project
- The US Department of Agriculture's releases GIS-based Plant Hardiness Zone map
- Bluesky releases LiDAR map of Britain online
- IfSAR data detects horizontal fault in Kohat Plateau earthquake
- Singapore's National Water Agency to use 3D map for flood prediction
- SuperGeo to release SuperGIS Spatial Analyst 3.0
- Clark Labs to release 17th Version of IDRISI Selva
- CyberSWIFT assists Jharkhand state government in India to develop a GIS-based call centre
- The National Atmospheric Research Laboratory, India to set up a LiDAR network to study climate change in India
- Gogopal introduces easy-to-use navigation solutions for Malaysia
- DMCii 2011 country image packs available in half price
- ISRO helps Tumkur university set up GIS centre

Tracking of shoppers condemned

Civil rights campaigners spoke out against a technology, 'FootPath', used by several shopping centres in the UK to track consumers using their mobile signals. The shopping centres claimed that the technology helped them in providing better services to consumers and retailers without compromising privacy. It allowed them to know how are people spending time in a shopping centre, which spots they visit the most and even the route they take while walking around in a shopping centre. The fact that the technology keeps the consumers' anonymous has been appreciated but several organisations claim that is wrong to assume that shopping centres have a right to track the movement of the consumers. *www.gaurdian.co.uk*

SiRFstudio Client LoCoMo API now available

CSR has announced the availability of the SiRFstudio Client LoCoMo API, which gives developers the tools to add location, as well as context-awareness of pedestrian motion, on any MEMS-enabled Android device. LoCoMo API innovations are based on the concept of "Locomotion" allowing the differentiation between different modes of physical movement, such as walking and running. *www.csr.com*

Magellan Introduces Newest Addition to eXplorist Outdoor GPS Family

Magellan has announced the introduction of the Magellan eXplorist 110 GPS receiver, a waterproof and rugged handheld GPS with core outdoor navigation features. With a vibrant, sunlight readable color display plus a highly sensitive GPS chipset providing 3-5 meters of accuracy, and the ability to record hundreds of waypoints, tracks, and routes, the eXplorist 110 GPS receiver is an amazing value for any beginning outdoor enthusiast. *www.magellangps.com*

Bing Maps to be rebranded as Nokia Maps

Bing Maps would be rebranded as Nokia Maps across all platforms. Nokia owns NAVTEQ maps database, which now powers Bing Maps on all Windows Phone devices. The news will probably come as a surprise to companies involved with Bing, such as Research In Motion (RIM) who makes the popular BlackBerry smartphones. *www.pocket-lint.com*

TomTom to provide traffic info to British Automobile Association

TomTom will provide British Automobile Association (the AA) real-time traffic information for The AA's Traffic News website. It will now include TomTom HD Traffic data, which provides a live view of road conditions and areas of congestion, enabling consumers to better plan their journeys.

'Connected Vehicle Integrated Solution' by Accenture

Accenture has unveiled an integrated solution for auto and truck manufacturers that will help them meet growing demand from consumers for in-vehicle technologies with capabilities ranging from wi-fi access to the ability to process mobile payments for parking, insurance and tolls. The Accenture Connected Vehicle Integrated Solution (ACVIS) helps original equipment manufacturers (OEMs) design and integrate technologies such as on-board devices, telematics and mobile connectivity. *www.accenture.com.*

Long-range obstacle detection for autonomous vehicle navigation by TORC Robotics

TORC Robotics in USA has been subcontracted through the Robotics Technology Consortium (RTC) to develop an advanced sensor fusion system for the Department of Defense that will significantly increase high-speed obstacle detection range. This long-range obstacle detection, classification and prediction system will enhance autonomous navigation capabilities for unmanned ground vehicles operating in mission-relevant environments at speeds up to 100 KPH. The system will be capable of detecting and maintaining a variety of tracking statistics for each obstacle. *www.torcrobotics.com*

NAVTEQ launches real-time traffic service in India

NAVTEQ launched real-time traffic service, NAVTEQ Traffic Pro, in India. It will deliver comprehensive, real-time traffic information to more than 26 million people in the country's two largest cities by population, Delhi and Mumbai. *www.navteq.com*

Chinese satellite navigation market to reach USD 35 bn

The annual output value of China's satellite navigation industry will reach more than 225 billion yuan in 2015, according to a report by National Administration of Surveying, Mapping and Geoinformation. The report predicted the industry would become the country's third new IT economic growth point, after mobile communication and Internet. More than 5,000 Chinese firms and organisations were now involved in the application and services of satellite navigation and the industry generated more than 50 billion yuan of output value in 2010.

