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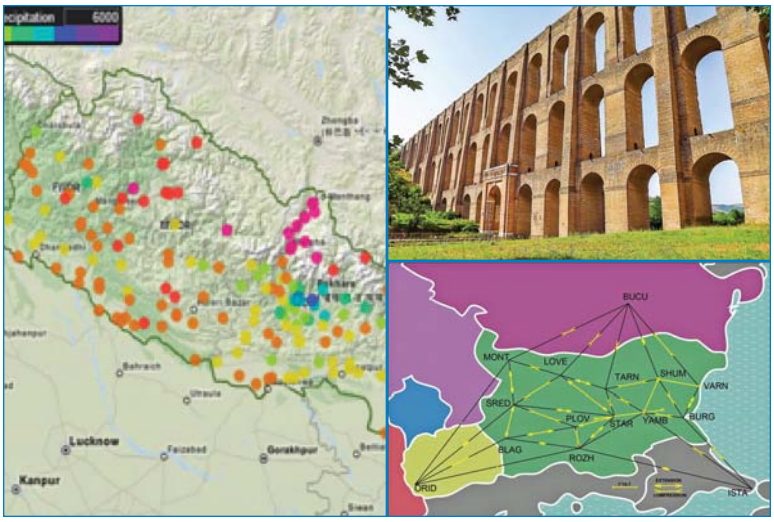

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Articles

Columns

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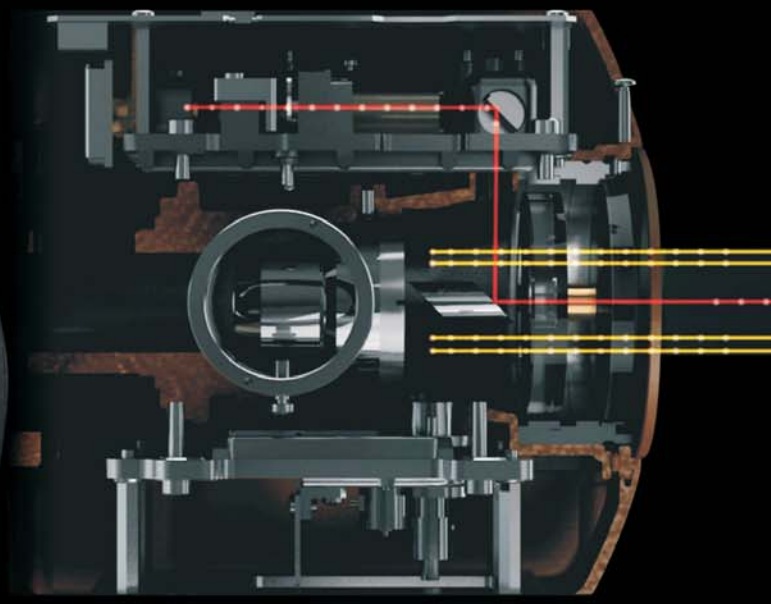
Changed! Upgraded!



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In search of fresh air

As the world's diplomats

Grapple in Paris to clinch the climate deal

At United Nations Conference on Climate Change,

Delhi and Beijing

Scramble for strategies

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Of unprecedented levels.

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To restricting vehicular traffic flow,

Health appears to be an immediate casualty

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To our readers, authors and advertisers.

Bal Krishna, Editor
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Non-invasive modelling of a monumental masonry aqueduct

This paper illustrates the combination of non-invasive surveying methodologies for the modeling of an old masonry aqueduct bridge, the "Ponti della Valle", as a support to its structural analysis

This paper illustrates the combination of non-invasive surveying methodologies for the modeling of an old masonry aqueduct bridge, the "Ponti della Valle", as a support to its structural analysis. The photogrammetric technique of Structure for Motion is used to process photograms taken from specified positions; the created dense point cloud is then edited in order to meet the geometry visualization's needs prescribed by the engineering team of the monument. Finally, some simple visualization and interrogation techniques are used to evidence planarity, verticality, co-planarity, shape and dimensions of the structure's south façade.

Studying the past for a better future

Cultural heritage is present everywhere. Its structural control, documentation and conservation is one of human's main duties (UNESCO 2013). In this contest, researchers continually are working to identify methodologies that guarantee accurate information regarding shape, state and dimensions, noninvasive, fast as possible and secure for the surveying operators. These techniques often integrate even multidisciplinary sciences like geomatics, information technology statistics and machine learning in order to entail results needed in good time manner.

Within the methodology presented in this paper and according to the criteria and rules of the structural analysis, it is possible achieve a significate support in order to properly conserve structural heritage, and to estimate situations, sometimes critical, as well as eventual planning and maintenance efforts and costs, control and restoration.

The case study

Vanvitelli's masonry aqueduct is located in the central Italy, near Caserta city, it has been constructed during in the second mid of the 17th century by Luigi Vanvitelli under the orders of King Charles III of Spain (figures 1a and 1b). It is considered a structure of considerable architectonical merit both because it belongs to the monumental complex of the Caserta's royal palace and due to its massive and technologically advanced for the time characteristics. The bridge is at the moment perfectly conserved, has a length of 529 meters, made of three rows of arches that reach a height of 55 meters at its highest part. The structure was nominated "World Heritage Site" by UNESCO in 1997.

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Figure 1a: Actual state of the Vanvitelli's masonry aqueduct

Figure 1b: Artistic representation of the bridge

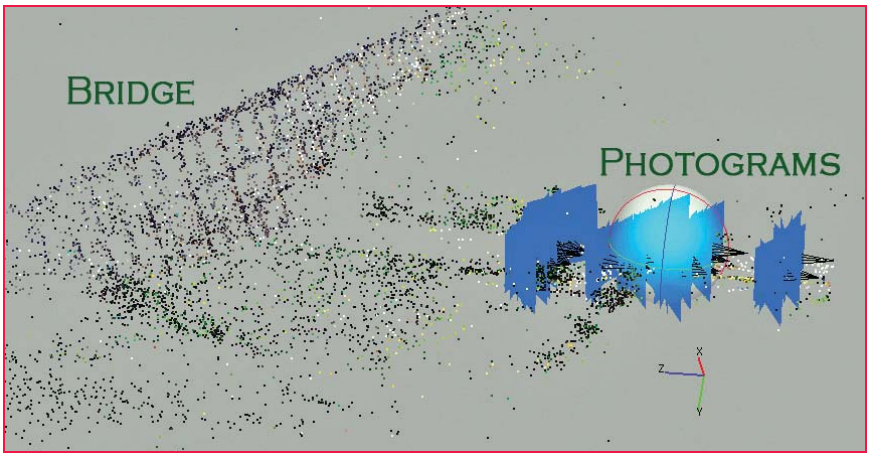

Figure 2: The three order of acquisition

The choice of the best surveying approach

For this case study some serious constraints connected with the accessibility of the site and impossibility to install invasive surveying pillars did not permit the use of traditional surveying routines like total stations. Laser scanning was rejected during the evaluation of the various techniques mainly because in short distances there was a very steep, almost vertical visually while good visual was too far for laser scanning and among too many obstacles. Terrestrial photogrammetry in this context has been considered the best approach, absolutely noninvasive for the structure, secure as did not consider interaction between the structure and any operator, accurate enough as only qualitative considerations were needed and fast enough to respond the monument's management needs (Guidi et al 2004). This choice was further supported by recent bibliography proving the far by now consolidated combination between photogrammetry and Cultural Heritage (Bay et al 2008,). Then, both commercial and open source software that proved a significant success in the field of three-dimensional surveying was evaluated in order to define the solution that best meets this case's needs (Westoby MJ 2012, Barazzetti et al 2011, Lisein et al 2013). Within this evaluation Agisoft Photoscan, representing the Structure for Motion algorithms, has been chosen for its analytical robustness, its relatively easy application, the reasonable elaboration times and the most important, the quality of the results demonstrated in various pushed works.

SFM data surveying and processing

One of the most important phases in this work has been the accurate preparation of the photogrammetric surveying. During this activity, the relation between best distance from the object, focal length, ground sampling distance (GSD) and sensor's resolution permitted identify the best positions needed to achieve an

Figure 3: The final textured result

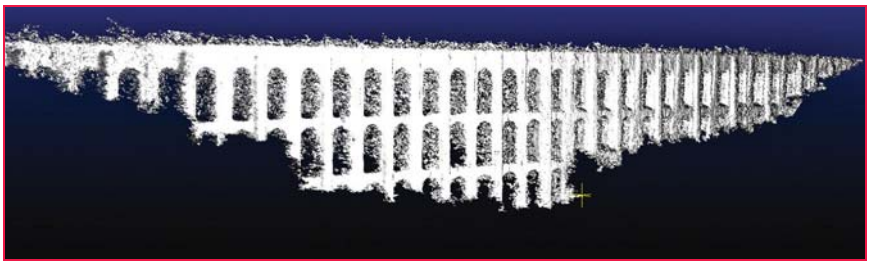

Figure 4: The final point cloud

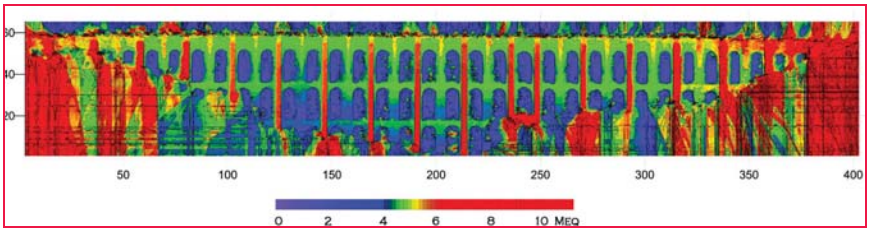

Figure 5: Co-planarity and geometric regularity representation

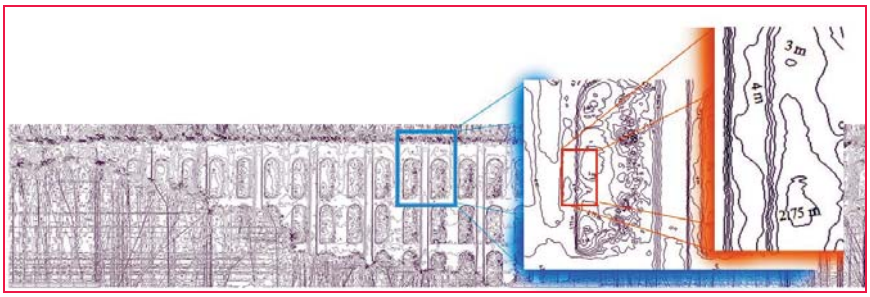

Figure 6: Co-planarity and geometric regularity evaluation by level curves (isolines)

adequate around a centimeter a priori precision. With this information three parallel acquisitions have been made all of them using vertical overlapping of at least 60% (figure 2) (Kraus, K., 2007).

Immediately after the image acquisition a visual inspection of al images was needed in order to decide which of them were able to satisfy the quality criteria and undergo the data processing. Finally, 39 photos where elaborated for the south facade undergoing the well-known routine of photo alignment, sparse cloud generation, dense cloud generation and texturing. Even if in this case only the dense point cloud was needed the final textured result is shown in figure 3. Around 25 ground control points have been surveyed in NRTK mode have been surveyed mainly in visible parts to the top of the bridge in order to add robustness and prevent deformative behavior of the whole model.

The final point cloud has been exported having 5 million points (figure 4). The point cloud has then imported for ulterior editing in Cloud Compare open source software. Using a volume point density, the point cloud has been decimated without lowing the information level to one million of points having an average distance of 1 cm, more than enough for the scope of this project. The registered and georeferenced global point cloud, has then been roto-translated in order to orientate one of its axis parallel the bridges façade. Thus, the obtained modified coordinates have been introduced in a surface plotting software in order to represent its shape and morphology using color scales that led to an easy interpretation by the structural department.

The final product of this analysis is presented in figure 5. In this elaborate, color scale has been used in order represent the level of each area evidencing co-planarity, verticality and the geometry's overall regularity; thus, red colors represent zone more exposed with respect to blue areas that show the reference plane positioned to the bridge's axis of symmetry. In the same way, a contouring algorithm that permitted a numerical lever curves has been used in order to permit local comparison of the various parts, this elaborate is shown in figure 6.

An additional quite useful data needed for the structural analysis regards the estimation of the vertical sections of the façade (figure 8). For this elaborate, the dance, decimated point cloud has been interrogated, sectioning it with a reference plane characterized by a 20 cm width, positioned vertically and in a normal direction with respect to the façade. All points belonging to the overlapping space between the reference plane and the façade's point cloud (vertical sections or sub clouds) have been elaborated in in order to plot them in three dimension and to calculate trend lines. In this way 28 sections have been obtained and plotted as shown in figure 7 where the displacement are in "meters equivalent". This methodological approach must be considered as a valid tool for the structural department experts and consultants, whose experience is irreplaceable.

Conclusion and result's discussion

The described methodology represents a synthesis of a simple but quite efficient

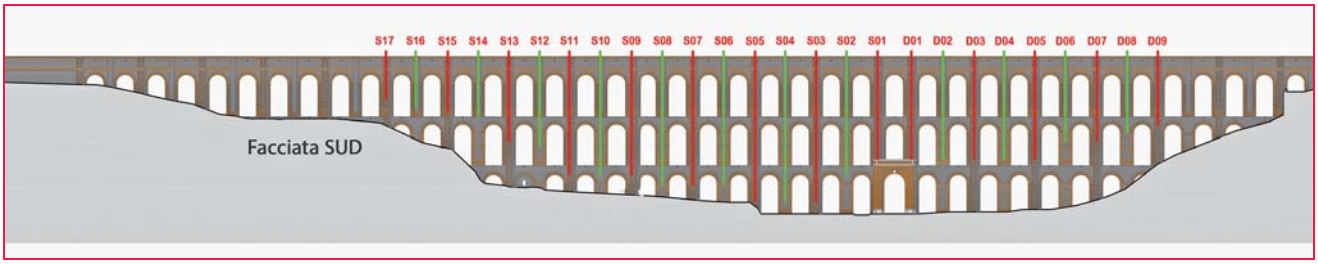

Figure 7: The 28 vertical sections of the structure

synergy between more processing algorithms with photogrammetry. It also evidences how new technologies can represent a valid support to the structural analysis of masonry monumental facades, using a risk-free surveying strategy, absolutely noninvasive for the monument, of relatively fast application and economically convenient. Great part of the elaboration procedure has been done using open-source software while the photogrammetric survey has been executed using a commercial reflex camera. Among the proven advantages of the chosen methodology, the adequate resolution, precision and operational simplify have to be mentioned confirming it as a quite efficient way to obtain three-dimensional modelling and analysis of monumental facades.

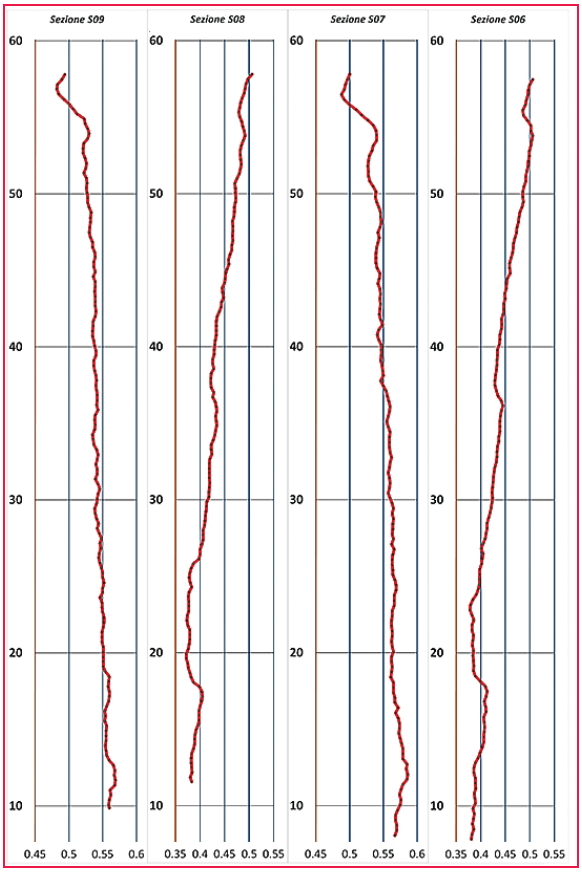

Figure 8: Example of four vertical section of the structure: S06, S07, S08, S09.

Future evolutions

The methodology can be further improved with the integration of machine learning algorithms in order to enhance efficiency and accuracy to obtain ulterior results in, at least, two applications. The first one regards the detection, classification and codification of the structural behavior of a site using a not supervised neural network. The second one is the implementation of genetic algorithms in order to significantly improve mathematical procedures like the point cloud filtering, editing and interpolation, and thus, to achieve higher quality in all results.

Bibliography

Barazzetti, L., Forlani, G., Remondino, F., Roncella, R., Scaioni, M., 2011. "Experiences and achievements in automated image sequence orientation for close-range photogrammetric projects." *Proc. of Videometrics, Range Imaging and Applications XI, SPIE Optical Metrology*, Vol. 80850F-1-13. DOI: 10.1117/12.890116

Westoby MJ, Brasington J, Glasser NF et al. (2012) . 'Structure-from-Motion' photogrammetry: A low-cost, effective tool for geoscience applications. *Geomorphology* vol. 179, 300-314. DOI: 10.1016/j.geomorph.2012.08.021

Lisein F., Pierrot-Deseilligny M, Bonnet S., Lejeune P., 2013, "A Photogrammetric Workflow for the Creation of a Forest Canopy Height Model from Small Unmanned Aerial System Imagery" 4, 922-944; doi:10.3390/f4040922, ISSN 1999-4907.

Kraus, K., 2007. Photogrammetry: Geometry from Image and Laser Scans. Walter de Gruyter, 459 pp. ISBN: 978-3-11-019007-6

Operational Guidelines for the Implementation of the World Heritage Convention, 2013. United Nations Educational, Scientific and Cultural Organisation. WHC. 13/01,July 2013. URL: http://www.unesco.beniculturali.it/index.php?it/7/linee-guida

Agisoft Photocan user manual: Profesional edition, version 0.9.0 Di Loreto M., 2006.

Bay H., Ess A., Tuytelaars T., Van Gool L., 2008. "SURF: Speeded Up Robust Features", *Computer Vision and Image Understanding (CVIU),* Vol. 110, No. 3, pp. 346–359, 2008. DOI: 10.1016/j.cviu.2007.09.014

Guidi. G.; Beraldin, J.A.; Atzeni, C. High accuracy 3D modelling of cultural heritage: The digitizing of Donatello. IEEE Trans. Image Process. 2004, 13, 370-380

Deformation analysis of the Territory of Bulgaria from GNSS observations

The present study is an attempt to contribute to the geokinematics of the territory of Bulgaria by means of Finite Elements Method (FEM) on the base of estimated GNSS station coordinates in different observational epochs

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The territory of Bulgaria is one within the Balkan Peninsula region with active tectonics and seismotectonics. A number of geodynamical investigations try to give an adequate interpretation of the obtained results (Burchfiel et al., 2006), (Kotzev et al., 2006), (Matev, 2011), (Milev, Dabovski, 2006), etc.