Vodafone India to penetrate rural market using GIS

Vodafone India is considering using GIS maps and population data under the 'Project Pappu'. Through this way, the company aims to strengthen its presence in rural India. Vodafone decided to go off the beaten track by tweaking its network coverage and choosing not to follow the conventional route of a linear expansion along the highways. Instead it covered a villager's "community of interests." These are the different pockets or milieus he/she frequents for his/her various socio-economic needs. *www.business-standard.com*

Warrant compulsory for GPS tracking: Supreme Court

The US Supreme Court ruled that police need a search warrant before tracking a suspect with a GPS device, in a case involving privacy and 21st century technology. The highest US court ruled 9-0 that police had violated the rights of a suspected drug dealer when they placed a GPS or tracking device, on his vehicle without a warrant and tracked his movements.

The Fourth Amendment of the US Constitution provides guarantees against unreasonable search and seizure. The case was seen as an important test of how far police can go in using technology to investigate and track suspects. It drew wide interest from civil liberties groups amid concern that new technologies can be used to get around constitutional protections of privacy and other rights. *www.gpsdaily.com*

GLONASS seeks private investment

Russian government refused to fund GLONASS programme because the GLONASS team failed to submit detailed report of the expenses they were planning. The funding programme was to be implemented by December 31, 2011, with the government approving a USD 10 billion draft back in autumn. Now they will have to seek private sources to fund the project. *www.rt.com*

Experts to prepare common standards for SBAS

Programme managers and technical experts overseeing four of the world's regional satellite navigation augmentation systems congregated in Munich, Germany, to participate in Satellite-Based Augmentation Systems (SBAS) Interoperability Working Group (IWG) meeting. There was no representation from India's GPS and Geo-Augmented Navigation (GAGAN) team in meeting.

Among the most important achievements of the two-day meeting was the preliminary definition of a common SBAS message based on dual GPS and Galileo signals, with an aim of extending coverage to achieve quasi-global service by 2020. *www.esa.int*

GLONASS to be 'mandatory' for all new Russian cars

From 2013, all new Russian-made cars will be equipped with the ERA-GLONASS by default, according to Yaroslav Domaratskiy, Director of Customer Equipment R&D Centre at NIS-GLONASS. Experts believe that in case of emergency GLONASS will locate the place of the accident, and transmit the data to a response centre. *www.rusemb.org.uk*

Scientists find GPS most power consuming feature in phones

Computer scientists at the University of Texas at Austin, USA and the Australian National University conducted the first systematic power profiles of microprocessors, which could help cut the power consumption of both small cell phones and giant data centres. "In terms of energy, the GPS is one of the most expensive functions on your phone. A bad algorithm might ping your GPS far

FCC, LightSquared face legal roadblocks

The recently enacted National Defense Authorization Act of 2012, signed by President Obama on December 31, 2011, can further delay LightSquared's launch of a nationwide wireless data network. The clause prohibits the FCC from approving LightSquared's request to begin commercial land-based operations until the FCC "has resolved concerns" about possible interference with military GPS systems. The defence authorisation bill also orders the Secretary of Defense to conduct a review every 90 days on whether defence GPS devices will be affected by commercial radio transmissions on neighbouring bands. If DoD finds a problem, it must report to Congress on the devices affected, source of the interference and the cost of fixing the problem. The restrictions on LightSquared are not to be lifted, the act says, until the Defense Secretary "determines that commercial communications services are not causing any widespread harmful interference with covered GPS devices." *www.forbes.com*

GPS tests were rigged, Lightsquared claims

LightSquared and former FCC chief engineer Edmond Thomas said the GPS test devices that were used by a government agency to test its new network were rigged by "manufacturers of GPS receivers and government end users to produce bogus results." The company said that devices from GPS manufacturers, which have claimed LightSquared's network interferes with GPS communications, were "cherry picked" in secret and that independent authorities were not allowed to partake or oversee the tests or test results. *www.foxnews.com*

Defense and Transportation Dep Secs tell FCC to stop LightSquared

Ashton Carter, U.S. deputy secretary for defense, and John Porcari, deputy secretary for transportation, have written an official letter to the assistant secretary for commerce, stating that "there appear to be no practical solutions or mitigations that would permit the LightSquared broadband service."

FCC asks if GPS should be protected from Interference

The FCC has opened an Internet docket for public comment on the LightSquared position that GPS users and receivers "do not merit legal protection from interference" created by LightSquared. The FCC asks for comments by February 27.