Global Navigation Satellite Systems (GNSS) have been recently used for geodetic observations and determination of the earth crust movements in millimetre level. Velocity vectors of located GNSS stations can be estimated and their behaviour can be analyzed. Except station behaviour also surface deformations are of interest for the earth movements of blocks or large areas.

The present study is an attempt to contribute to the geokinematics of the territory of Bulgaria by means of Finite Elements Method (FEM) on the base of estimated GNSS station coordinates in different observational epochs.

Finite elements method for space

At present the finite elements method is used successfully in the analysis of movements of stations, which are results from GNSS data processing in order to be obtained strain tensors and strain accumulation (Bogusz et al., 2013), (Deniz, Ozener, 2010), (Hu et al., 2004), (Valev, Kastreva, 2006), (Valev, Vassileva, 2000). Here this method is developed and applied for deformation analysis in the space - determination of principal deformations and their directions as an appropriate method for large territories. The finite elements (triangles) for different observational epochs are formed in such a way that they are not overlapped.

First the ellipsoidal station coordinates φ, λ and h of point P in space are transformed into Cartesian coordinates $P_0(X_0, Y_0, Z_0)$ of the projected onto the ellipsoid point P_0 (Valev, 1987) by the well known formulas.

Let X_0, Y_0 and Z_0 are the Cartesian coordinates of point P_0, which point is the piercing of the normal line through point P with the ellipsoid. Point P_0 must satisfy both the equation of meridian ellipse and the equation of the normal line through the point $P(X, Y, Z)$ to this ellipse, namely

$$r_0^2 + Z_0^2(1+e'^2) = a^2 \quad (1)$$

$$\frac{Z - Z_0}{r - r_0} = \frac{Z_0(1+e'^2)}{r_0} \quad (2)$$

where r_0 is the radius of the parallel, which passes through point P_0, r' is the distance from point P to the Z axis and they are calculated as follows

$$r_0 = \sqrt{X_0^2 + Y_0^2}, \quad r' = \sqrt{X^2 + Y^2} \quad (3)$$

After elimination of Z_0 from

equations (1) and (2) an equation of 4th degree is obtained:

$$r_0^4 + Ar_0^3 + Br_0^2 + Cr_0 + D = 0, \quad (4)$$

where

$$A = -\frac{2r'}{e^2}, B = \frac{r'^2}{e^4} + \frac{z^2}{e^2 e'^2} - a^2, C = -Aa^2, D = \frac{AC}{4}, \quad (5)$$

and e, e' are the first and second eccentricity of the meridian ellipse.

The Ferrari method is the most convenient for the solution of equation (4) as it is a method for reducing the solution of an equation of degree 4 to the solution of one cubic and two quadratic equations. After solution of these equations the root r_o is obtained and finally the Cartesian station coordinates (X_0, Y_0, Z_0) of point P_0 are calculated by

$$X_0 = X\frac{r_0}{r}, Y_0 = Y\frac{r_0}{r}, Z_0 = Z\frac{r_0}{r}, \quad (6)$$

where

$$r = \sqrt{X^2 + Y^2 + Z^2}$$

The azimuths $\alpha_{i,k}$ of the ellipsoidal triangle chords (baselines) between triangle apexes i and k of the finite elements are obtained from the following relationship:

$$tg\alpha_{i,k} = \frac{(\vec{b}.\vec{r})}{(\vec{t}.\vec{r})} \quad (7)$$

where

$b(-\sin\lambda, \cos\lambda, 0)$ and $t(-\sin\varphi.\cos\lambda, -\sin\varphi.\sin\lambda, \cos\varphi)$ are vectors $\vec{b}$ and $\vec{t}$ of the natural trihedron on the ellipsoid and $r_{i,k}(Xk - Xi, Yk - Yi, Zk - Zi)$ is the radius–vector $r_{i,k}$.

The lengths of the ellipsoidal chords $S_{i,k}$ between triangle apexes i and k are determined by the known relationships for the space, i.e.

$$S_{i,k} = \sqrt{(X^o_k - X^o_i)^2 + (Y^o_k - Y^o_i)^2 + (Z^o_k - Z^o_i)^2} \quad (8)$$

Linear deformations $m_{i,j}$, $m_{j,k}$, $m_{k,i}$ (i, j, k – triangle apexes) of respective triangle sides S, S' between two observation epochs t and t' are calculated as follows:

$$m_{i,j} = \frac{S'_{i,j}}{S_{i,j}}, m_{j,k} = \frac{S'_{j,k}}{S_{j,k}}, m_{k,i} = \frac{S'_{k,i}}{S_{k,i}} \quad (9)$$

Following relations are used for obtaining the principal deformations

$$m^2_{i,j} = a^2.\cos^2\gamma_{i,j} - b^2.\sin^2\gamma_{i,j},$$
$$m^2_{j,k} = a^2.\cos^2\gamma_{j,k} - b^2.\sin^2\gamma_{j,k}, \quad (10)$$
$$m^2_{k,i} = a^2.\cos^2\gamma_{k,i} - b^2.\sin^2\gamma_{k,i},$$

where a, b are the maximal and minimal deformations, γ – the angle between direction α_a of the maximal deformation and direction α of the respective triangle side, i.e. $\gamma = \alpha - \alpha_a$.

Finally, the linear deformations m of the triangle sides are obtained from the following equations

$$m_{i,j} - 1 = \frac{S'_{i,j} - S_{i,j}}{S_{i,j}}, m_{j,k} - 1 = \frac{S'_{j,k} - S_{j,k}}{S_{j,k}}, m_{k,i} - 1 = \frac{S'_{k,i} - S_{k,i}}{S_{k,i}} \quad (11)$$

Semi-axes of the ellipses of deformations a, b (Valev, 1995), (Kastreva, 2000) are obtained by use of linear deformations m of either triangle side, i.e.

$$(b^2 - a^2) = (m^2_{j,k} - m^2_{i,j}) / (\sin^2\gamma_{j,k} - \sin^2\gamma_{i,j}), \quad (12)$$

$$a = \sqrt{m^2_{i,j} - (b^2 - a^2).\sin^2\gamma_{i,j}} \quad (13)$$

$$b = \sqrt{a^2 + (b^2 - a^2)} \quad (14)$$

Finally the principal deformations a' and b' (major and minor) and their directions are determined from

$$a' = 1 - b$$
$$b' = 1 - a \quad (15)$$
$$\alpha_b = \alpha_a + 90^\circ$$

GPS data processing of BULiPOS reference network

As an appropriate method for deformation analysis based on GNSS data for large territories the proposed finite elements model is applied for the territory of Bulgaria using estimated Cartesian coordinates of BULiPOS GNSS network stations (Milev et al., 2014). Stations of the BULiPOS GNSS network are shown in figure 1.

One week GPS data from each of the five years 2009 - 2013 of BULiPOS network stations have been processed with Bernese software, version 5.0. Ten IGS stations have been involved in the processing. The estimated Cartesian coordinates of the stations have been transformed in ETRF2000 by applying ETRF components of the Eurasia plate rotation pole. These relative to the Eurasia stable plate station coordinates have been used in the finite elements model.

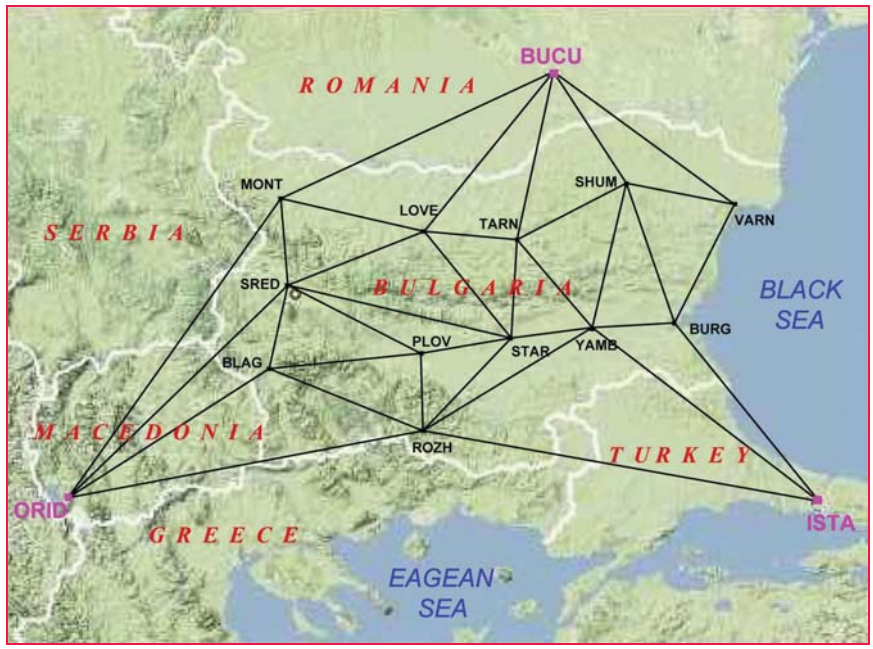

Figure 1: Configured finite elements

Application of FEM for the BULiPOS reference network

The finite elements have been configured using all BULiPOS stations on the territory of Bulgaria and the nearest three IGS stations – BUCU, ISTA, ORID from all together 10 IGS stations, as it is shown in figure 1.

All together 21 finite elements (triangles) have been formed. The ETRF2000 coordinates *X, Y, Z* of all stations in each year have been transformed into ellipsoidal station coordinates φ, λ, h and then they have been transformed into Cartesian station coordinates (X_0, Y_0, Z_0) onto the ellipsoid used. The (X_0, Y_0, Z_0) station coordinates have been used for determination of the ellipsoidal chords (baselines) between stations on the ellipsoid by formula (7), which are actually triangle sides of every finite element in each year. According to the formula (11) linear deformations of all triangle sides have been determined using obtained lengths of triangle sides from all five years in all combinations between five year's results. Deformations of compression and extension of triangle sides obtained by formula (11) are shown in yellow colour in figure 2 for the longest time period of four years 2009-2013.

The smallest relative movements are obtained between station BUCU-TARN, TARN-STAR, ORID-ROZH, ORID-MONT and ROZH-YAMB, which are between $0{,}005 \div 0{,}015.10^{-7}$ and that corresponds to the extension of 0,1÷0,2mm for all the mention sides except BUCU-TARN, which is compressed. Considering the obtained results for the west part of Bulgaria where they show an extension in direction north-south it can be concluded that there is a good agreement with the directions of estimated GPS velocities of movement from other studies (Burchfiel et al., 2006; Georgiev et al., 2011; Kotzev et al., 2008; Matev, 2011; Zagorchev, 2011) and the results confirm the belonging of south-west Bulgaria to the Aegean extensional zone. The largest relative movements are obtained between stations STAR and LOVE – extension of amount of $1{,}031.10^{-7}$ and between stations

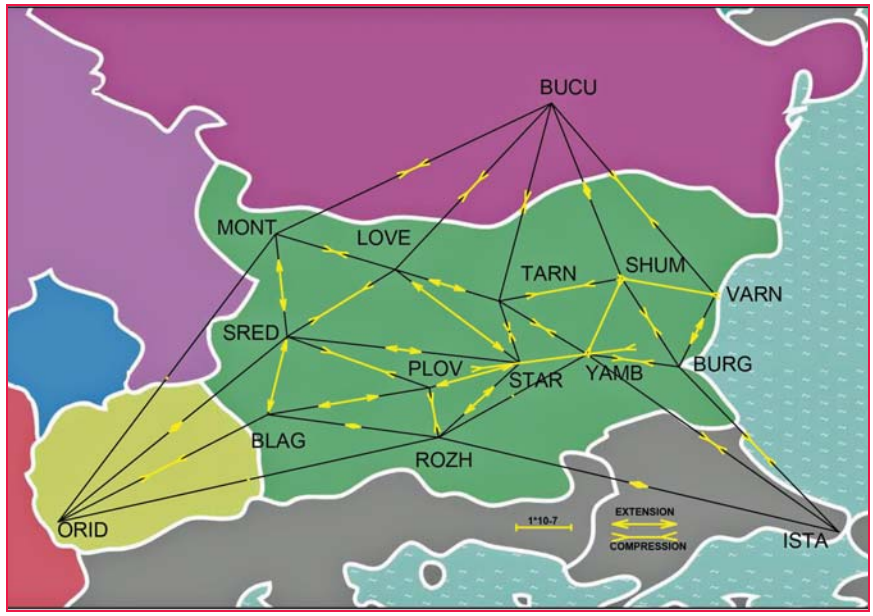

Figure 2: Deformations of compression and extension of finite element sides for time span 2009–2013

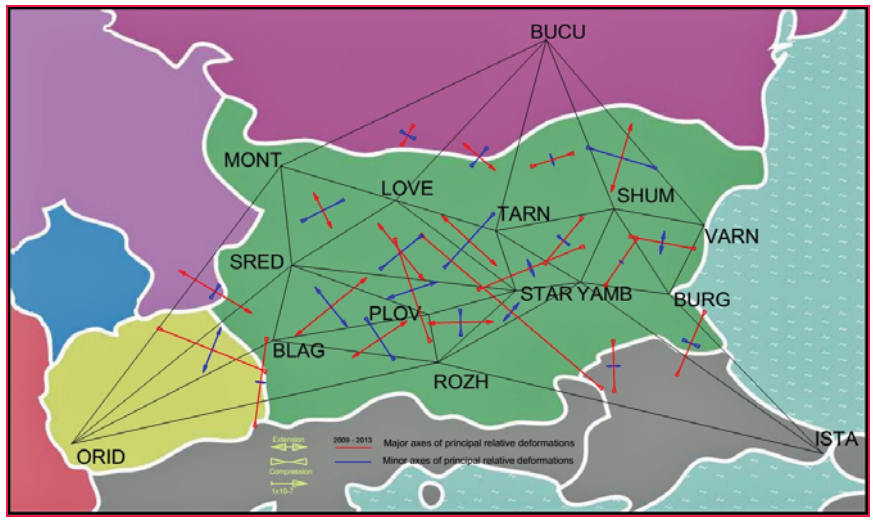

Figure 3: Principal deformations for the longest time span 2009–2013

STAR and YAMB – compression of amount of $1{,}316.10^{-7}$. In fact these are 9,6mm, respectively - 11,3 mm linear deformations. For most of the finite element's sides there is no disagreement of the obtained deformations in all time spans studied except a few of them.

Magnitudes and directions of the principal deformations of each finite element are obtained by formula (15). They are calculated for time spans 2009-2013, 2010-2013 and 2011-2013. The magnitudes and directions of the principal deformations for the longest time span 2009-2013 are shown in figure 3.

The obtained results for the three time spans agree very well except for the finite elements including stations with very small movements (Love, Burg) and with the problematic station Varn. Deformations in north-west and in part of central Bulgaria show extension in north-south direction and compression in south-west to the north-east direction. Central-east and south-east part of the country are under compression with different directions of particular areas. The largest deformations of compression appear in central Bulgaria, close to station Star in direction north-west to south-east.

Conclusion

The finite elements model in space is applied for deformation analysis of whole territory of Bulgaria for the first time. On the base of the obtained linear deformations of finite element sides (Figure 2), their analysis and comparison it could be generalized and suggested that in northern Bulgaria (Moesia platform) there is compression, in west Bulgaria – extension with direction north-south, in central Bulgaria (Maritsa basin) – extension and in east-south Bulgaria – compression. On the base of the obtained principal deformations (Figure 3) several areas of compressions and extensions could be distinguished but not quite clear. Generally it can be suggested that deformations in part of central, central-east and south-east Bulgaria are of compression, in north-west, south-west and in part of central Bulgaria – of extension, which agree with the linear deformations. More stations over the territory of the country will contribute to better clarification of deformation processes.

Generally it can be suggested that deformations in part of central, central-east and south-east Bulgaria are of compression, in north-west, south-west and in part of central Bulgaria – of extension, which agree with the linear deformations

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References

Bogusz, J., A. Klos, M. Figurski, M. Jarosinski, B. Kontny, 2013. Investigation of the reliability of local strain analysis by means of the triangle modelling. Acta Geodyn. Geomater., Vol. 10, No. 3 (171), 293–305, 2013 DOI: 10.13168/AGG.2013.0029

Burchfiel, B. C., R. W. King, A., Todosov, V., Kotzev, N., Durmurdzanov, T., Serafimovski, B., Nurce, 2006. GPS results for Macedonia and its importance for the tectonics of the Southern Balkan extensional regime, Tectonophysics, 413, 239–248.

Deniz, I., H. Ozener, 2010. Estimation of strain accumulation of densification network in Northern Marmara Region, Turkey. Nat. Hazards Earth Syst. Sci., 10, 2135–2143, 2010 www.nat-hazards-earth-syst-sci.net/10/2135/2010/ doi:10.5194/nhess-10-2135-2010

Hu, Y., K. Wang, J. He, J. Klotz, G. Khazaradze, 2004. Three-dimensional viscoelastic finite element model for postseismic deformation of the great 1960 Chile earthquake. Journal of geophysical research, Vol. 109, B12403, doi:10.1029/2004JB003163, 2004

Kastreva, P., 2000. A way for defining the deformations according to the method of the final elements and its application to the geodynamic network "Krupnik". Reports of Geodesy, Warsaw University of Technology, No 4(49), 229-233.

Kotzev, V., R. Nakov, Tz. Georgiev, B.C. Burchfiel, R.W. King, 2006. Crustal motion and strain accumulation in western Bulgaria, Tectonophysics, 413, 127–145.

Kotzev, V., R.W. King, B.C. Burchfiel, A. Todosov, B. Nurce, R. Nakov. (2008). Crustal motion and strain accumulation in the South Balkan Region Inferred from GPS Measurements, in Husebye, E., ed., Earthquake monitoring and seismic hazard mitigation in Balkan countries: Proceedings of the NATO Advanced Research Workshop on Earthquake Monitoring and Seismic Hazard Mitigation in Balkan Countries, Borovetz, Bulgaria, 11–18 September 2005: NATO Science Series IV: Earth and Environmental Sciences. Volume 81, 19–43.

Matev, K., 2011. GPS constrains on current tectonics of southwest Bulgaria, northern Greece and Albania. Thesis, Doctor of university of Grenoble, 203pp.

Milev, G., Dabovski, C. (Eds), 2006. Geodynamics of the Balkan Peninsula, Monograph, Reports on Geodesy, Warsaw University of Technology, Institute of Geodesy and Geodetic Astronomy, 647 pp.

Milev, G., K. Vassileva, I. Milev, R. Pelovski, I. Andreev, G. Gerova, 2014. Current status and activities of Satellite Ground-Based System EUPOS and EUPOS-BG. SES 2013, Proceedings of Ninth Scientific Conference "Space, Ecology, Safety", 163-173.

Valev, G., 1987. Projection of points onto the earth ellipsoid. Geodesy, Cartography and Land Management, 4, 6-11. (in bulg.)

Valev, G., 1995. Another approach to derive the parameters of the ellipse of deformations. Geodesy, Cartography and Land Management, 2-3, 15-19 (in bulg.)