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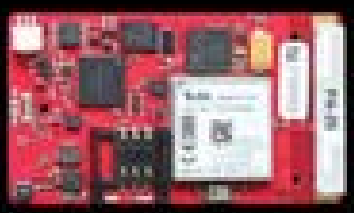

Hardware dimensions of the smallest version: 44 x 22 x 7mm
Extremely small and lightweight including housing, antennas and battery.

TraceME applications: Personal tracking with SOS. Object protection and tracking. Logistics. M2M. Security and Surveillance. Remote control and Diagnostics. ODB-II version available. Vehicle immobilisation. Rentals tracking. Alternative and cheaper solution for SCADA. Alzheimer-, eldery-, patients- and people tracking. Remote control of Vending- and other machines in the field. Animal tracking. Backup Power Generators. OEM version is possible.

more than is necessary for the application to function well. If the application writer could analyze the power profile, they would be motivated to write an algorithm that pings it half as often to save energy without compromising functionality," stated Kathryn McKinley, professor of computer science at The University of Texas at Austin, US.

According to the scientists, this study may point the way to how companies like Google, Apple, Intel and Microsoft can make software and hardware that will lower the energy costs of very small and very large devices. *www.timesofindia.com*

Commercial debut of Beidou leads to speculations in Taiwan

With the commercial debut of the China's Beidou satellite navigation system, Chinese military can turn its dumb bombs into smart bombs, Taiwanese media reported.

According to the report, one of the most lethal bombs is the Lei Shi-6 (LS-6) "Thunder Stone", a precision-guided glide bomb, first unveiled by the Luoyang Optoelectro Technology Development Center in late 2006. It is similar to the US-developed Joint Attack Direct Munition (JDAM), which relies on US satellites for guidance. However, the Taiwan Affairs Office last week denied the Beidou system would be used by the Chinese military and played down reports in Taiwan that the satellites posed a threat to the region. *www.taipeitimes.com*

GPS app makes jobs just a phone away!

LocationValue, a Japanese placement agency, is using cellphones' GPS feature to quickly match workers to temporary jobs. Job applicants need to send the company their resumes and make requests about the times of the day and workplaces where they want to work. The firm locates the applicants, using the GPS built into their cellphones and promptly contacts prospective employers. *www.timesofindia.com*

Taiwanese municipality gets cloud-based map

The GIS Research Centre at Feng Chia University in Taiwan developed Taiwan's first municipal works cloud-based map platform. It will allow city government officials and policy makers to have a clear picture of the city's major construction projects. The platform, which was commissioned by the Taichung City Government, will integrate the city's digital map libraries including urban planning and cadastral map libraries, and will allow users to browse records concerning the city's major construction projects and tenders. *www.futuregov.asia*

National Address Gazetteer Database to replace NLPG

The National Address Gazetteer Database will add a new element to the capabilities in combining the National Land and Property Gazetteer (NLPG) with Ordnance Survey's address layer, the national dataset with addresses and their precise locations. It is also expected to gradually replace the NLPG as a basis for local land and property gazetteers. It has been developed and managed by GeoPlace, a joint venture between the Local Government Association (LGA) and national mapping agency Ordnance Survey, GeoPlace went live in April 2011 and raised the possibility of authorities extracting even more value from their geographic information. *www.guardian.co.uk*

Malaria maps show global pattern of disease

In a study published in Malaria Journal, a multinational team of researchers from the Malaria Atlas Project (MAP), funded mainly by the Wellcome Trust, presented results of a two-year effort to assemble all available data worldwide on the risk of Plasmodium falciparum malaria, the most deadly form of the disease. Using computer modelling and data on climate and human populations, they revealed the complex landscape of malaria across the globe. The maps build on the first ever Atlas of Malaria-Eliminating Countries. The maps have been made freely available at *www.map.ox.ac.uk*

NSDI India likely to get Rs 750 crore under 12th plan

For strengthening the National Spatial Data Infrastructure (NSDI), an outlay of INR 750 crore has been planned during the 12th Five Year Plan (2012-17), according to Surveyor General of India, Swarna Subba Rao. He informed that the Department of Science and Technology (DST) has taken up several initiatives to build the capacities for spatial data creation. The country needs nearly five lakh people who need to be spatially literate in the next five years to make use of these data sets coming through networking infrastructure created. *www.thehindubusinessline.com*

WorldView data to be used to digitize land records in Haryana

The entire revenue record of Haryana state in India would be digitized and updated using 0.5 metre resolution WorldView satellite data for the seamless preparation of a database of land records. The updated maps would be geo-referenced using the benchmark Ground Control Points being identified and fixed in the state using DGPS. The geo-referenced data would be overlaid on the digitised cadastral maps used to correct inaccuracies in the data, which would also create the latest database about the land use, forestry, geomorphology, soil and land degradation. *www.hindustantimes.com*

GIS-based tool for industrial land info in Karnataka

Chief Minister of Karnataka state in India launched 'Kaigarika Bhoomi', a GIS-based web tool to manage industrial areas in the state. 'Kaigarika Bhoomi' (www.kiadb.in)enables people, especially investors, access information about existing industrial areas - like status of occupancy, availability of plots, etc. Besides, the extent of land available for investors can also be obtained through the system. *www.deccanherald.com*

FBI needs mapping app to monitor social networking sites

The Federal Bureau of Investigation (FBI) in the US raised eyebrows in the tech world with a public document that asks for advice on how to harvest information from social networking sites. According to the document, the bureau is looking for a mapping app – or a "geospatial alert and analysis mapping application" – that, among other things, helps it search "publicly available" sources like Facebook and Twitter for national security threats. *www.npr.org*

Oman to digitally map schools

Her Excellency Dr Madiha Bint Ahmed Al Shibaniyah, Minister of Education, Oman, announced digital school map project (also known as the Digital Atlas) recently. She stated that the project will use GIS technology and help experts analyse and process geographical data. *www.muscatdaily.com*

GIA publishes global outlook on the GIS Industry

According to Global Industry Analysts, Inc., market research report, global GIS market is estimated to reach USD 10.6 billion by 2015. With rebounding of global economy from the recession, developed countries in North America and Europe are expected to increase expenditures into GIS technology in near future. Additionally, growing awareness of the technology in developing countries in Asia, Middle East and Latin America adds impetus to market growth. *www.prweb.com*

Google accused of tampering OSM data

High-ranking members of the OpenStreetMap (OSM) project – an open source mapping project that competes with Google Maps – claimed that user accounts attached to a range of Google internet addresses in India have been maliciously tampering with its data. The accusation from OSM follows a widely reported incident in which users behind a Google IP address in India were caught scraping data from a Kenyan online business directory called Mocality. Recently, Google apologized for the incident. *www.wired.com*

Pakistan to tighten measures for mapping

The Ministry of Defence (MoD), Pakistan, suggested to the government to frame a law that could stop unlawful activities of mapping firms, given that several countries, including Australia, China, India, Turkey, USA and UK, have enacted supportive laws. The Survey of Pakistan (SoP) is responsible for meeting the surveying and mapping requirements of the armed forces as well as civil organisations/ departments. With the objective of regulating and implementing surveying and mapping standards in the country, to obviate potential security risk to sensitive information, to prevent damage to affixed survey makers, to avoid duplication of effort in mapping and to transform SoP into a national mapping agency, a draft land surveying and mapping bill has been prepared by the SoP. *www.brecorder.com*

Autodesk, Pitney Bowes sign strategic alliance agreement

Autodesk, Inc. entered into a strategic alliance agreement with Pitney Bowes Software, Inc. The new agreement will serve as a framework for both companies to provide resources, services and solutions to help infrastructure owners and architecture, engineering and construction (AEC) organisations make more informed decisions and drive greater efficiencies across the plan, design, build, manage lifecycle of infrastructure. *http://finance.yahoo.com*

GoI approves three national land record centres

The Government of India has approved creation of three National Land Records Modernization Programme (NLRMP) centres at Salboni in West Bengal, Union territory of Puducherry and at Berhampur. The government also sanctioned about Rs 196 lakh for each of the centres during the financial year 2011-12.

DENR Philippines set to conduct cadastral survey

The Department of Environment and Natural Resources (DENR), Philippines, in Region 7 is set to conduct a cadastral survey covering a total of 73,661 hectares at a cost estimated to reach PHP 163.09 million. The survey will be conducted in selected municipalities in Central Visayas. *www.mb.com.ph*

Vietnam to modernize land administration

The World Bank and the Embassy of New Zealand collaborated with Vietnam's Ministry of Natural Resources and Environment to develop a complete and modern land management system. The collaboration aims to increase access to land information services by all stakeholders. The Land Administration Project (LAP), which is estimated to cost at around USD 47.2 million, has three components and will be implemented in selected provinces in Vietnam. *www.futuregov.net*