Valev, G., P. Kastreva, 2006. Stress strain analysis of the Balkan Peninsula. Balkan Peninsula monograph, Reports on Geodesy, Warsaw University of Technology, No 5(80), 2006, 597-605.

Valev G., K. Vassileva, 2000. Application of Different Models of Adjustment to the Processing of Geodetic Measurements on Geodynamic Poligons. Reports of Geodesy, Warsaw University of Technology, No 4(49), 219-227.

Zagorchev, I. (2011). Cenozoic Block Rotations in the Balkan Peninsula. Proceedings of 3rd International Symposium of the Black Sea region, 1-10 October, 2011, Bucharest, Romania, 220-222.

Necessity of a European strategic plan

In this paper Galileo Services offers an input to the general debate about the role of a coordinated industrial policy to support the European economy and the contribute to the competitiveness of European enterprises

The concern of the European downstream industry

The justification for the Galileo Programme relies on a two fold objective:

- To achieve independence and autonomy for Europe in relation to non-European GNSSs
- To win a significant share of the huge and continuously growing worldwide GNSS downstream market - the market of technologies, applications and services based on satellite positioning, navigation and timinig

The GNSS downstream market continues to be one of the most promising markets in terms of European growth, with anannual growth rate of the global GNSS market of about +7% per year. The core and the enabled GNSS markets are expected to reach around EUR 110 billion and EUR 290 billion respectively by 2023 (see GSA's GNSS Market Report 2015).

However, Europe is not gaining an adequate share of this market. The current European share of the global market is approximately 20% - if not lower – compared to a traditional European share of 33% for any other global high-tech sector. Europe's GNSS market share is even declining. In the mature GNSS applications markets, 80% of well-established market owners are of US origin. Further more, the size and growth of Chinese industry, which has already in just a few years outperformed European industry in the field of telecommunications, is particularly worrying. As things stand, in a few years, it will be difficult or nearly impossible for European Industry to survive in the highly competitive GNSS global market.

Unless an effective and long-term strategy is put in place during the Galileo early services exploitation phase (2016-2020), the window of opportunity for European industry to benefit from the current GNSS market boom will soon be closed.

Europe's goal of achieving GNSS autonomy is also at risk. To have Galileo fully and sustainably operational is indeed a necessary, but not sufficient condition to achieve autonomy. Economic and social dependence on GNSS increases together with the market, and Galileo is just one of three new GNSS solutions complementing America's GPS: most of the applications do not require four GNSS constellations and GPS, GLONASS (Russian Global Satellite Navigation System) and BeiDou (Chinese Global Satellite Navigation System) are already inplace. GPS is the common standard. Russia has regulated the use of GLONASS in all equipment sold in its territory. BeiDou benefits from a matchless internal market demand in China. Finally, due to the decrease of the industrial base in Europe, much Galileo equipment including critical elements may not be manufactured in Europe. Europe could thus depend on the capacity and strategy of non-European providers.

The targeted European autonomy will be achieved if and only if Galileo is widely used with equipment designed and manufactured in Europe, as well as applications and services developed in Europe.

The socio-economic expectations will be met if and only if European industry succeeds in winning a reasonable share of the global GNSS downstream market.

Growth, competitiveness and job creation in Europe must remain the main objective of the European GNSS Programmes. Return of investments–and consequently growth, competitiveness and job creation–can only be expected from the downstream sector.

The industry of GNSS-based applications and services must be placed at the heart of a Galileo-and EGNOS-based economy to ensure a full return of investments in European GNSS infrastructure.

The existing and near operational European GNSS systems, EGNOS and Galileo, offer outstanding possibilities for the downstream sector and could generate significant growth opportunities. However, Europe's GNSS downstream industry suffers from a dramatic competitive disadvantage vis-à-vis worldwide competitors who have benefited from strong institutional support for decades and have increased their supremacy year after year.

In the US, Russia, China, and Japan, dedicated national strategies exist indeed to support competitiveness of their down-stream industry and enhance GNSS market take up, including massive funding for R&D and manufacturing capabilities, regulations and public procurement.

Hereafter are some examples of combined institutional support actions implemented by Europe's competitors:

- Large and continued military applications R&D programme, which helps to underpin the investments of companies in commercial and civil applications

- Investments equivalent to several tens of millions of euros for manufacturing capabilities, which supports the development of industry
- Massive procurements equivalent to several billions of euros from the public sector, as anchor customer, which radically boosts private investment
- Regulations, such as giving preference to indigenous GNSS equipment and services

It is crucial for Europe to promptly provide European GNSS downstream industry with the means to become competitive in the global market and create industrial leadership.

The creation or strengthening of European champions able to compete on an equal basis in the worldwide market is necessary.

The opportunities ahead

The game is not over. There are a number of key GNSS applications and services markets – including the most promising services and applications markets in terms of growth potential and strategic markets– in which European Industry must position itself (see Figure 1).

In particular, European equipment and industries have a strong reputation for quality and reliability. The leading position of Europe in GNSS security and resilience domains should be strengthened, as it is critical for today's and tomorrow's markets.

There are a lot of unexplored opportunities for GNSS applications and services in Europe.

The potential and capabilities of all global constellations (GPS, Galileo, GLONASS and BeiDou) –leveraging in particular the key European GNSS differentiators (Improved performance, authentication, high precision, robustness and security) also in a multi-constellation environment -offer opportunities that Europe must not miss.

They include:

- Opportunity to develop new GNSS-based positioning, navigation and timing applications and services

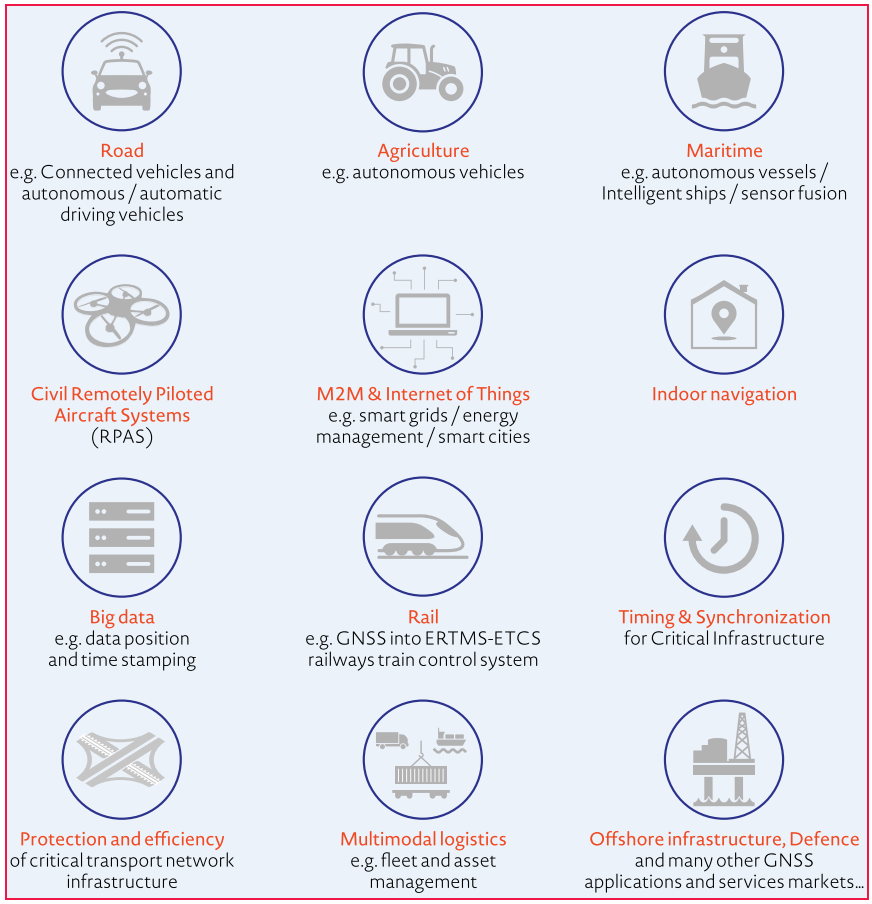

Figure 1: Promising GNSS services and applications markets

- Opportunity to create new industrial activities in Europe and, with them, hundreds of thousands of jobs

A strategic plan to develop the GNSS downstream sector in europe

The European Union must establish a strategic plan aiming at enhancing European GNSS downstream industry competitiveness and fostering European GNSS uptake.

This strategic plan must include an industrial policy in which the public and private sectors coordinate their efforts to develop new technologies, applications, services and industries in Europe.

A comprehensive and assertive industrial policy is essential to develop Europe's GNSS downstream sector and must aim to:

- Protect and strengthen the existing European industry and foster the emergence of European champions in key GNSS applications and services markets, including strategic domains and domains with significant growth potential
- Support European downstream industry competitiveness and help European companies to gain market share in the GNSS global market
- Foster the design, development and manufacture of European GNSS based technologies, applications and services in Europe

Such a strategic plan must also aim at supporting coordination between existing National or European initiatives to maximise synergy and efficiency, and minimise duplication. Any new support action initiated by the institutions must be consistent with the existing supportactions.

The Commission GNSS Action Plan 2010 to foster the development and adoption of satellite navigation applications using EGNOS and Galileo is a first step in that direction.

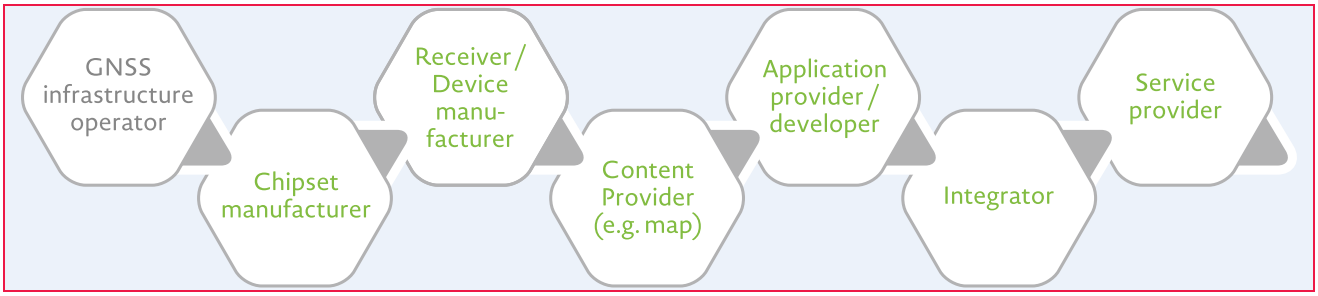

Figure 2: GNSS application generic value chain

Europe can benefit from the particular mandates and skills of its institutions

The role of European institutions in the growth process is especially decisive in times of economic and financial crisis. All stakeholders of the European GNSS Programmes must organise themselves and combine their strengths to give a chance to Europe to take a significant part of this growth and indirectly recover some of the massive investments in infrastructure made by Europe-tax payer money.

European institutions, in particular the European Parliament, the European Commission, the European GNSS Agency and the European Space Agency, must work together and combine their particular skills and competences in a pragmatic way, to guarantee the full success of the European GNSS Programmes from upstream to downstream, and European industry's competitiveness.

Definition and establishment of a european strategic plan

Purpose of a strategic plan to develop the GNSS downstream sector in europe

European institutions must establish a strategic plan to support the development of a competitive GNSS downstream industry in Europe, building on competitive advantages offered by the European GNSS, and at the same time recognizing multi-constellation opportunities for European industry.

This strategic plan must include an industrial policy to increase

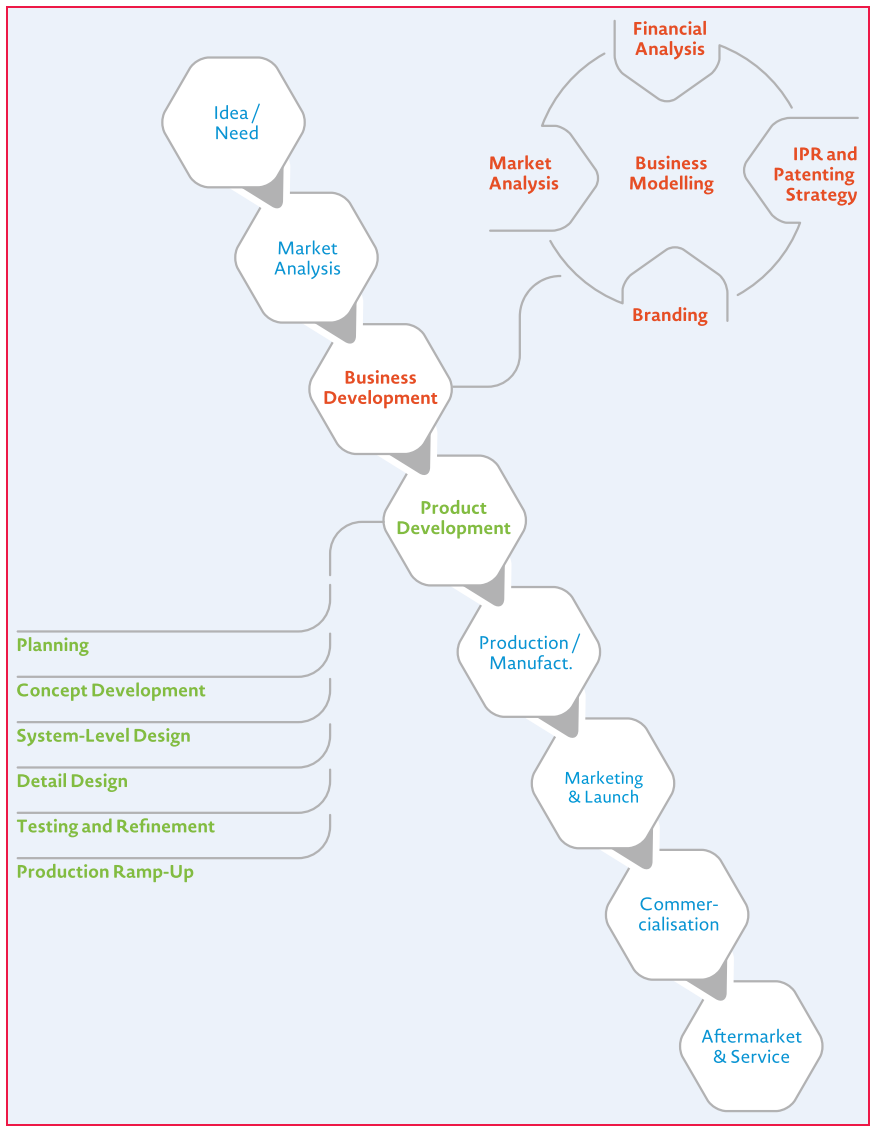

Figure 3: Generic product development process

European GNSS downstream industry's presence in the different application markets by defining:

- Clear and quantitative objectives in terms of European industry position in the market with targets in terms of market share, revenue, and job creation or strategic expectations
- Clear support actions from European institutions (e.g. public procurement, regulations) with associated milestones to reach these objectives
- Key performance indicators (KPIs) to assess the achievement of these objectives

Europe needs to do everything to deliver a fully operational Galileo system by 2020. Any delays beyond that will seriously impact the uptake of Galileo, and important design investments already made by the downstream industry based on the assumptions stated by the EU institutions would be rendered obsolete. Furthermore, a clear and consistent roadmap for the European GNSS systems and their services must be established and shared with European companies. For instance, a risk exists where Galileo PRS, Galileo Commercial Service and EGNOS could compete with services operated today by European industry. The European institutions must regularly share their plans regarding European GNSS services and all relevant information related to Galileo System design with European industry to ensure that European companies can benefit from EGNOS and Galileo services to maintain and strengthen their market position.

An industrial policy includes any kind of action from the institutions that has an impact on the industry (ref. next section). The identified support actions should be shared between the different institutional bodies according to their particular skills and competence.

European institutions can help to mitigate the technology risks, the marketing risks, the financing risks and the regulatory risks. The risks associated with the main market segments should be classified in order to identify the main challenges and threats that market players have to deal with in each segment (currently and in the short, medium and long terms). The assessment of these risks will indicate the nature and the size of the effort required from dedicated institutional actions devoted to the European GNSS downstream sector.

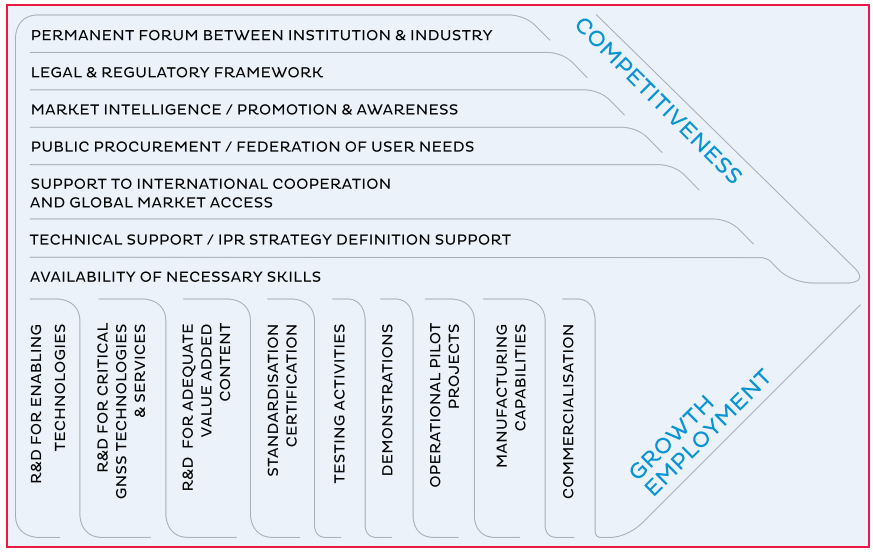

Figure 4: Examples of key support actions from the institutions

Each time European institutions take an initiative impacting the downstream sector (e.g. to include GNSS in a regulation, to launch evolutions of the European GNSS infrastructure and services), it is crucial to assess at the same time the potential impact on the European downstream players, in terms of competitiveness, business and jobcreation. This must be a major criterion in the decision process.

The industrial policy must address each element of the GNSS downstream value chain (see Figure 2) and cover the whole product development process (see Figure 3) so as to enhance the opportunities for genuine European products to emerge.

The first version of such a plan must be established by the start of the Galileo early services exploitation phase (2016-2020), and must embrace the full duration of the Galileo early services exploitation phase as a minimum.

It must be a multi-annual plan putting actions and targets into the required global perspective.Annual plans must be adjustments to the long term plan to describe detailed actions for the year to come. The five year plan must be revised each year accordingly. From 2021, the future version must align with the financial perspectives of the European institutions and cover 7 years (Multi-annual Financial Framework).

Recommendations on key support actions from the european institutions

A number of key support actions can be undertaken by public institutions to support market penetration and development. Some actions with examples of programmatic instruments/ elements to support the competitiveness of European industry are described below. Note that many of them already exist, but are not always implemented for the GNSS downstream sector.

Galileo Services urges co-ordinated actions in the areas identified in Figure 3. Without these actions, Europe will have funded a GNSS system that will not be used as intended and where the main downstream actors are not European.