ISAC to develop land administration model for tribes

A research team from Integrated Spatial Analytics Consultants (ISAC), an Indian multi disciplinary and multiline consultancy firm will develop a Land Administration Domain Model (LADM) for Forest Rights of Indigenous Tribes in Brazil. The team includes João Paulo Hespanha and Tarun Ghawana from the ISAC. In addition, Brazilian land administration specialist Dr. Silvane Paixão, joined the team. The LADM aims to integrate the core elements to define land administration issues with flexibility to include spatial and temporal dimensions specific to a particular case study. *www.gsdi.org*

US defense to buy less commercial satellite imagery

The US Defense Department intends to reduce planned purchases of commercial satellite imagery in 2013 as part of a broader initiative aimed at reducing US military expenditures by USD 259 billion over the next five years, according to the Pentagon planning document, Defense Budget Priorities and Choices. On the hand, the National Geospatial Intelligence Agency's (NGA) budget is classified, meaning it will not release details of its 2013 funding request for commercial imagery. *www.spacenews.com*

Scientists help farmers by tracking microclimate

Scientists in Israel developed a way of using satellite images to help farmers detect small-scale changes in climate and improve their harvests. Uri Dayan, a climatologist from Hebrew University; and Itamar Lensky, Head of the remote sensing laboratory at Bar Ilan University; explained that this new method uses real-time thermal images made available from NASA and then analyses the surface temperature of each plot at a fine scale. *www.dawn.com*

Ex-ISRO chief, three other scientists barred from government positions

In an unprecedented disciplinary action, four of the biggest names in the space community, including former chairman of the Indian Space Research Organisation (ISRO) have been barred from occupying any government position — current or in future — for their role in the Antrix-Devas deal, in which a private company was accused to have been wrongfully allotted S-band frequencies for radio waves. *www.indianexpress.com*

India soon to launch RISAT-1

Indigenously developed radar satellite RISAT-1, which can take images of the earth in all weather conditions, would be launched anytime after March 15, 2012. In addition, the first regional navigation satellite system is also scheduled for launch in 2012, according to Indian Space Research Organisation (ISRO) Chairman K Radhakrishnan. The 1850 kg RISAT-1, earlier slated for launch last year onboard PSLV-C19, would be a major milestone for the country and a boon for regions perennially under cloud cover. Besides use in the agriculture sector, the RISAT-1 satellite's all weather capability to take images of the earth could also be used to keep an eye on the country's borders round-the-clock and to help in anti-terrorist and anti-infiltration operations, he said. *www.dnaindia.com*

ESA may cancel Sentinel launch

Jean-Jacques Dordain Director-General of European Space Agency (ESA) threatened to cancel the planned 2013 launching of a series of earth observation satellites (Sentinel satellites) co-financed with the European Commission (EC) unless the commission commits to financing their operation beyond 2014. He further said the agency has retained legal ownership of the Sentinel 1A, Sentinel 2A and Sentinel 3A satellites until they are in their operating orbits. As the sole owner, he added, the ESA has no need to seek EC's approval to leave the spacecraft on the ground. *www.earsc.org*

Vietnam to launch first EO satellite

With Japanese aid, Vietnam will launch its first earth observation (EO) satellite in 2017 and second in 2020, according to Shohei Matsuura, senior advisor with the Japan International Cooperation Agency (JICA) in Hanoi, Vietnam. Japanese experts are helping Vietnam in a bid to help the South-East Asian country minimise adverse impact of climate change and natural disasters. *www.scidev.net*

China launches RS satellite

China launched Ziyuan III, a high-resolution remote-sensing satellite, for civilian use from its Taiyuan Satellite Launch Centre in Shanxi province. According to a statement from the centre, the satellite aims to aid the country's land-resources surveys, natural-disaster prevention, agriculture development, water-resources management and urban planning. *www.chinadaily.com*

Australia joins fight against space debris

Australia backed a proposal to minimise 'space debris' circling the planet. The plan has been put forward by the EU, and calls for an international code of conduct for outer space activities. The code will aim to prevent both accidental and deliberate damage to satellites and other space objects, which creates long-lived debris and poses risks for crucial space-based infrastructure. Current estimates suggest there are around 500,000 pieces of long-lived orbiting space debris large enough to seriously damage or destroy satellites or human space flights. *www.spacemart.com*

Canadian satellites face threats from space debris

A space operations centre in the United States alerted Canadian Space Agency about possible threat to three Canadian satellites: RADARSAT-1, RADARSAT-2 and SCISAT, from softball size space debris.

So far, there have been 13 alerts involving close approaches to RADARSAT-1 which required two manoeuvres. RADARSAT-2 faced 14 alerts, prompting three changes in orbit to avoid being hit by space junk. And SCISAT has had three warnings. *www.canadianbusiness.com*

US to endorse EU's space code of conduct

US Secretary of State Hillary Clinton announced that the US government will endorse the idea of a space conduct code, which has been proposed by the 27-nation European Union. The US will join Europe and other nations in developing an international code of conduct for space operations so long as the resulting text does not restrict "our national security-related activities in space." *www.spacenews.com*

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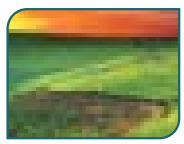
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Supervisor+GPS Tablet Computer by Carlson

The "SuperG," the Carlson Supervisor+ GPS Tablet, is here. It is Carlson's popular Supervisor tablet computer, a super rugged tablet PC that can be used anywhere, upgraded to include an integrated high-precision GNSS receiver and providing wireless support for Bluetooth, 802.11, GSM and CDMA. It is designed to work with more total stations, robots, GPS systems than any other solution. Both the Carlson Supervisor tablet and the new SuperG offer the industry's largest data collector screen – a full seven inches – that is sunlight viewable. They also supply the industry's fastest data collector processor with 64 Gb of memory and 2 Gb of RAM. This is all on a PC that weighs just 1.1kg.

Leica GeoMoS Web v2.1 enhances online visualisation of data

Leica Geosystems released an update of Leica GeoMoS Web, a web-based service for visualisation and analysis of monitoring data via the Internet. It provides advanced visualisation capabilities and can be accessed by using a web browser, PDA, or mobile phone.

UK Police Forces Embrace Leica ScanStation C10's

Leica Geosystems bagged the largest ever order of Leica ScanStation C10's as UK Police Forces embrace High Definition SurveyingTM (HDS). The scanners will be supplied as part of a £2.7 million investment from the Department of Transport. Delivery of the instruments, full onsite training and support will commence soon in readiness to help ease the potential traffic congestion caused by major collisions, especially in light of the forthcoming 2012 Olympics.

Spectracom Assures GPS Integrity with Leap Second Testing Tools

Spectracom is a provider of practical test solutions for GPS and GNSS devices and systems, has published its Application Note: Leap Second Testing Made Easy in response to the recent announcement of a pending leap second. The last leap second occurred at the end of 2008. This will be the first mid-year leap second in 16 years. Spectracom's GPS/GNSS constellation simulators offer the easiest way to test a leap second. Simply set the leap second parameter "on" through any of the user interfaces (front panel, web interface, scenario configuration software) and run a scenario through UTC midnight on June 30, 2012. The application note describes the test protocol. It also offers its customers a sample test scenario as download from its website. *www.spectracom.com*

Fastrax IT530: OEM GPS module

Fastrax Ltd., has introduced the Fastrax IT530, an ultra-low power consuming and super-sensitive OEM GPS module in a tiny form factor. Advanced power-saving features ensure very fast time to first fix (TTFF) without sacrificing

Trimble handhelds help Latvian Rural Support Service Manage EU Agricultural Program

The Latvian Rural Support Service (RSS) is responsible for implementing European Union (EU) policy in the sectors of agriculture, forestry, fisheries, and rural development across the Eastern European country that is home to more than 2.2 million people. One of the organization's primary tasks is to oversee the EU's Single Area Payment Scheme, a subsidy program designed to provide direct payments to farmers who cultivate crops and maintain farmland in an environmentally friendly way.

For the Latvian Rural Support Service, this means carefully and continually monitoring land parcels throughout the country, including identifying land borders and keeping track of precisely how much area is farmed on a parcel of land. To do so, inspectors rely on GNSS technology to make on-the-spot checks (OTS) for claimant farms.

"We have been using Trimble® GeoExplorer® handhelds since 2003, and it simplified our data collection and management work," said Edgar Bordāns from Rural Support Service. "This summer, we upgraded again, purchasing 35 of the new Trimble GeoExplorer 6000 series GeoXT™ handhelds, with a larger screen size, longer battery life, and built-in camera."

The Trimble GeoXT 6000 series is a rugged GNSS handheld receiver with Trimble Floodlight™ technology for satellite shadow reduction that dramatically improves position availability and accuracy in difficult GNSS environments, which is particularly important for Latvian RSS inspectors.