Different kinds of actions – legal, institutional, organisational, political or business-oriented – must be undertaken and combined depending on the application domain being considered and the targeted objectives: targets in terms of market share, revenue, and job creation or strategic expectations.

Permanent forum between institution & industry

- Creation of a forum enabling the public and private stakeholders to regularly interact (please refer to section 4 of this paper)

Legal and regulatory framework

- Reinforcement of the regulatory and legal framework to facilitate and encourage European GNSS use in Europe, favouring and incentivising the European GNSS downstream industry, while ensuring that associated standardisation bodies and certification entities anticipate and support industry developments

Provision of market intelligence

- Provision of market analyses and specific business cases allowing identification of opportunities or key markets in which European Industry must position itself: either the most promising service and application markets in terms of growth potential or strategic markets

Promotion & awareness

- Communication actions towards decision makers, procurement agencies and industry to increase their awareness of GNSS applications and services, and of the specific advantages of European GNSS services (e.g. authenticated Open Service, Commercial Service and Public Regulated Service)
- Promotion and awareness raising campaigns to stimulate the take-up of possible users by helping to clarify their requirements (cities, regions, various industrial sectors, etc.) and targeted to promising domains– in terms of window of opportunity and volume – demonstrating European GNSS differentiators and showcasing European industry skills to stimulate European and non-European markets, clarify their requirements and focus procurements

Public procurement & federation ofregional and national user needs

- Large scale public procurement in some key sectors (e.g. critical infrastructure, defence and security) to decrease market risk, support competitiveness, and boost private investment in GNSS technology
- Federation of regional and national needs and coordination of procurement plans for European GNSS products and services at the European level, to create continental-scale markets in Europe and deliver associated economies of scale

European institutions must establish a strategic plan to support the development of a competitive GNSS downstream industry in Europe, building on competitive advantages offered by the European GNSS, and at the same time recognizing multi-constellation opportunities for European industry

- Leveraging on ad hoc take up actions, such as Pre Commercial Procurement (PCP) and Public Procurement of Innovation (PPI) to facilitate the adoption of GNSS solutions

Establishment of user groups

- Establishment of user groups to capture common requirements and develop adequate services to comply with requirements, and avoiding over specifying of services

Establishment of partnership with market owners

- Support to the establishment of partnership with market owners such as MNOs (Mobile Network Operators), infrastructure operators, content providers, or insurance companies, so as to stimulate the opportunities by clarifying the need for European GNSS applications in key economic sectors and there by improve Europe's competitive position and enhance access to major global markets

Support to international cooperation and global market access

- Carefully establish international cooperation favouring European industry interests, involving non-European partners when providing either opportunities for market penetration beyond Europe's borders or specific skills and/or technology not available in Europe, and setting up adequate Intellectual Property Rights (IPR) policies
- Support to global market access by providing knowledge on export markets and trade agreements, and by organising trade missions and providing support to exports

Technical support & IPR strategy

- Provision of technical expertise on European GNSS infrastructure, systems, and signals for R&D, standardisation and certification activities to (a) support the development of equipment and services embedding European GNSS specific features and promote and foster the uptake of specific European GNSS features such as ionospheric models, longer code, authentication and EGNOS Data Access Service (EDAS)
- Availability of laboratories and technical experts to support application developers
- Continuous monitoring of technology state-of-the-art in all technologies related to GNSS applications (e.g. signal processing, clocks)
- Establishment of an IPR Policy preserving European industry interests and guaranteeing reciprocity with other GNSS constellations and associated services

Availability of necessary skills

- Encourage universities and other educational and research institutions in Europe to strengthen their activities within GNSS technology in support of industry

Support to research & development

- Public institutions must contribute to the R&D effort for:
  - Key enabling technologies, such as clocks, improved antennas or signal processing technologies for European GNSS receivers
  - Critical technologies, applications and services based on end user requirements, such as

reliability, robustness, security and high performance
- Address the GNSS application layer in complementary and efficient R&D programmes, such as Horizon 2020, Fundamental elements, Fast Track to Innovation at EU level or ARTES 3-4 and GSTP at ESA level which together provide the key to the development of the GNSS downstream sector
- Continuous open calls to encourage the emergence of innovative ideas and foster technology research, what ever the domain and the technology area
- Launch R&D calls for proposals on a yearly basis (*Note the absence of FP7 GNSS applications R&D budget from 2011 to 2014 – the dedicated FP7 budget being exhausted due to extensive cuts leaving only EUR 100 million in the GNSS FP7 budget line, instead of the EUR 350 million agreed at the outset. Note also the EC plans to launch H2020 calls for proposals for Galileo applications R&D every two years.*) to ensure continued innovation and market development
- Reduction of time to market, crucial in the innovation process, through for example:
  - Fast procurement for R&D activities –maximum time limit of 4 months from the proposal submission to the contract signature
  - Use of an Authorization to Proceed to allow the industrialists to start R&D at their own risk before the contractis awarded
- Simplification of the administrative burden of EU R&D programmes, which many consider are extremely time and resource consuming or even discouraging, in particular for SMEs
- Importance to clearly place IPR under the control of the proposer in all R&D Programmes

Standardisation, certification, testingfacilities

- Support to the standardisation work in relevant domains as well as the certification process for safety/security critical applications, addressing in particular the specific features of European GNSS (e.g. authentication, robustness and security)
- To ensure the existence or facilitate the access to test facilities, particularly in strategic domains
- Update, replacement or augmentation of existing standards – implicitly based on conventional technology or GPS – with alternatives to facilitate and promote the use of Galileo and EGNOS

Demonstrations and operational pilot projects

- Setting up of Demonstrations and Operational Pilot Projects focusing on implementation of GNSS solutions tightly integrated in the real operational user workflow, involving all value chain actors, and highlighting EGNOS and Galileo differentiators
- Establishment and maintenance of a set of market-driven demonstration centres in cooperation with relevant market owners to enhance the adoption of European GNSS-based solutions and overall market penetration

Manufacturing capabilities

- Support to the development of manufacturing capabilities for strategic sectors

Specificcase of start-UPS and SMES

- Additional instruments specifically tailored to SME, like the EU SME Instrument to be contemplated, for instance:
  - Fast procurement 'purchase order type'
  - Simplified payment plan with increased up-front payment
  - Fast track for garage box innovative ideas
  - Funding mechanisms to bridge the "valley-of-death" between the R&D step and the industrialisation/ market development leading to the with- drawal of many SMEs at the end of the R&D phase
  - Innovative co-funding concepts for SMEs as a kind of Return On Investment (ROI) in case of commercial success
  - Investors' Fora while capitalizing on Pilot Customers' first feedback on experience
  - Dedicated support on IPR at the outset of a project: IPR intentions, status and ownership plans
- Need to pursue start-up financing and explore new co-funding concepts involving potential investors or customers

References

The proposals and discussions in this paper are backed up by the following publications of the European Commission and its Agencies, the European Parliament, the European Space Agency and Galileo Services:

- "European GNSS Programmes & European Transport Policy", EC/GS Meeting, 2 October 2014, EC premises, Brussels
- "Necessity of a European industry policy to develop the European GNSS downstream sector", ESAPB-NAV, 1 October 2014, ESA Headquarters, Paris
- GS position paper "Satellite Navigation Applications Realizing the Ambitions of EU 2020", 2011
- "Manifesto for a more committed Europe towards the development of GNSS Applications", 2010
- REG (EU) No 1285/2013 of 11 December 2013 on the implementation and exploitation of European satellite navigation systems
- GNSS Market Report, Issue 4, European GNSS Agency
- European Parliament resolution of 15 January 2014 on reindustrialising Europe to promote competitiveness and sustainability
- EC COM (2013) 108 "EU space industrial policy releasing the potential for economic growth in the space sector", 28 February 2013
- EC COM/2010/0308 "Action Plan on Global Navigation Satellite System (GNSS) Applications", 14 June 2010

The paper also has a concluding section "Galileo Services Forum" explaining the purpose and the plans of the forum. For further information: ***Axelle Pomies**, Galileo Services Permanent Representative, axelle.pomies@galileo-services.org*

Nepal climate data portal in the context of Spatial Data Infrastructure

The proposed approach tries to design an SDI based approach capable of monitoring, detecting, and predicting climate change so as to enable effective decision making

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With the growing concerns of global climate change and its impacts on the environment, the importance of spatial data infrastructure (SDI) play a crucial role in offering accessibility to climate data and information to researchers interested in addressing the issues related to climate change. This paper describes a climate data portal developed for Nepal in the context of linking it with Spatial Data Infrastructure with the aim of reducing costs of climate data and improving data quality, making data more accessible to the users, while at the same time increasing the benefit of using available data. The proposed approach tries to design an SDI based approach capable of monitoring, detecting, and predicting climate change so as to enable effective decision making. It will also ensure the best sharing and exchange between partners and stakeholders so that they are interactively connected to use the data efficiently and in a flexible manner.

Introduction to Nepal Climate Data Portal

It is a known fact that in the today's world internet plays a crucial role in exchanging large amounts of spatial data. Professional data centers have found secure ways to share their data resources with peers and third-party users, either as a free service or as a commercial activity (van der Wel, 2005). The GIS community has been working tirelessly to make spatial data available through internet. Therefore, it is worth considering the need for having a data infrastructure for conducting any climatological and meteorological research (van der Wel, 2005). A meteorological data infrastructure can be developed by taking the guidance from any existing Spatial Data Infrastructure (SDI). Environmental problems demand decision making and monitoring tools that are based on readily available and accessible spatial data.

Therefore, open access to accurate and representative climate information has a huge impact on awareness raising, especially issues concerning with climate change and climate variability. Availability of climatic data is identified as one of the most important elements under the United Nations Framework Convention on Climate Change (UNFCCC) and its subsequent Kyoto Protocol to combat unprecedented climate change. In addition, access to meteorological/climatological database via a web portal is essential for understanding the climate change impacts in climate sensitive sectors such as agriculture and food security; water resources; biodiversity; health; and so on which is of utmost importance for sector specific policymakers, planners, stakeholders, end users and for the general public to plan their routing works.

The Nepal Climate Data Portal is designed to facilitate the analysis of historical climate/meteorological data as well as future climate scenarios in different geographical setting in the country using a publicly accessible web based interface. It is also designed to be a rather sophisticated calculator with its own meteorological

database to produce maps, time-series charts or downloadable data. It uses simple language to represent arithmetic and statistical operations like a spreadsheet. The intended audience for the web portal are research scientists, meteorologists, hydrologists university students, sector specific decision makers and anyone who needs to understand past and future (projected) weather and climate patterns in the country. The web portal allows and facilitates the clients to purchase historical meteorological data, which are being collected and maintained by Department of Hydrology and Meteorology (DHM) for over several decades.

Objectives of Designing the Portal

Understanding vulnerability and impacts associated with climate change and climate variability in different climate sensitive sectors in different climatic zones is key for managing risks of weather and climate disasters and taking appropriate proactive adaptation measures for climate change. As the current degree of vulnerability and impacts to communities in Nepal and their resilience depend on physical, environmental, social and economic aspects, analysis of historical meteorological information on different temporal and spatial scales is of vital importance.

It is equally important to provide future climate change scenarios using state-of-the-art dynamical downscaling tools such as PRECIS (Providing Regional Climates for Impacts Studies-Model), RegCM4 (Regional Climate Model-4) and WRF (Weather Research and Forecasting-Model) at high spatial resolution. This will allow scientists and researchers to quantify the projected potential changes in mean climate and its extremes, which would help policy makers, planners and stakeholders for taking proactive adaptation measures in the vulnerable sectors such as agriculture, water, energy, health, etc.

> The portal developed for Nepal already addresses the functionality to effectively manage climate data through data ingestion, extraction and metadata management which is also within the required WMO standards of 2014

Asian Disaster Preparedness Center and Bjerknes Centre for Climate Research (BCCR), Norway, in association with Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands and The Energy and Resources Institute (TERI), India, have implemented a project on "Climate Data Digitization and Downscaling of Climate Change Projections in Nepal: Strengthening Capacity for Managing Climate Change" that was funded by Asian Development Bank (ADB). The ADPC team worked jointly with the Department of Hydrology and Meteorology (DHM) and Tribhuvan University in Nepal. The Climate Data Portal was officially launched in August 2012. Several technical and capacity building trainings were conducted for DHM for long term sustainability of the data portal.

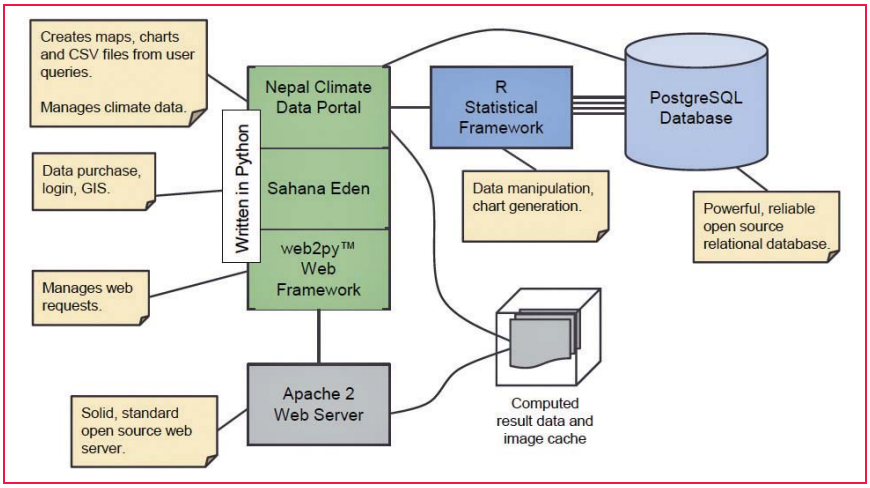


Figure 1: Architecture of Nepal Climate Data Portal

Design, Structure and Features of Nepal Climate Data Portal

Stakeholders were involved in the development of the portal throughout the project implantation stage. At the technical level, there was a close alignment between the requirements of the Nepal Climate Data Portal for historical climate data and projected future climate scenarios. The portal was designed with the aim of providing users with an integrated platform to access climate data and the ability to compare historical and projected climate information and data (Figure 1). Sahana Eden Humanitarian Open Source Software platform had been used for developing the portal and Python 2.6, R, R multicore library, RPostgreSQL, rpy2, PIL, xvfb, PyQT4, QTWebKit were used to design it. The Portal allows the users to view the climate data on an interactive map and generate different information products including exporting the raw data.

Information Products

The Nepal Climate Data Portal produces various information products from observed, gridded and projected climate data to cater to the needs of different stakeholders (Figure 2). It is seen that technical experts and climate professionals prefer raw data for their own analysis while other professionals, such as government officials, policymakers

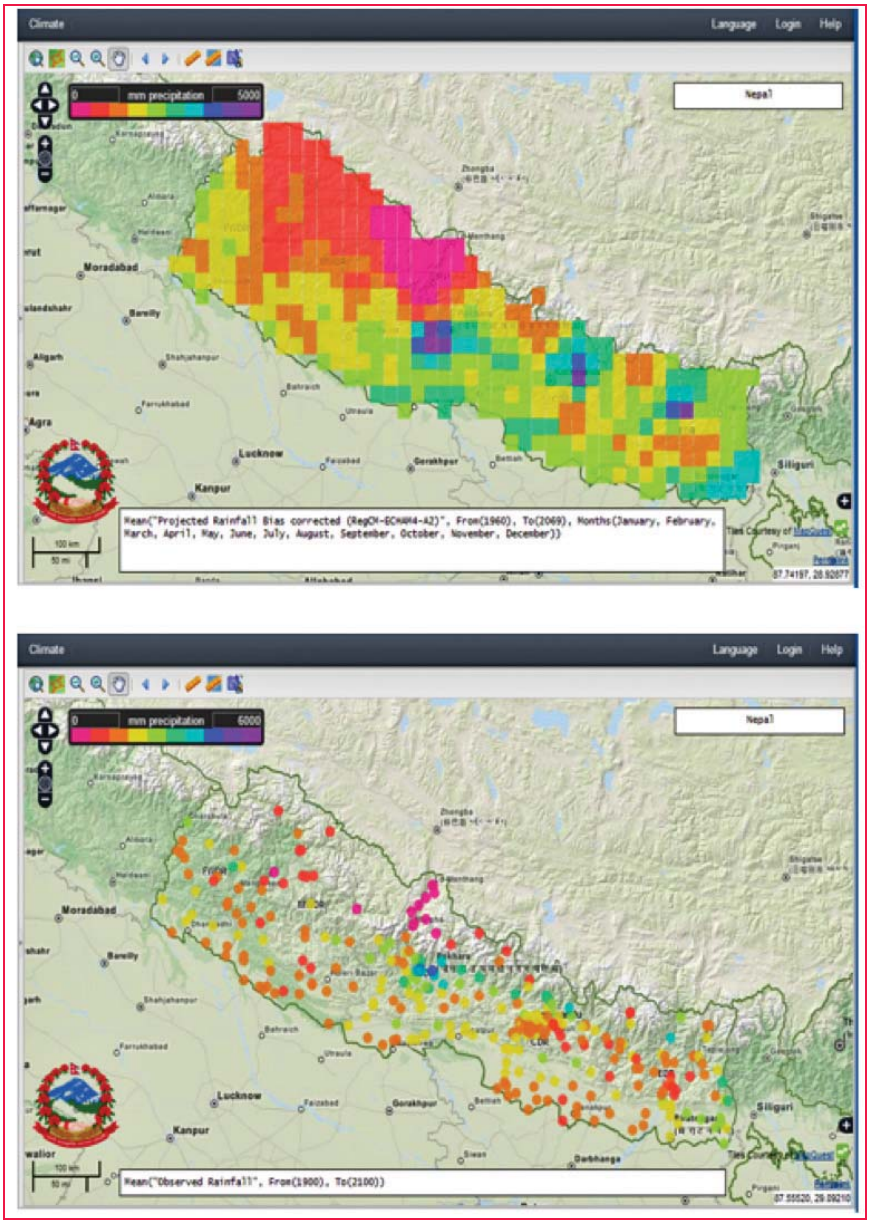


Figure 2: User friendly interface and some information products that are derived from the Nepal Climate Data Portal

and sector specific planners prefers analyzed end products such as maps and charts. The Nepal Climate Data Portal provides the following data types based on specific queries:

- Pont (observed) and Gridded Climate Data (observed and projected) in .dat (ASCII) and netCDF (where appropriate) formats;
- Maps visualizing gridded observed climatic variables (Monthly/Seasonal/Annual) in GIF and PNG image formats;
- Time series plots of modeled climate parameters (present-day and future scenarios) in GIF and PNG image formats.

Features of the Web Portal

The Nepal Climate Data Portal has been designed for providing better access to the historical meteorological/climatological data and future climate scenarios of the country. Therefore, the portal is provided with features which includes:

- Performing as a sophisticated web-based calculating engine with its own database;
- Facilitating the analysis of climatological/meteorological, geographical and projection data using a publicly accessible web-based interface;
- Producing maps, time-series charts or downloadable CSV data;
- Allowing additional climate data in netCDF format to be uploaded into the portal through its user interface.

However, raw observed meteorological/climatological time series data are accessible on purchase. The portal also includes information on pricing options as specified by the DHM. Users will be able to purchase the data directly from the site with payments being made offline to DHM office or Bank.

Usability and Applicability of Nepal Climate Data Portal

Climate data has been extensively used to assess the impacts of climate change and to identify the degree of vulnerability in climatic sensitive sectors such as agriculture, water, energy, health, etc. Therefore researchers, scientists, academics, sector specific planners and policy makers will be benefited from the Portal in terms of carrying out activities such as:

- Research and Developments;
- Assessing impacts and vulnerability in climate sensitive sectors such as agriculture, water resources, energy, health, etc.;
- Developing adaptation strategies for vulnerable sectors;
- Infrastructure planning such as adaptation measures and;
- Contingency planning.

Considering Nepal Climate Data Portal as a Climate Based Spatial Data Infrastructure (CSDI)

To understand the climate system, one must understand a wide range of complex processes occurring over time. It can be naturally induced or man-made. Therefore, to understand such processes taking place

Efforts should be made to integrate already available climate and geospatial databases including the CSDI to address the needs and concerns of the end-users

and its impacts and consequences, a wide variety of climate related information are required that needs to be routinely maintained, stored, managed and analyzed within a system. Such a system can be considered within the ambit of a spatial data infrastructure (SDI). The Nepal Climate Data Portal may be one such system which can be called as the Climate Base Spatial Data Infrastructure (CSDI). The portal developed for Nepal already addresses the functionality to effectively manage climate data through data ingestion, extraction and metadata management which is also within the required WMO standards of 2014. Considering the portal as a CSDI will open up data sharing needs of the agencies based on cooperative relationships. It will further enable DHM in collecting and integrating climate related data from various sources which will help analyze and validate data and information for effective decision making. Integrating data from various sources will increase the effectiveness of the system while at the same time will reduce the duplication and increase cost effectiveness. According to Sharma and Acharya (2004), the aggregation and integration of fundamental data sets and framework data sets should solve the purpose of National Spatial Data Infrastructure (NSDI) for Nepal and should pave the way for easy accessibility of data and resources thereby making the works of user's community more simple, efficient and effective. Therefore, efforts should be made to integrate already available climate and geospatial databases including the CSDI to address the needs and concerns of the end-users. Not only is access to climate data and information needs to be linked or integrated within the SDI framework, so is the capacity of national institutions, leadership and civil society to determine what climate data and information is needed for adaptation-related decision-making (UNFCCC 2008; Dutta and Jayasinghe 2015). This can be further stated in the guiding policy statement on the importance of building a CSDI in Nepal and its probable links to make it operational as described under Nepal's NSDI framework.

Improving the Capacity of Department of Hydrology and Meteorology (DHM)

It is very important to improve the capacity of DHM in the context of maintaining the portal so that it is sustainable and its functioning remains effective. The work implemented in Nepal tried to address the ways to improve the climate data collection process of DHM to meet future challenges based on the country needs. Based on the assessments carried out in the country, it was found that the current network of meteorological stations needs to be further expanded for better coverage of meteorological data, enhancing infrastructure, and upgrading equipment's as well as increasing human resource needs for improving DHM. Time to time capacity building of DHM staffs would help maintain the sustainability of the portal with better efficiency.

Acknowledgement

The authors wish to acknowledge Asian Development Bank (ADB) for financial assistance to develop Nepal Climate Data Portal for DHM, Nepal. They also wish to thank Ms. Cindy Malvicini, Senior Water Resources Specialist, Environment, Natural Resources and Agriculture Division (SAER) of ADB for valuable guidance during the project period. They also wish to extend their gratitude to the Ministry of Environment Science and Technology, Government of Nepal for granting the project "Climate Data Digitization and Downscaling of Climate Change Projections in Nepal" under "TA7173-NEP: Strengthening Capacity for Managing Climate Change" to Department of Hydrology and Meteorology of Nepal.

References

Asian Development Bank (2013). Nepal: Strengthening Capacity for Managing Climate Change and the Environment: Climate Data Digitization and Downscaling of Climate Change Projections in Nepal. *Technical Assistance Report*, 2013. Project Number: TA7173-NEP.

Dutta, R. and Jayasinghe, S. (2015). Integrating Spatial Data Infrastructure in Monitoring Climate Change Impacts: A Research Oriented Approach. Approach (TS-3: SDI Development; Commission: 2 of the International Federation of Surveyors (FIG), and Technical Commission: IV, Working Group: 4 of the International Society for Photogrammetry and Remote Sensing (ISPRS)). Peer Reviewed and published in the Proceedings of the International Workshop on the Role of Land Professionals and SDI in Disaster Risk Reduction: In the Context of Post 2015 Nepal Earthquake, Kathmandu, Nepal, 25 – 27 November, 2015.

Sharma, R.K. and Acharya, B.R. (2004). Spatial Data Infrastructure for Prosperous Nepal. *Technical Session 2-Spatial Information Management Promoting Sustainable Development*, 3rd FIG Regional Conference, Jakarta, Indonesia; 3-7 October, 2004.

UNFCCC (2007). Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Available at unfccc.int/resource/docs/publications/impacts.pdf

Van der Wel, Frans J.M. (2005). Spatial Data Infrastructure for Meteorological and Climatic Data. *Meteorological Applications*, 12: pp. 7 – 8 (DOI: 10.1017/S1350482704001471).

WMO (2014). Climate Data Management System Specifications. Version 1.0.

Working together for a safer world

Report on the 2nd international symposium on disaster management, October 12-14, 2015 - Melbourne

The 2nd International Symposium on Disaster Management was an invite-only event held over 3 days at the University of Melbourne which attracted over 130 attendees from across Australia, and internationally from 14 countries. The theme of the event was 'Working Together for a Better World' and key sessions of the event were dedicated to discussions on: Global Disaster Management, Mission Critical Communications, Disaster Management Platforms and Technology, Emergency Management, Trends and Issues in Disaster Management, Disaster Recovery and Reconstruction, and Community Resilience. The event was chaired by CDMPS Director, Prof. Abbas Rajabifard, and was supported by several national and international partners including The University of Melbourne, Carlton Connect, GSDI, IBM Research Australia, Emergency Management Victoria, UN-GGIM, FIG, CSDILA, APCO International, Victorian Spatial Council, BNHCRC and Coordinates Magazine as a media partner.

Symposium aim and objectives

The aim of the Symposium was to present and discuss the latest innovations, research and practice related to disaster management, and establish connections for future research and collaboration.

Five key objectives were identified for the event:

- To present the latest innovation, research and practice
- To exchange ideas
- To establish and extend partnerships
- To develop a future research agenda
- To contribute to knowledge

Quick statistics of ISDM 2015

- Over 130 attendees
- Attendees from 14 countries
- 63 presenters
- 13 key topics
- 4 workshops

Highlights of the event

The Minister for Emergency Services, the Honourable Jane Garrett officially opened the symposium on Tuesday 13th October. The Minister gave a talk which emphasised the importance of organisational collaboration and community engagement and resilience in the context of disaster management.

The ISDM event coincided with the International day for Disaster Risk Reduction which is held on October 13 each year. The day celebrates how people and communities are reducing their exposure to disasters, and aims to also raise awareness about the importance of Disaster Risk Reduction (DRR). To mark the occasion, presentations at ISDM on this day focused on community resilience and disaster risk reduction activities and research.

At the symposium the Emergency Management Commissioner of Victoria Craig Lapsley officially launched the new document 'A Modern Emergency Management System for Victoria' during his keynote talk within the plenary session on emergency management. Commissioner Lapsley first spoke on the vision for emergency management in Victoria, Australia, and the challenges faced in disaster situations which require the community to survive, adapt and grow, before launching the strategy. The strategy outlines what community resilience is and how this understanding can be used to develop a resilience-based approach to emergency management in the context of Victoria today.

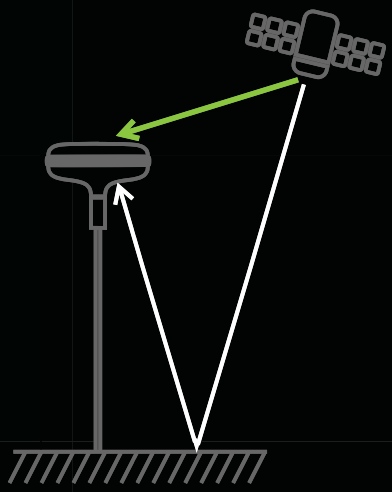
The ISDM event attracted delegated from 14 countries worldwide, and from a large range of organisations and sectors across Australia including representation from a range of sectors including local, state and federal government, industry, and academia. Notably, at Federal level in attendance was a representative from the Department of Foreign Affairs and Trade (DFAT), and a representative from the Department of Communications. At the Victorian level, attendees included representatives from: the office of the Productivity Commissioner, Emergency Management Victoria (including the Emergency Management Commissioner), the Department of Justice (including the Inspector General of Emergency Management), and the Country Fire Authority (including the CFA Chief Officer).

Outcomes

The discussions throughout the event, including panel discussions and workshops, yielded a broad range of ideas and focus areas to concentrate on for future research and collaborative activities. By bringing together a range of experts from countries around the world with different perspectives and experience, the opportunity for researchers, industry members and government representatives to work closely together to maximise return was presented, and the event acted as a platform for new connections and ongoing relationships to be established. These actions strengthened and mirrored the theme of the event – working together for a safer world.

The event has also emphasized the commitment of the University to addressing disaster management issues and achieving a resilient society in line with the grand challenges, and additionally has highlighted the importance of engagement between government, industry and academia, and the community – at a local, national and international level.

MULTIPATH BUSTERS



Multipath appears like a **ghost signal** that degrades the accuracy of your shots. We **detect and bust** these ghosts by sophisticated signal processing techniques in our **TRIUMPH** chip. We also show the **signature** of these ghosts that we bust. Below are two screen shots from the TRIUMPH-LS.

SAT	EL	AZ	L1	P1	P2	L2C	L5	SAT	EL	AZ	L1	P1	P2	L2C	L5
GPS2	29↑	154	7	7	2	--	--	BDU11	75↑	158	-6	--	--	--	-5
GPS6	44↑	98	11	9	2	2	-13	BDU12	36↓	60	-6	--	--	--	-14
GPS12	70↑	282	7	8	-2	-2	--	GPS3	10	26	--	--	--	--	--
GPS14	25˜	302	5	8	-4	--	--	GPS29	3	229	--	--	--	--	--
GPS17	23↓	58	6	9	-6	-2	--	GPS32	3	346	--	--	--	--	--
GPS24	53↓	196	1	4	13	1	-12	GLN7	3	297	--	--	--	--	--
GPS25	30↑	282	4	8	7	1	-32	GLN19	12	210	--	--	--	--	--
GLN1	10↑	34	1	4	-15	-23	--								
GLN8	16↓	344	12	15	17	25	--								
GLN9	32↑	316	0	2	-3	-6	--								
GLN15	31↓	142	5	5	0	1	--								
GLN16	84↑	266	2	2	-11	-18	--								
GLN17	39↓	44	-1	-4	-12	-10	--								
GLN18	69↑	188	-1	3	-1	-6	--								
GAL12	68˜	108	0	-26	0	--	-14								
SB127	25˜	160	7	--	--	--	-4								
SB128	15˜	130	9	--	--	--	-11								
QZ193	13↑	68	-3	-1	--	1	-19								
BDU2	16˜	132	-7	--	--	--	-17								
BDU5	25˜	154	-4	--	--	--	-7								
BDU8	25↓	54	-10	--	--	--	-20								

In each column the relative amount of multipath ghosts that has been detected and busted from each signal **carrier phase** is shown (in millimeters). In the carrier phase it is up to a **quarter of a cycle** (wavelength).

SAT	EL	L1	P1	P2	L2C	L5	SAT	EL	L1	P1	P2	L2C	L5
GPS2	29↑	273	281	-76	--	--	BDU11	75↑	362	--	--	--	305
GPS6	44↑	55	201	-60	-5	189	BDU12	36↓	288	--	--	--	200
GPS12	70↑	183	190	-90	-94	--	GPS3	10	--	--	--	--	--
GPS14	25˜	281	317	-97	--	--	GPS29	3	--	--	--	--	--
GPS17	23↓	332	364	-74	6	--	GPS32	3	--	--	--	--	--
GPS24	53↓	117	566	67	-64	124	GLN7	3	--	--	--	--	--
GPS25	30↑	243	218	-42	-50	-34	GLN19	12	--	--	--	--	--
GLN1	10↑	305	229	-126	-404	--							
GLN8	16↓	26	87	-484	-617	--							
GLN9	32↑	359	301	-246	55	--							
GLN15	31↓	276	203	-93	-2	--							
GLN16	84↑	235	309	-133	-109	--							
GLN17	39↓	52	-84	-156	-52	--							
GLN18	69↑	190	168	-177	-184	--							
GAL12	68˜	680	-121	246	--	32							
SB127	25˜	469	--	--	--	319							
SB128	15˜	206	--	--	--	322							
QZ193	13↑	550	513	--	56	55							
BDU2	16˜	299	--	--	--	275							
BDU5	25˜	269	--	--	--	230							
BDU8	25↓	145	--	--	--	143							

In each column the relative amount of multipath ghost that has been detected and busted from each signal **Code phase** (range) is shown (in centimeters). In the code phase it is approximately **several meters**.

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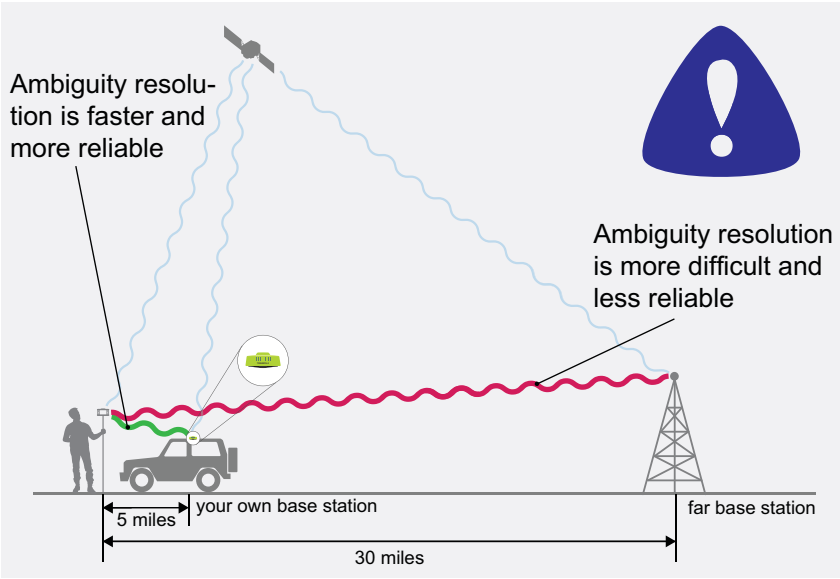
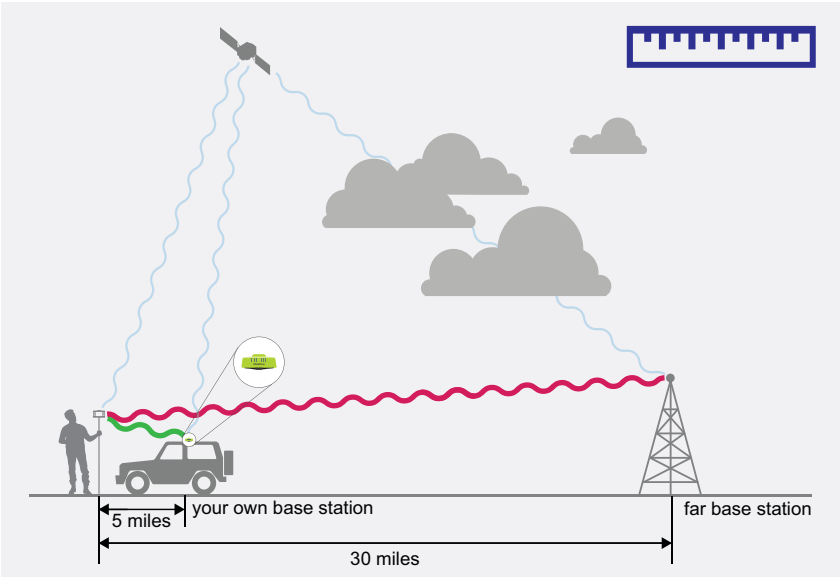
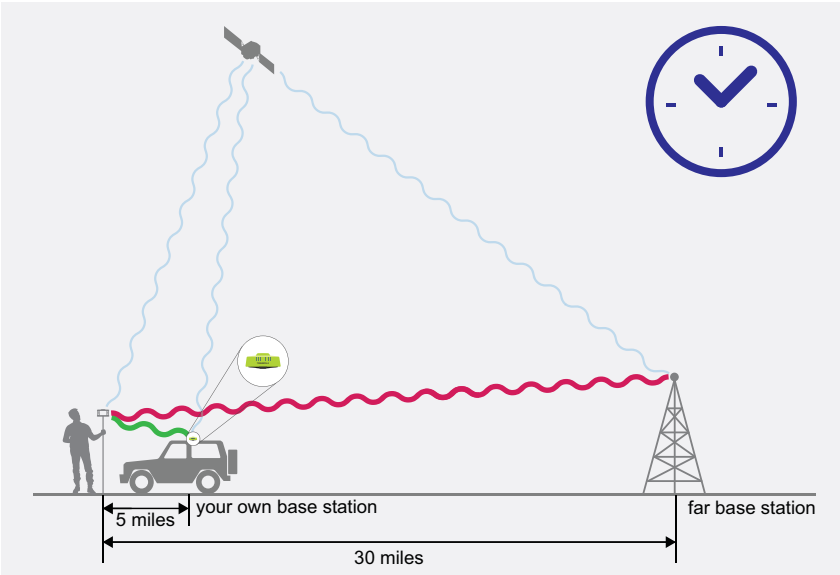
Advantages of your own base station...



1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.



2. Shorter baseline has better **accuracy** because most of errors (like atmospheric and tropospheric effects) are common and cancel.



3. Shorter baseline ambiguities are resolved much **faster**. In longer baselines, incorrect ambiguities may pose as being correct in the statistical evaluations and it takes longer to isolate incorrect ambiguities.

1 Equip your car

Mount the TRIUMPH-2 and radio on top of your car or truck. You can use either **UHF or FHSS** (Frequency Hopping Spread Spectrum) radios. You may want to bolt them down in your car for everyday use. FHSS does not need a license but its range is limited to a couple of miles. UHF has a longer range (up to 50 miles with a 35 Watt amplifier) but it needs a license. FHSS is particularly helpful in connection with our Beast Mode RTK which provides corrections from a TRIUMPH-2 near your job site. Use an appropriate long whip UHF/FHSS for longer range transmission.