Each field inspector has a Trimble GeoXT 6000 series handheld, loaded with Esri® Shapefiles, reference parcel data from the Land Parcel Identification System (LPIS), and land property boundary data (cadastre). Once they reach the farm in question, the field inspectors record the GNSS position, area, perimeter, shape, and size of the different agricultural crops. As they move through the forms loaded on the handheld, they record attributes such as parcel number, crop type, and remarks as necessary.

battery life. The sensitivity of -148 dBm in acquisition, -165 dBm in navigation and power consumption of just 35 mW at 3.3 V are ideally suited to battery-operated devices. *www.fastraxgps.com*

French provinces select Fugro

Fugro bagged a contract to conduct an airborne LiDAR bathymetry (ALB) survey of the Finistère and the Provence-Alpes-Côte d'Azur (PACA) regions of France. The surveys will be conducted with the Fugro LADS Mk 3 ALB system. The project is being conducted as part of the Litto3D programme. *www.fugro-uae.com*

AllTrails partners with NatGeo Maps

National Geographic (NatGeo) Maps partnered with AllTrails, an online network for outdoor enthusiasts, to launch a co-branded service at alltrails.com. The site aims to be a comprehensive destination for people planning hikes or other backcountry outings. Its 200,000 users can browse nearby or search for trails, post reviews and photos and share trails with friends. *www.readwriteweb.com*

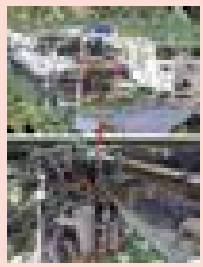
USAF awards USD 21.5 mn contract to Lockheed Martin

The US Air Force awarded USD 21.5 million contract to Lockheed Martin to provide a Launch and Checkout Capability (LCC) to command and control all GPS III satellites from launch through early on-orbit testing. The LCC, which will be integrated into the Raytheon-developed Next Generation Operational Control System (OCX), will ensure launch availability for the first GPS III satellite in 2014. *www.lockheedmartin.com*

USAF awards USD 179.5 mn contract to Raytheon

Raytheon has bagged USD 179.5 million follow-on contract by the US Air Force to provide Contractor Field Service (CFS) support for U-2 sensors, data links and the Air Force Distributed Common Ground System (DCGS). It will provide support at the Air National Guard and Predator Operations Center, Air Force Flight Test Facility, Consolidated Remote Operations-Facility Airborne and DGS-X Test-bed Facility. The U-2 CFS contract also calls for Raytheon engineers and technicians to perform other services, such as training. *www.raytheon.com*

High-fidelity digital archives created for Wenchuan Earthquake Memorial



While this is but one of the many physical reminders of the adversity the Chinese people have endured after the Great Sichuan Earthquake took the globe by surprise when it happened in the early afternoon on May 12, 2008, what sets the Wenchuan Earthquake Memorial Park apart from the rest is its high-technology focus. Right from the beginning, the project initiators, Beijing Institute of Surveying & Mapping, had planned to acquire and use three-dimensional (3D) images for various parts of the memorial. The project is also particularly significant because it is the largest life-sized 3D virtual reality scan of any subject matter, both domestically and globally.

The team behind the memorial designed a comprehensive study using a multi-pronged approach, involving high-technology equipment in many areas. Mr Yin Wenguang, Project Leader from Beijing Hao Yu World Mapping Technology Development Co., Ltd. shared, "We used an unmanned aerial vehicle to collect data from a bird's eye view. And on the ground, we employed laser scanning technology, precision control measurement technology, and close range photography to gather a wide variety of images for full digital reconstruction of the site.

When portable 3D measurement company FARO first heard about the project scope, it was immediately keen to support.

After a live demonstration of the product, the company was enlisted to be part of the nearly year-long project. "We were thoroughly convinced that FARO's Laser Scanner was what we needed to complete the ground scans," said Yin.

After seven months of data collection and processing, the team reconstructed a comprehensive digital archive of the core zone that totaled an impressive area of approximately 0.3km2. This included both the Wenchuan Earthquake Memorial Park, as well as the Earthquake Relief Memorial Square. Using multi-source data processing, the team managed to corroborate the various sets of images to produce point cloud models and 3D coloured models that have had coordinates registered and transformed.

3D Laser Mapping bags GBP 2.7 mn contract from UK's DOT

3D Laser Mapping, UK has been awarded of GBP 2.7 million (USD 4.2 million) by the Department of Transport. It will enable 27 police forces across the UK to purchase 3D laser scanners - used to collect highly detailed, 3D images of crash sites up to 50 percent faster than traditional survey techniques. *www.3dlasermapping.com*

Nis Glonass signs agreement with Landsmiths Pojects Pvt. Ltd.