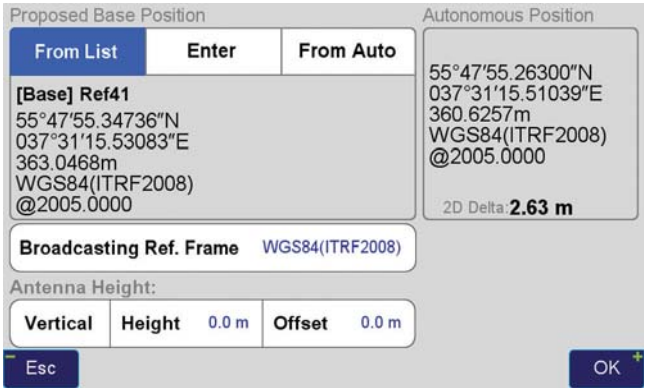
HPT401BT, 1W UHF Radio

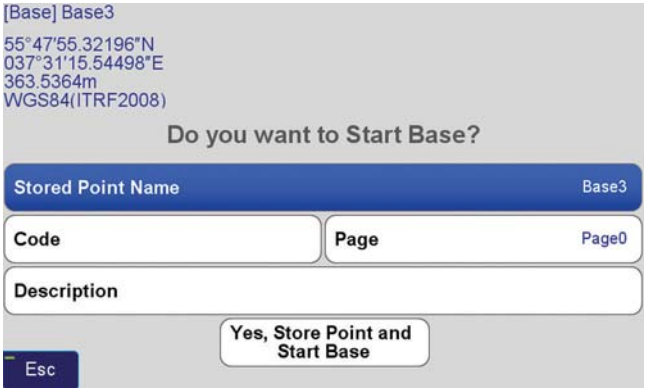
TRIUMPH-2, GPS+GLONASS, L1/L2

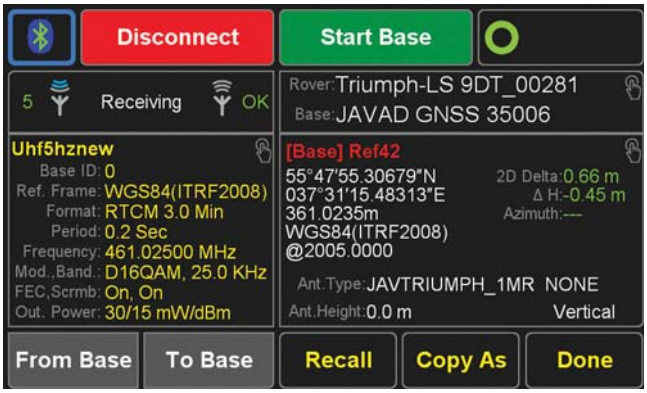
2 Park your car, Start Base

Park your car in an open area near your job site. It may be even in the middle of your site job. Engage all the brakes and ensure the car will not move. The Base/ Rover Setup screen makes it easy to configure the base and rover with the same parameters.

Use "**Auto**" for the base coordinate. "Auto" will use an autonomous solution as the base coordinates which may be off by several meters (this will be corrected later). Then click **Start Base**.

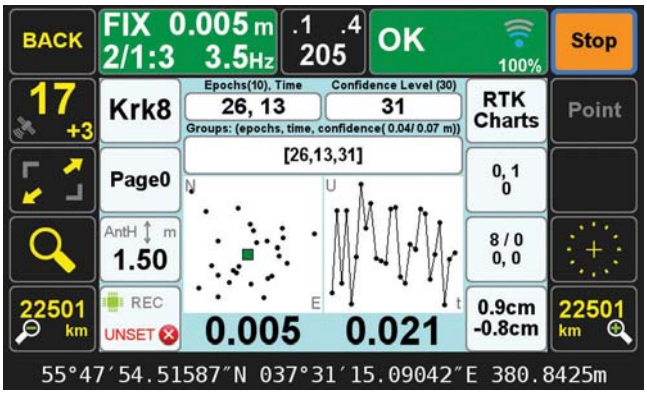




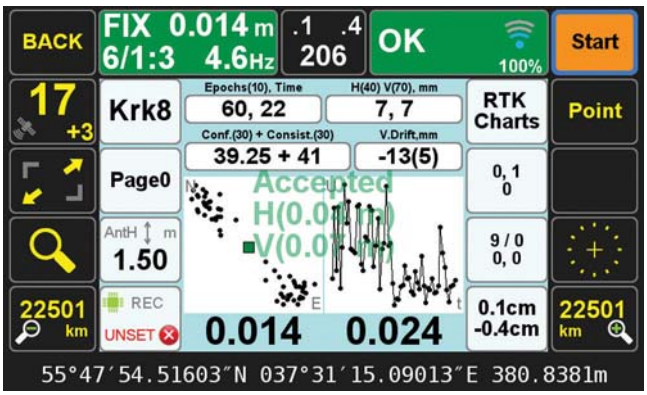


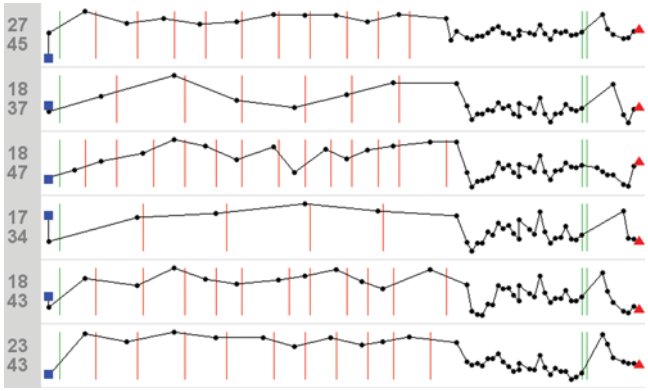
3 RTK Survey

Use your rover to perform your tasks. We have combined UHF and Spread Spectrum Frequency Hopping (FHSS) in the same module in TRIUMPH-LS as an option. The automatic "**Verify**" feature (Phase-1 and Phase-2) ensures that you will never get a wrong solution.



Since your RTK baselines are short, you benefit from all advantages that we discussed earlier BUT all your rover shots are shifted by the offset error of the autonomous base coordinates (up to several meters). "DPOS-It" or "Reverse-Shift-It" to correct for the error from the autonomous position.

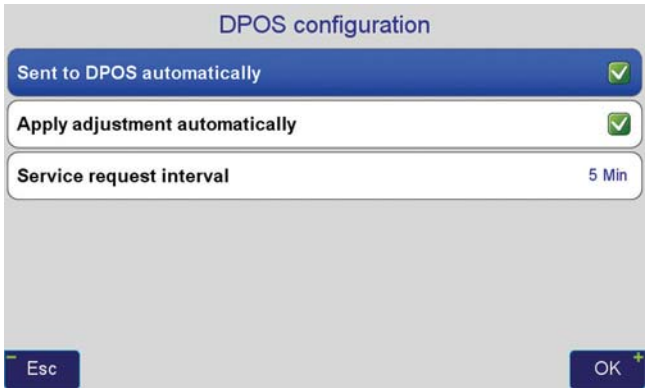


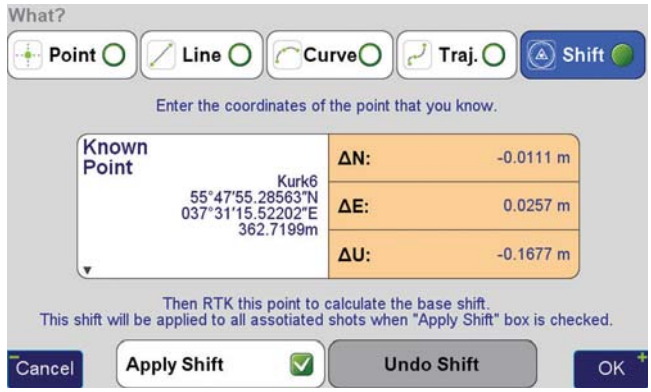


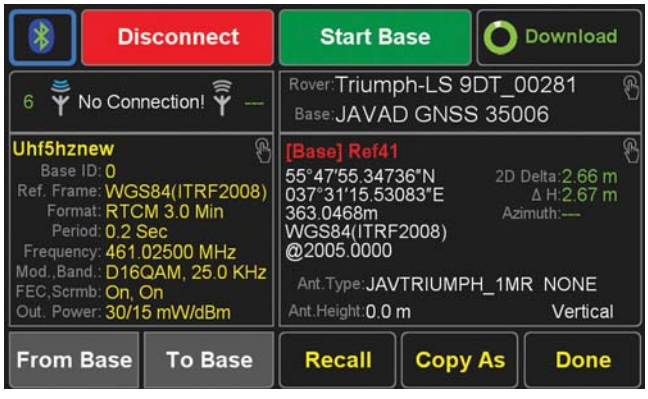
4 DPOS-it or Reverse-Shift-it

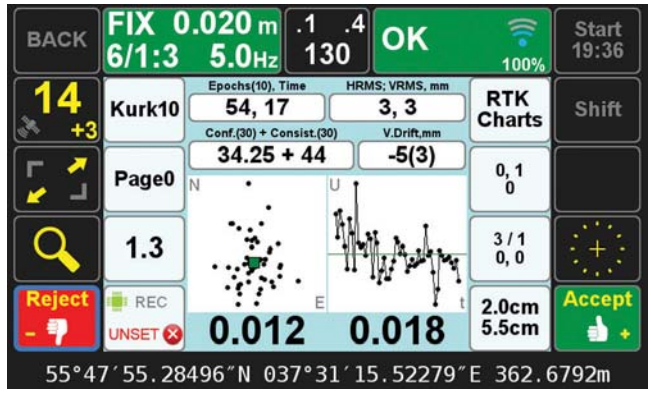
DPOS-it:
Press Stop Base and this will automatically **download** the raw GNSS base data to TRIUMPH-LS and send it to **DPOS** for processing with data from nearby CORS receivers. The TRIUMPH-LS then receives the **correct coordinates** of the base and **shifts** all the rover points accordingly. DPOS, CORS data and J-Field's RTK Verification guarantee your rover solutions.

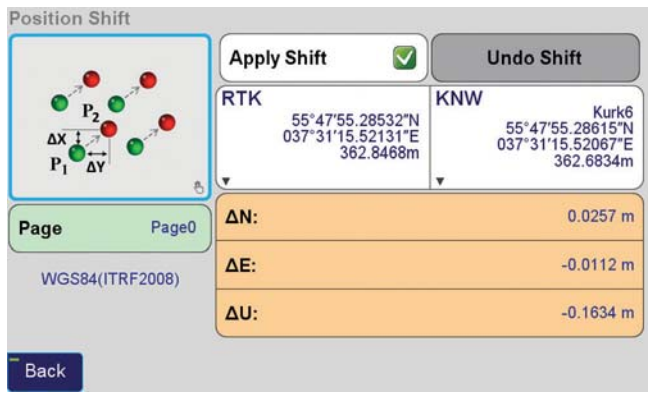
Reverse-Shift-it:
1) Take the TRIUMPH-LS to a **known point** and select the "**Shift**" function in the Setup Advanced screen. 2) Enter the **known coordinates** of that point. 3) Take a **shot** at that point and a base station shift will be **calculated and applied** to all previous and subsequent points surveyed in this session. You can then also use the newly surveyed points as known point for leap frogging during the project.





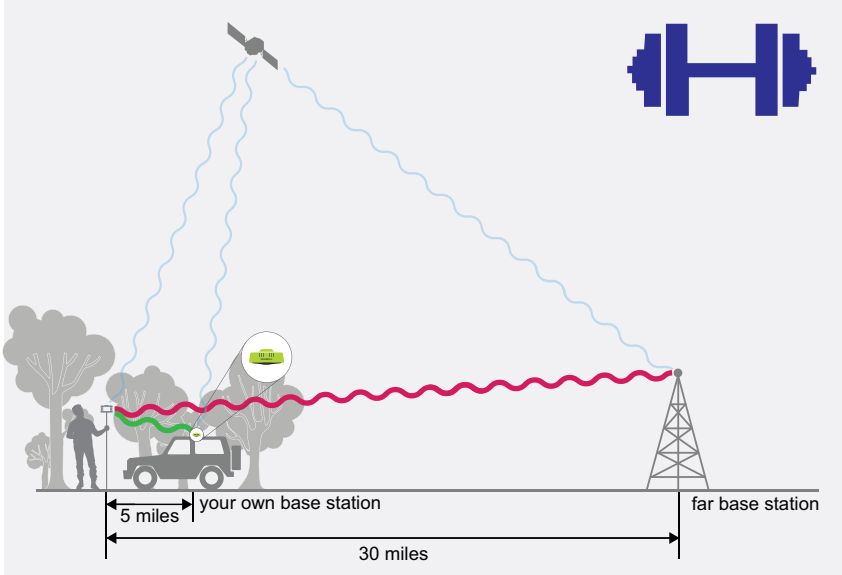




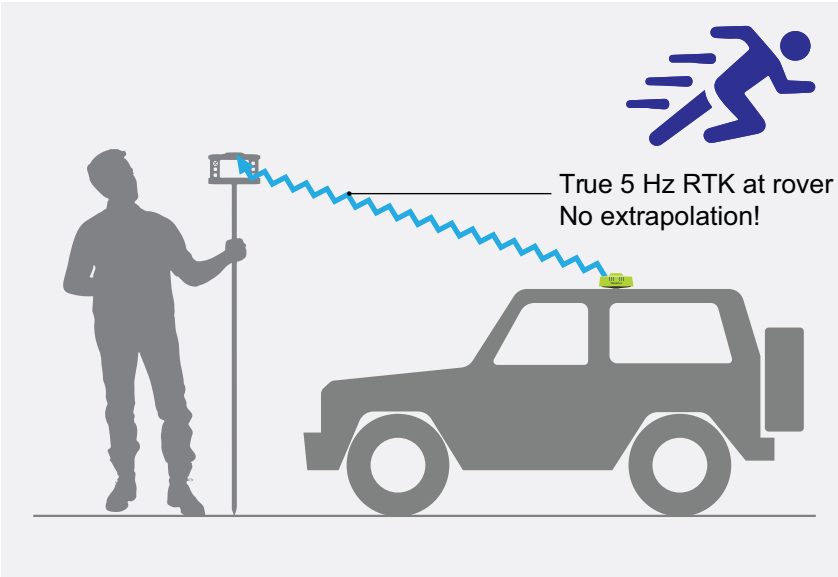


...and short baselines

4. Shorter baselines make it feasible to work in **difficult** areas (under tree canopy and in urban environments) because ambiguities have better contrast and are easier to resolve.



5. **Beast Mode RTK** is available only via our TRIUMPH-2 and TRIUMPH-1M base station. It makes ambiguity resolution up to 5 times faster because base station transmits base data 5 times per second. 5-Hz Beast Mode RTK is totally different from the up to 100-Hz RTK that is done by extrapolating the same 1-Hz data 100 times per second AFTER the ambiguities are fixed. This extrapolation technique does not improve the ambiguity resolution speed and is mainly used in applications like machine control after the ambiguities are fixed.



6. In addition to savings due to speed and reliability, it saves you RTN and communication charges. A complete system, Base + Rover + Radio + Controller & Controller Software, starts at $19,990. 0% financing available ($1,537.69 per month for 13 months) to active license US Professional Land Surveyors (PLS). Extended finance terms also available, contact sales@javad.com for details.

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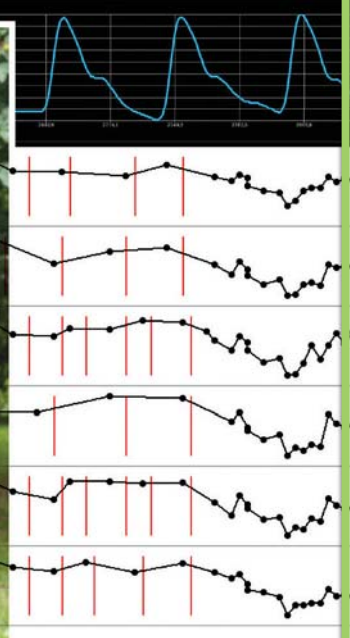

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Comparative study on Cadastral Surveying using Total Station and High Resolution Satellite Image

This study proposes the comparative study of Cadastral boundary Surveying and mapping using Total Station and Satellite Imageries in Nepal

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Recent technological advancements have shown that even RTK GPS and satellite imageries with high resolution can also be used for the cadastral surveying. Cadastral mapping using GPS Technologies and High Resolution Satellite Imagery are increasingly renowned in many developing countries of the world, substituting the traditional graphical Surveying method. The accuracies between the cadastral data obtained by RTK GPS technology are comparable with those acquired by conventional EDM/Total Station surveying for most cadastral purposes (Wan et al., 1999). The emerging new satellite technologies have brought revolutionary changes in the field of GIS-based Cadastral mapping system facilitating high resolution satellite images of 0.5 m (GeoEye-1) or even 0.34 m (GeoEye-2) spatial resolution. Creation and updating of cadastral maps, multifunctional cadastral data as land value maps and descriptions of study area in an economical manner are some of the potential use of HRSI in Cadastral works (Nisanci and Yomrahoglu, 2002). Study shows that HRSI such as QuickBird and IKONOS imagery are accurate enough for mapping purpose up to scale 1:5000 (Büyüksalih and Jacobsen, 2005). It is possible to achieve an accuracy of +/- 2 meters using 1 m resolution satellite imagery and GPS controls (Cay et al.)

Background

The cadastral mapping of the entire Nepal, completed in 1996 using graphical plane table surveying technique, was mainly carried out for the fiscal/revenue purposes. Due to urbanization and population growth, the value of land is increasing rapidly and those graphical cadastral maps are not adequate to reflect the real field situation in the urban areas. Due to the scale constraint, the cadastral maps prepared by graphical cadastral surveying method does not satisfy the land owners as they are asking for the accuracy of centimeter of land in the front face of their land parcel. The maps are in very ruin condition due to the continuously used and improper documentation. Even the land owners are asking for the recording and documentation of 3D real estate objects. Also, Survey Department has supported FIG's Cadastre Vision 2014. Considering these facts, SD has prepared its Logical Framework Plan (10 years from fiscal year 2005/2006) and one of the outputs after ten year will be the replacement of traditional technology with digital cadastral system for effective service delivery in cadastral related organizations in Nepal (Survey Department, 2006). Cadastral Survey Branch under Survey Department has introduced digital technology for data acquisition in Banepa Municipality as a piloting. After the success of this technology in piloting phase, the Program has been continued in other urban areas and improvements are going on. The traditional plane tabling method has been replaced by modern numerical cadastral surveying method using total station instruments and the cadastral database has been developed in fully digital environment.

But the pace of surveying activities is very slow and it seems impossible to achieve the progress as per LFP.

With continual research and development remote sensing (satellite image), techniques and systems developed have become more reliable, cheaper and more productive making satellite image more attractive for a range of surveying solutions. The question then arises that if satellite image is offering high quality data, can this technology be accurate and viable enough to compete with Total Station methods? Can this technology be used for boundary surveys, most notably boundary definitions and redefinitions? This case study is oriented to answer these questions.

Objectives

This project has centered its research on the comparative study of parcel boundary delineation from total station and High Resolution satellite imagery. The main purpose of the case study survey is to investigate the use of High Resolution satellite imagery for boundary survey in the context of cadastral mapping in Nepal.