NIS GLONASS Pvt. Ltd. has signed an agreement in December 2011 appointing Landsmiths Projects Pvt. Ltd. as its exclusive marketing agent for the territories of Punjab, Haryana, Himachal Pradesh and J&K.Landsmiths Projects Pvt. Ltd.

based in Chandigarh is promoted by Mr Ajaypal Singh Randhawa. *www.sbwire.com*

3D Modelling using Georeferenced Photography

The software suite tridicon® 3D LANDMARK provides the necessary tools for modelling buildings from digital photography. One component of the package is a calibrated camera with geotagger for taking high-resolution close-range photographs of the buildings. The automatic georeferencing of the 3D models as well as export options into all common data formats make sure that the landmarks can be integrated into any existing 3D city model without problems. *www.tridicon.de*

Esri to strengthen Panama National geospatial capabilities

The government of Panama signed a MoU with Esri to leverage geospatial technology in support of national development. The agreement affirms Panama's recognition of the value of GIS in improving decision making and infrastructure management throughout the country.

Study shows alternatives for commercial sat imagery market

Innovative Analytics and Training, LLC released an independent study on alternative futures for US commercial satellite imagery in 2020.The study posited three alternative remote sensing futures in the 2020 time frame:

- US Commercial Satellite Imagery is A Thriving Business;
- A Slow Growth Business, Still a US Government Appendage;
- Failure as US Government Funds Erode and Competition Grows.

www.innovative-analytics.com

RIEGL bags "Inventum 2011" Award

The Austrian Department for Traffic, Innovation and Technology, the Austrian Patent Office, and the publishing company Bohmann honored the 10 best Austrian patents in the context of a ceremonial act in Vienna. "Inventum 2011", the award for the "Patent of the Year" went to RIEGL.

MARK YOUR CALENDAR

March 2012

Munich Satellite Navigation Summit 2012
13-15 March
Munich, Germany
www.munich-satellite-navigation-summit.org

ASPRS Annual Conference
19-23 March
Sacramento, California, USA
www.asprs.org

3rd HUNAGI conference and Exhibition
21-22 March
Budapest, Hungary
http://mycoordinates.org/3rd-hunagi-conference-and-exhibition-2/

April 2012

6th International Satellite Navigation Forum
17-18 April, 2012
Moscow, Russia
http://mycoordinates.org/the-6th-international-satellite-navigation-forum/

Interexpo Geo-Siberia
17-19 April, 2012
Novosibirsk, Russia
http://itcsib.ru/event/4-INTEREKSPO_GEO-SIBIR

Europeon Navigation Conference 2012
23-25 April
Gdansk, Poland
www.enc2012.org

2012 European Frequency and Time Forum
23-26 April
Gothenburg, Sweden
www.eftf2012.org

Geo Siberia
25-27 April
Novosibirsk, Russia
www.biztradeshows.com

The Seventh National GIS Symposium in Saudi Arabia
29 April – 1 May
Eastern Province – Dammam,
Saudi Arabia
www.saudigis.org

May 2012

FIG Working Week 2012
6-10 May
Rome, Italy
www.fig.net

2nd International conference and exhibition on mapping and spatial information (ICMSI2012)
8-10 May
Tehran, Iran
http://conf.ncc.org.ir

Global Geospatial Joint Conference 2012
14-17 May
Quebee City, Canada
www.gsdi.org/gsdiconf/gsdi13

Geospatial Intelligence Middle East
15 - 18, May
Abu Dhabi, United Arab Emirates
www.geospatialdefence.com

6th GNSS Vulnerabilities and Solutions Conference
21-24 May
Baska, Croatia
www.rin.org.uk

MundoGEO#Connect 2012
29-31 May Sao Paulo, Brazil
http://mundogeoconnect.com/2012/en/

The 3rd China Satellite Navigation Conference
May 2012
Goangzhou, China
www.beidou.org

June 2012

Hexagon
4-7 June
Las Vegas, USA
www.hexagonconference.com

The International Summer School on Mobile Mapping Technology 2012
11 – 15 June
Tainan, Taiwan
http://conf.ncku.edu.tw/mmt2013/intro01.htm

20th International Conference on GeoInformatics
15-17 June
Hong Kong
http://old.nabble.com

July 2012

ESRI International User Conference 2012
23-27 July
San Diego, USA
www.esri.com

August 2012

The XXII Congress of the ISPRS
25 August-1 September
Melbourne, Australia
www.isprs.org

September 2012

ION GNSS 2012
September 17-21, 2012 (Tutorials & CGSIC: September 17-18)
Nashville Convention Centre, Nashville, Tennessee, USA
www.ion.org

October 2012

INTERGEO 2012
9-11 October
Hanover, Germany
www.intergeo.de/en

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