Study Area

The location of the study area in Figure 1 is Charpane village which is located in the Birtamode Municipality - 4, Jhapa former charpane VDC - 8. It lies in the Eastern region of Nepal over the Terai belt. The village has almost flat terrain and because of the fertile soil, the land is mostly used for agriculture, effecting the urbanization to be minimal in the study area. The extent of study area spans from 26° 35' 31.10"N to 26° 35' 50.76" N and 87° 57' 8.16"E to 87° 57' 31.05"E. Charpane village area consists of agricultural parcels predominantly while the settlements are meagerly distributed.

Datasets

3 sets of data were used for the study above viz., 3rd order Control points, Total Station survey data and GeoEye HRSI. Third order Control points were obtained from Geodetic Survey Division, Survey Department, Government of Nepal. Cadastral Survey data acquired by Total station were obtained from Surveying-Mapping Section of Survey Office Chandragadi, Jhapa. A total of 102 parcels covering an area of 20.50 hectares of flat land were considered for the comparison and analysis. GeoEye Satellite Image of resolution 0.5m acquired on 14th March 2014 was used for the study. The image was, radiometrically as well as geometrically corrected and obtained from Topographical Survey Division, Survey Department, Government of Nepal.

Methodology

The methodology used in this study is shown in Figure 2 Initially, field survey using total station was carried out to obtain Ground Control points for geo-referencing the high resolution processed satellite Image. Further survey points were collected to delineate the parcel boundary. Secondly, geo-referenced satellite image were used for extraction of cadastral boundaries. Existing cadastral maps dating back to 1965 A.D collected from Department of Land Information & Archive (DOLIA) were outdated and surveyed without control points i.e. arbitrarily, hence was not used for the comparison. Thus the parcels acquired from different sources were used for comparison later.

Acquisition of Cadastral Data by Total Station

The study area comprised of existing geodetic control points (GCP) established by Geodetic Branch of Survey Department. However, these points were not adequate for conducting digital cadastral survey by total station. Furthermore, sufficient & well spread control points were required for geo-referencing the satellite image. Therefore, additional control points were established to meet the requirement of acquiring cadastral data using total station.

With ample amount of control points covering the study area, the collection of survey points were carried out. Prior to the traditional method of pegging or marking the parcel corners, respective land owners were asked to determine their boundary during adjudication. Reflectors were mounted on these demarked boundary corners and measured by the total station. Likewise successive parcel boundary points were recorded on the total station for delineation of parcel boundary.

The collected boundary points recorded on the total station were transferred into

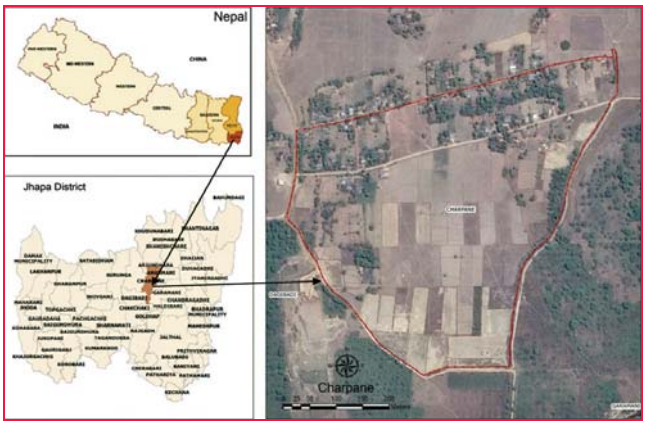

Figure 1: Location of Study Area

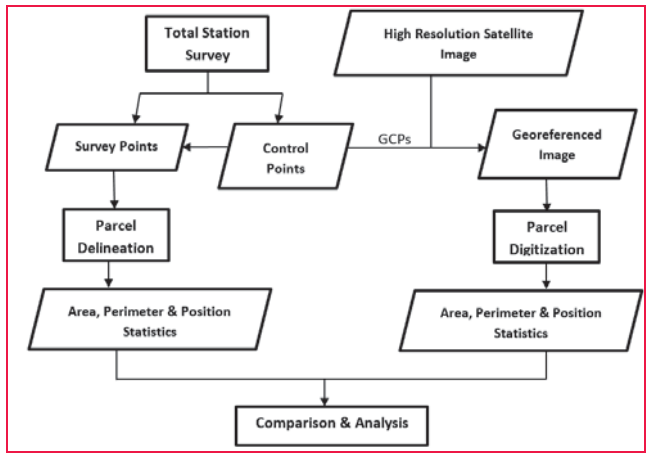

Figure 2: Methodology

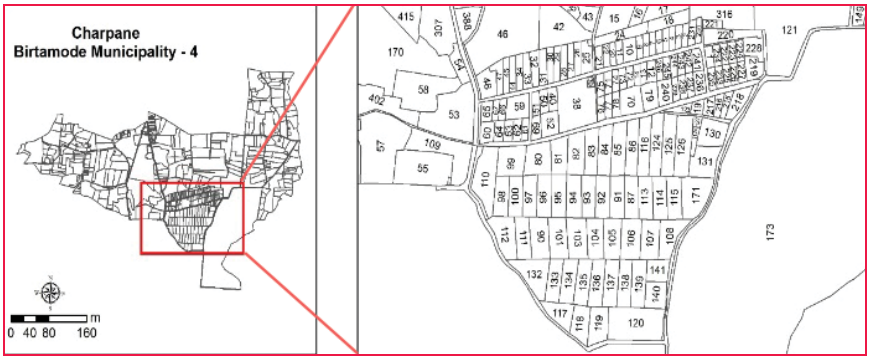

Figure 3: Cadastral map prepared by total station Survey

the computer via cable. Appropriate software was used to convert the total station file to CSV (comma separated value) file. This file was loaded into the GIS environment via GIS software ARCGIS 10.3, which was further used for processing and analysis. These data were stored in a predefined database schema to prepare the cadastral database. Parcel boundaries were delineated with the help of sketch made during the collection of survey points. Also the information related to the parcel such as land owner, address, type of land, etc. were stored in the attribute table of the respective parcel. Later the completed database is used for publishing notice, preparing field book, land ownership certificates etc. Thus, the final output is a database, where the parcel and its related documents are stored, which can be printed on a paper.

The final output were printed in form of maps in order to carry out the field verification to determine the flaws during measurements or data processing. Parcels were verified on the field and errors during measurements or processing were identified. Later these errors were checked and corrected and hence finalized to be used for providing service to the public.

Acquisition of Cadastral Data by HRSI

For this study purpose, we used 0.5 m resolution panchromatic GeoEye image. Since the image was previously radiometrically and geometrically corrected no further processing were required except for geo-referencing. For this GCPs were collected during control point densification for enhancing the positional accuracy of the image. The control points were collected by field observation using total station with reference to the existing third order control point established by Geodetic Survey Branch. The control points collected were well distributed over the study area and sufficient enough for the image to be georeferenced.

Sometimes the location information delivered by the satellite image are inadequate, and the data does not align

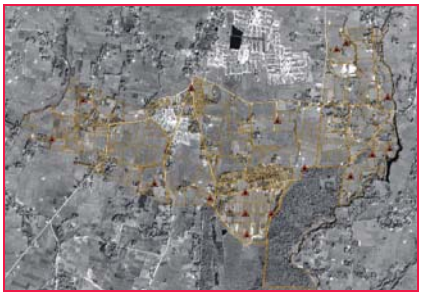

Figure 4: Control points for orientation of satellite Image

properly with field data. To ensure the locational accuracy the satellite image was aligned or georeferenced using the GCP acquired during field observations by total station. First order transformation was used for mapping each raster point to the target location as the satellite image was preprocessed before its procurement. About 15 control points were used in this process to increase the overall accuracy of the transformation as shown in Figure 4.

After geo-referencing the satellite image, parcels were digitized and verified on the map by overlaying the parcel boundary obtained from total station survey. Furthermore, mismatch of the parcel boundaries acquired from different sources were compared as stated in the next section.

Table 1: Time Analysis for Parcel delineation by TS

SN	Task Name	Duration
1	Control Survey	7 days
2	Detail Observation and data processing	18 days
3	Map printing	2 days
	Total	**27 days**

Table 2: Time Analysis for Parcel delineation by HRSI

SN	Task Name	Duration
1	Densification of Control Point	4 days
2	Preparation of OrthoImage	3 days
3	Digitization	1 day
4	Field Verification and Parcel Identification	6 days
5	Data Processing and Map Making	2 days
	Total	**16 days**

Result and Analysis

Time Comparison

The Table 1 & 2 shows the detail time involvement for deriving parcel using Total Station method and HRSI method respectively. Parcel Boundary delineation using Total Station requires intensive field observation thus consuming more cost and more time on field, whereas Parcel Boundary delineation using Satellite Image involves less field work and is economical compared to the method using total station.

It took 27 days for the total station method to delineate the parcel boundary and prepare its map while the same process was completed in 16 days by using Satellite Image. Hence it can be concluded that Cadastral mapping using HRSI requires less time than mapping done by the total station.

Resource Comparison

For the parcel boundary delineation using Total Station, more human resources and machinery equipment are involved in the activities like detail field observation and data processing, whereas less manpower with few machinery equipment can delineate parcel boundary using Satellite Image. The Figure 5 shows human resources involved in this study using both the Total Station and HRSI method.

Area Comparison

The parcels derived from the GeoEye image (0.5m) were used for analysis

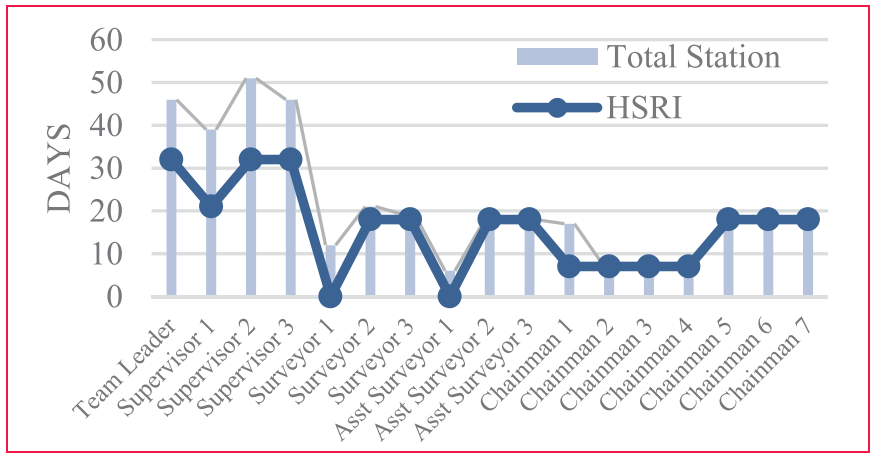

Figure 5: Human Resources required by TS & HRSI method

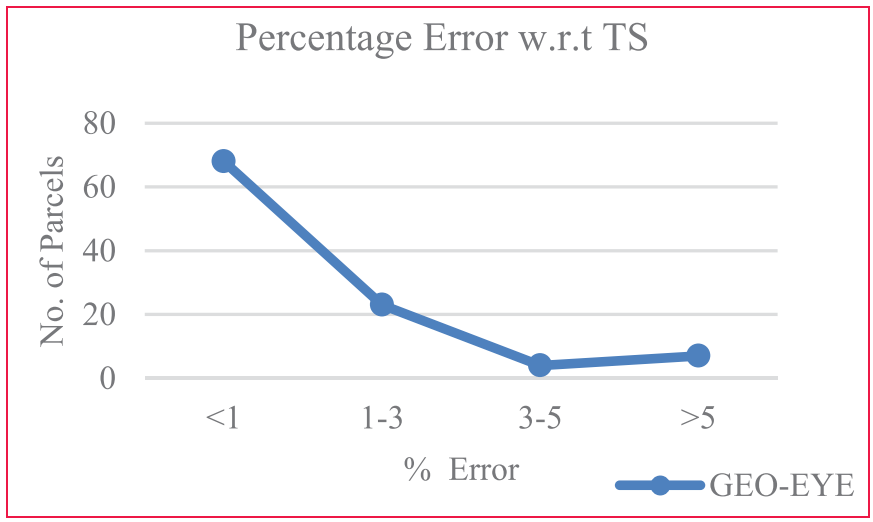

Figure 6: Plot on Number of parcels against the percentage error of area in GeoEye HSRI w.r.t TS Survey

Table 3: Comparison of Area deviation w.r.t TS Survey in GeoEye HRSI

%Error	No of Parcels	Percentage
<1	68	66.67
1-3	23	22.55
3-5	4	3.92
>5	7	6.86
Total	**102**	**100**

Table 4: Comparison of Perimeter deviation w.r.t TS Survey in GeoEye HRSI

%Error	No of Parcels	Percentage
<1	78	76
1-3	22	22
3-5	1	1
>5	1	1
Total	**102**	**100**

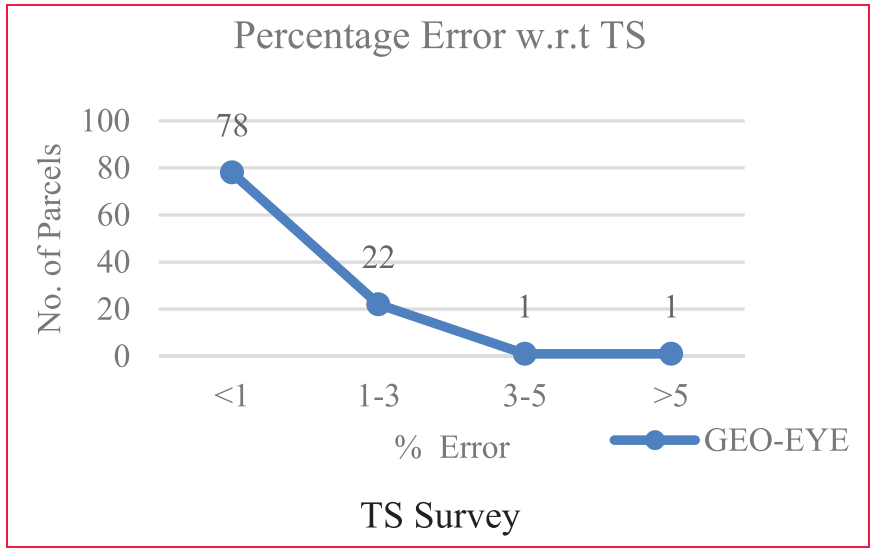

Figure 7: Plot on Number of parcels against the percentage error of perimeter in GeoEye HSRI w.r.t TS Survey

and compared with the parcels obtained from total station survey, as these data were used as reference area for the comparison. Matching parcels from both the layers were extracted and used for the analysis. A total of 102 parcels were extracted from the satellite image and used for comparison with the matching parcels derived from Total Station Survey.

The Figure 6 illustrates the percentage error ensued during mismatch between the two parcel layers derived from Total Station Survey and HRSI. It can be stated that 90 % of the parcels can be marked with less than 5% error using HRSI.

Also when observing the facts from the Table 3 , 67 % Parcels (68 Parcels) derived from the GeoEye image had area deviation less than 1 % with respect to TS Survey which shows an accurate match between two parcel layers. Around 23 % Parcels (23 Parcels) derived from the GeoEye Image had an area deviation between 1% and 3% w.r.t TS Survey which shows a minimal mismatch between these two parcel layers. However, very low percentage i.e around 4 % Parcels (4 parcels) derived from GeoEye Image had an area deviation between 3% and 5 % w.r.t TS Survey which indicates mismatch between two layers and considered to be a large deviation. These large deviations are due to several factors creating hindrance in derivation of parcels from the Satellite image such as unclear parcel boundaries and high canopy cover over the boundaries.

Perimeter Comparison

The perimeter of the derived parcels from GeoEye and TS Survey were used for the analysis. A total of 102 parcels were extracted from the satellite image and used for comparison with the matching parcels derived from Total Station Survey.

The Figure 7 shows the percentage error comparison of perimeter between two layers of parcels derived from GeoEye image and TS Survey. Observing the steep declination, it can be stated that larger no of parcels can be matched with higher accuracy between the two layers.

When observed in the Table 4, 76% Parcels (78 Parcels) derived from GeoEye had perimeter deviation less than 1% w.r.t to TS Survey which shows an accurate match between two parcel layers. Around 22% Parcels (22 Parcels) derived from GeoEye image had perimeter deviation between 1 % and 3% which shows a minimal mismatch between these two parcel layers. Only 1% Parcels derived from GeoEye had perimeter deviation between 3% and 5% w.r.t TS Survey which indicates small mismatch between two layers.

Position Comparison

Positional Accuracy of the parcel boundary derived from GeoEye Image and TS Survey were assessed by identifying the shift in position of the parcels Centroid coordinates calculated in terms of distance between them .A total of 102 parcels were extracted from the satellite image and used for comparison with the matching parcels derived from Total Station Survey. Centroid Coordinates of each parcel derived from TS Survey as well as parcel derived from GeoEye image were calculated and the distance

Though the obtained results from the comparison of two techniques in delineating the parcel boundaries shows good potential for HRSI's use in cadastral survey, higher accuracy cannot be achieved as that of the total station

Table 5: Comparison of position Deviation w.r.t. TS survey and GeoEye HRSI

Shift (m)	No of Parcels	Percentage
<1	86	84
1-3	15	15
3-5	1	1
>5	0	0
Total	**102**	**100**

between the centroids of the corresponding parcel boundary was measured using the Euler's Distance Formula (1):

$$\Delta d = \sqrt{\{(x1 + x2)^2 + (y1 + y2)^2\}} \quad (1)$$

Where Δd is the shift in meters, (x,y) is the coordinate value of the point From Table 5, we can observe that 84% Parcels (86 Parcels) derived from GeoEye image had centroid shift less than 1 m w.r.t TS Survey which shows an accurate match between these two parcels. About 15 % Parcels derived from GeoEye image had centroid shift between 1% and 3% which shows a minimal mismatch between these two parcel layers. Only 1 % Parcels had centroid shift between 3% and 5% indicating mismatch between two layers. From this it can be depicted that more number of parcels can be derived with acceptable accuracy using HRSI.

High Resolution satellite imagery provides clear identification of parcel boundaries and other features due to which conventional and traditional method of cadastral mapping is shifting towards more advanced, reliable and economic methods

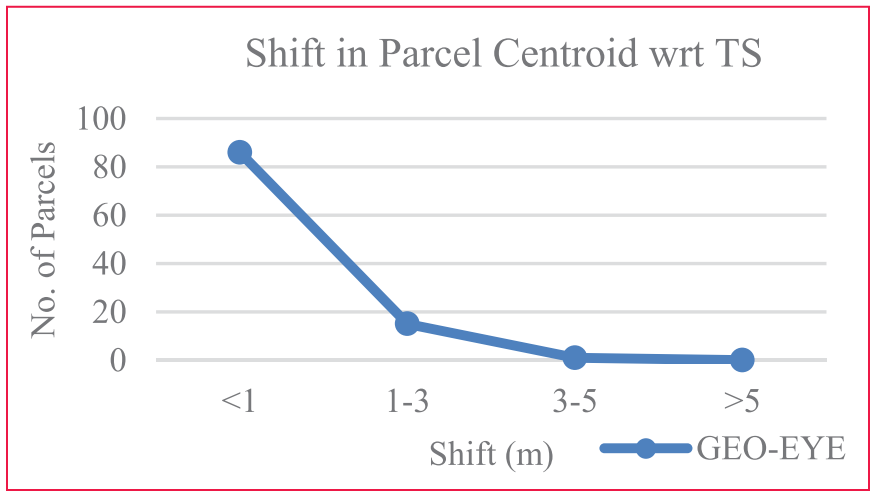

Figure 8: Plot on Number of parcels against the percentage error of position in GeoEye HSRI w.r.t TS Survey

Limitations

The study was carried out under favorable conditions and circumstances for which the tough part can go neglected. Some of the limitations that govern this study are as follows:

i. Study area comprised of flat lands, mostly agricultural fields with almost no settlements.
ii. Considerably large parcel plots were used for the comparison.
iii. Image acquired was of during harvesting season where the parcel boundary could be easily depicted.
iv. The best digitization of the parcel boundary among three digitizers were used for the comparison.

Conclusions

Todays' emerging new Satellite Technologies with high resolution has proved to be a boon in the field of land surveying for cadastral mapping with high accuracy, cost effective and time efficient manner. High Resolution satellite imagery provides clear identification of parcel boundaries and other features due to which conventional and traditional method of cadastral mapping is shifting towards more advanced, reliable and economic methods. This study incorporates the potential use of High Resolution satellite image for indirect land surveying for cadastral survey /resurvey to achieve high accuracy with low cost and within small timeframe.

The principle objective of the project is to compare the cadastral survey done by High Resolution satellite image and that by Total Station in context of Nepal. Comparisons between parcel boundaries derived from total station Survey and HRSI shows good potential of the later for Cadastral Survey. For this, various attributes of the derived parcels such as area, perimeter and position from both techniques were compared along with human resource involved and time for the completion of task.

The comparisons shows that around 80% of the parcel boundary can be derived with acceptable accuracy and precision meeting the standards of cadastral Survey. In addition, use of HRSI will result in faster updating of Cadastral maps in more economical and convenient manner. From the above findings it's clear that use of HRSI can reduce the Cost, Time and Human resources as compared to the total Station method.Also the parcel boundary can be derived with acceptable accuracy with the use of HRSI

However, large deviations in parcel areas were due to unclear boundaries with similar spectral response, high canopy cover over the boundaries. etc.

Recommendations

Though the obtained results from the comparison of two techniques in delineating the parcel boundaries shows good potential for HRSI's use in cadastral survey, higher

accuracy cannot be achieved as that of the total station. There are some limitations to this technique as it solely relies on visual interpretation. In case of highly dense settlement area, shadow region, high canopy cover, unclear boundaries due to similar spectral reflectance, small parcel etc. similar accuracy cannot be achieved.

Every techniques has its own flaws and benefit. To obscure the flaws of one with the benefits of the other would be the best option to overcome any task with high accuracy at minimal cost. Similar an integrated approach of both the techniques can be used to achieve higher accuracy in an economical manner and can even fasten the process. Furthermore, as aimed at the beginning of the project, introducing the GPS technology for cadastral survey could have enhanced more realistic picture of technologies intervention for expediting cadastral surveying.

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References

[1] T. Cay, O. Corumluoglu and F. Iscan, "A Study on Productivity of Satellite Images in the Planning Phase of Land Consolidation Projects," presented at the XXth ISPRS Congress "Geo-Imagery Bridging Continents", Istanbul, Turkey, 2004.

[2] G. Büyüksalih and K, Jacobsen, "Optimized Geometric Handling of High Resolution Space Images," ASPRS annual convention, Baltimore, p.9, 2005.

[3] Z. Ali, "Assessing Usefulness of High-Resolution Satellite Imagery (HRSI) in GIS-based Cadastral Land Information System," Journal of Settlements and Spatial Planning, 3(2), pp. 93-96, 2012.

[4] Z. Ali, A. Tuladhar and J. Zevenbergen, "An integrated approach for updating cadastral maps in Pakistan using satellite remote sensing data," International Journal of Applied Earth Observation and Geoinformation, 18, pp. 386-398, 2012

[5] S. S. Rao, J. R. Sharma, S. S. Rajasekhar, D. S. P. Rao, A. Arepalli, V. Arora., Kuldeep, R. P. Singh and M. Kanaparthi., "Assessing Usefulness Of High-Resolution Satellite Imagery (HRSI) for Re-Survey Of Cadastral Maps," ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume II-8, 2014.

The paper was presented at FIG - ISPRS workshop, 2015: International Workshop on Role of Land Professionals and SDI in Disaster Risk Reduction: In the Context of Post 2015 Nepal Earthquake. Kathmandu, Nepal, 25th - 27th November, 2015

Zone based indoor location using GNSS simulators

This paper describes the data collection, the synchronization methods, and the GNSS RF signal generation capability of the Intelligent Repeater System

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Indoor positioning is highly desired for many applications, including personnel tracking for safety in normally unmanned locations. There are several methods and technologies available to achieve accurate indoor position and location but the majority relies on dedicated, specialized equipment or modifications to achieve this goal. With the growing number of devices that contain GPS receivers it is practical to develop a system that will allow indoor positioning using these already available receivers.

GPS repeaters are typically used as a solution to bring GPS signals indoor. A traditional repeater consists of installing a GPS antenna outdoor along with an amplifier, and running a loss low coaxial cable to the indoor space with a radiating antenna or using a leaky-coaxial cable to transmit the signal to a wider area. There are several issues with this approach. The first is that any GPS receiver that receives the repeated signal will believe that it is in the location of the outdoor antenna, not the actual indoor position. This can make it difficult to locate people, especially if they are underground or if the indoor position is far away from the outdoor GPS antenna location. Secondly, if the system is using a leaky cable to supply the signal to the user, the signal will be strongest near the antenna amplifier which is typically located in an outdoor location, and could disrupt GPS for users in the local area.

The Intelligent Repeater System overcomes these issues. An outdoor antenna is installed anywhere with a clear view of the sky. Rather than attaching the antenna directly to an amplifier and antenna system in a traditional repeater system, the antenna in an Intelligent Repeater System is attached to a data collection and synchronization unit. The information about the live sky signals is collected and accurate 10MHz and 1PPS signals are produced. These signals can be used by a GNSS simulator to recreate the live sky signals, but instead of generating signals that would correspond to the outdoor antenna location, the generated location can be programmed to simulate a position anywhere in the world into the indoor zone.

Using the Intelligent Repeater System, personnel or equipment can be located within a given zone, making critical response times shorter, improving safety, and providing more accurate information than a traditional repeater system.

This paper describes the data collection, the synchronization methods, and the GNSS RF signal generation capability of the Intelligent Repeater System.

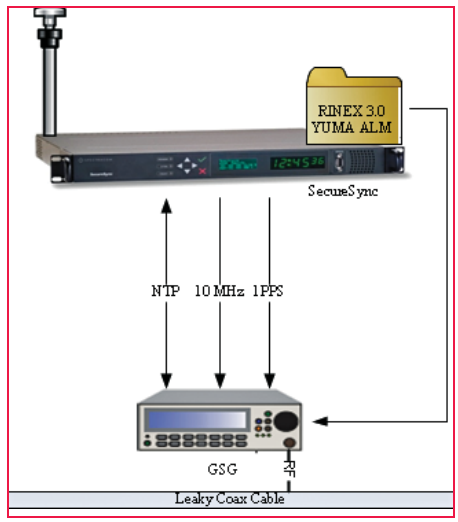


Figure 1: Intelligent Repeater System – Single Zone

Intelligent repeater system

The Intelligent Repeater System consists of a Spectracom SecureSync® for the data collection and synchronization signals, and multiple Spectracom GSG Simulators for the GNSS RF signal generation. Working together these components form a system to deliver zoned-based indoor location that any GPS receiver can use for indoor positioning in GPS-denied environments.

Data Collection

In order to re-generate the GNSS signals accurately the GNSS simulator needs to have information about the live signals. This information includes precise orbital information for the satellites in view (ephemeris data) and the almanac information for the entire constellation. The system also needs information about the leap second, the satellite clocks, and all the data contained in the NAV message for the constellation. This complete re-generation of the signals allows for seamless transition between the live sky signal and the signals generated within the zones.

This data is collected by the SecureSync. The receiver in the SecureSync receives the ephemeris and almanac information from the satellites in view and the SecureSync software generates ephemeris data files in RINEX 3.0 format and almanac data in YUMA format. These files are updated with current data at a user configurable rate. For the Intelligent Repeater System, the files are updated once every 10 minutes. The station name and the record duration are also configurable.

The files are stored in the SecureSync memory and can be retrieved manually by a user or automatically by a GSG Simulator using HTTP Wget.

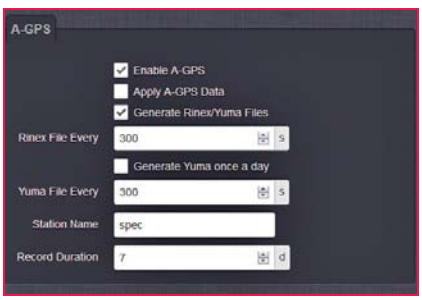


Figure 2: SecureSync Data Generation Settings

Synchronization

It is important that the re-generated signals are synchronized to the live sky signals. This synchronization is done by transferring UTC Time from the SecureSync using NTP and a 1PPS signal. The GSG Simulator gets the current time to the nearest second, loads the simulation scenario, and uses NTP to align to the precise current time. The GSG Simulator is set into ARM'ed mode, where it will open the arming window when the set NTP time has been reached. The SecureSync allows the 1PPS to be time aligned to the rising or falling edge and also allows for an offset to be added compensating for additional system delays. In this system the SecureSync 1PPS is set to align to the falling edge and an offset of 40ns is applied to compensate for internal delays in the simulator. The first falling edge detected from the 1PPS signal once the arming window is opened starts the RF generation in precise alignment with the live GNSS signals.

When the SecureSync is synchronized using GNSS directly with the NTP and 1PPS signal generated from that unit, the difference between live sky time and simulated time can be brought to < 1ns. When the SecureSync is connected to GNSS for data collection and timing is located in a remote location, local SecureSync units can be used to provide the 1PPS signal to the GSG Simulators. Time transfer between the local SecureSync receiving GNSS signals and the remote SecureSync can be done using IP based timing (PTP or NTP) or directly using coaxial cables (IRIG or 1PPS signals). Network timing can provide synchronization as low as 100's of nanoseconds to millisecond time differences.

The affect the difference in timing has on the system varies. With nanosecond level of timing, the system allows for transitions between live sky and indoor zone, or between indoor zone and indoor zone with no reset or loss of signal during transition, effectively providing a seamless rapid transition for the user. With microsecond and millisecond levels of time synchronization, it will take a longer time (up to 1 minute) for the receiver to transition between live sky and indoor zone. It may also require a loss of the live sky signals completely for the receiver to transition over to the indoor zone position. Indoor zone transitions (between zones) will still be very fast though because the zones will be < 1ns synchronized to the each other, the offset due to timing variations will only occur for the live sky to indoor zone case.

RF Generation

The GSG Simulator is used to generate the GNSS RF signals for transmission within each zone. Multiple GSG Simulators can utilize data and timing signals from a single SecureSync, so the number of outdoor antennas needed for the system is minimal. A single SecureSync can be configured with enough outputs to support up to 20 GSG Simulators, each representing a different zone. An unlimited number of GSG Simulators can receive the time using NTP and access the collected data of a single SecureSync, and multiple SecureSync unitss can be slaved to provide the 10MHz and 1PPS signals. This makes the system scalable and able to accommodate many zones for large deployments. Figure 3 illustrates an example deployment.

The GSG Simulator generates the GPS/GNSS signals by utilizing the available RINEX 3.0 and YUMA almanac files. The satellite orbits are determined using the RINEX 3.0 data, and the NAV message is

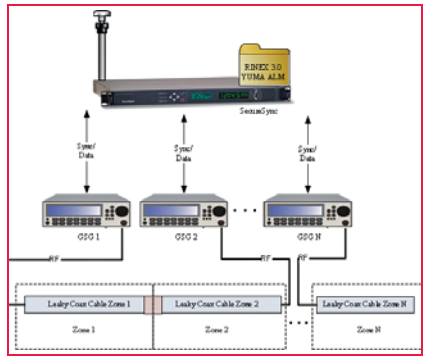


Figure 3: Example Deployment

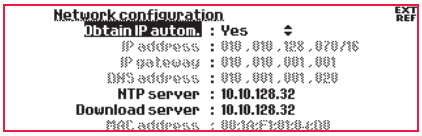


Figure 4: GSG Simulator Server Settings

filled using the data from the RINEX and YUMA files. This is a standard function of the GSG Simulator and therefore no special firmware or customization of the simulator software is needed. Both the SecureSync and the GSG Simulator are COTS products configured for use in the Intelligent Repeater System.

The sources for both the NTP server and the Download server in the GSG Simulator can be selected. Both of these can be set to a SecureSync or to an internet server. Figure 4 shows the NTP and Download server configuration.

When the SecureSync has a multi-GNSS receiver installed, it can simultaneous collect the data from multiple constellations simultaneously. GSG Simulators can then generate signals for any and all constellations that have been received by the SecureSync, enabling multi-frequency, multi-constellation signal re-generation for multiple indoor zones. Currently these constellations include GPS, GLONASS, BeiDou, and QZSS. In the future the system will support Galileo as well.

Zones

Careful planning, installation and commissioning is required to ensure the appropriate power levels within each zone. If the signals are too strong, users transitioning to adjacent zones will be difficult, and the generated signals could leak out of the indoor areas into the outdoor locations where users are utilizing live sky signals. The users in this proximity could be negatively and unexpectedly affected. On the other hand, if the signals are too weak, the user receiver might not pick up the indoor positioning signals in some areas of the zone, or the transition from zone to zone may take longer than expected or desired. Planning the zones based on the leaky cable or antenna deployment is absolutely necessary. During installation, a known receiver can be used to measure the received signals within the zones. Using this information it is possible to adjust the power levels from each GSG Simulator so that the power level of the first zone is 2dB less than the power level of the second zone at the transition point between zones. This will allow the receiver to move from zone to zone with quick transition times, avoiding the situation where the receiver would have to completely lose the signal from one zone before picking up the next zone's signal. Using GSG Simulators allows the power to be adjusted with a 0.1 dB resolution in each zone, so the power levels can be carefully configured and optimized during installation and commissioning.

The Intelligent Repeater System can be deployed to provide GNSS coverage into areas that do not normally receive GNSS signals. By creating zones in an underground area or within a building to differentiate floors or rooms, it is possible to locate personnel and assets to within a certain zone. Zone sizes can be set based on the area to be covered and the number of GSG Simulators deployed.

System Monitoring

In-Zone Monitoring

A GNSS receiver can be placed in each zone and monitored for the correct power level and position. This will allow for complete monitoring of the system from the signal generation to the signal distribution and transmission. The receivers in the zone can be monitored wirelessly or with an existing network. With large deployments, this option could become cost prohibitive and may be difficult to monitor but many of the functions could be automated to assist the user

Equipment Monitoring

The SecureSync and the GSG Simulators in the system can also be monitored for status and errors over network connections. A monitoring software can be installed on a network computer and can check the status of the SecureSync synchronization, data generation and NTP status remotely. The same monitoring software can also verify the GSG Simulator uptime, power level set, and the satellites generated. Remotely rebooting the SecureSync and GSG Simulator is also possible, to simplify maintenance procedures.

When the system is installed on individual local networks without LAN connection, network monitoring cannot be used. In this case the SecureSync can check the basic status of the GSG Simulators and report any errors using a single sum alarm via an installed relay card that can be sent to a local monitoring system.

Conclusion

Bringing GNSS signals indoors is a common solution to indoor positioning. A traditional GNSS repeater system can be used for this purpose but comes with several significant limitations. By dividing the coverage area into zones, personnel and assets can be located to the resolution of the zones. However, a traditional repeater system has several drawbacks. The need for an outdoor antenna for each zone indoor can rapidly drive up the system costs. Additionally, in some installations, it may not be possible to get permissions or licenses from landowners to install antennas in convenient locations above ground. Furthermore, the re-radiated position could be several hundred meters away from the actual position. On the other hand, the Intelligent Repeater System uses COTS products that can overcome these issues and still provide a reliable alternative that works with any GNSS receiver. By deploying the Intelligent Repeater System in an environment that does not normally receive GNSS signals, the safety of responders and maintenance personnel in the area is greatly improved, especially in the situations where they need to be located quickly and accurately. The flexibility and reliability of the Intelligent Repeater System make it a practical solution that can be deployed as part of building or underground infrastructure either during initial construction or as an addition to the area.

The paper was presented at International Symposium on GNSS 2015, Kyoto, Japan, November 16-19, 2015

GSA Announces Horizon 2020 European GNSS Grants

The European GNSS Agency (GSA) has announced on October 27, 2015 the evaluation results of its second Horizon 2020 call for Galileo applications. Some 13 projects made the main list to be funded, receiving grants totaling nearly €24.9 million (US$27.5 million).

In its second round, Horizon 2020, which represents the European Union's framework program for research and innovation, focused on "innovation actions" and received 91 total submissions. Funding went to those proposals that best showed "a significant focus toward impacting global markets with strong innovation and the incorporation of new knowledge," according to the GSA. The teams associated with the 13 selected proposals comprise 95 different participants that will receive funding this round.

Of the 91 submissions, 45 fell under the category of European GNSS (E-GNSS) applications, 31 under the topic of Small and Medium Enterprise (SME) Based European GNSS applications, and 15 under the topic of "releasing the potential of European GNSS applications through international cooperation." E-GNSS applications received the lion's share of funds: eight projects covering transport, surveying, LBS, agriculture, emergency services, and other professional applications were recommended to receive nearly €20.4 million.

Three SME-based E-GNSS projects were approved for €2.9 million in funding, addressing applications in niche markets and business models, mass market LBS products, market testing, and so on. Two projects were awarded €2.7 million to develop innovative international applications highlighting E-GNSS services.

Two Galileo satellites arrive in French Guiana for Arianespace's year-ending Soyuz mission

The satellites for Arianespace's 12th flight in 2015 – which will close out the company's record year of launch activity – have arrived in French Guiana with delivery of the latest two European Galileo navigation platforms to be lofted by Soyuz. Scheduled for sometime in December, the upcoming medium-lift Soyuz mission with its pair of Galileo satellites will conclude Arianespace's busiest launch activity year ever involving all three members of its launcher family – which also includes the heavy-lift Ariane 5 and lightweight Vega. *http://spaceref.com/news/*

China to set up BDS international maritime surveillance centre

China is planning to build an international maritime surveillance centre in its major Tianjin port city to monitor and assess the accuracy of BEIDOU. The surveillance centre will monitor and assess the accuracy, operating situation and signal quality of the system and report to users on the sea, ensuring high quality BDS service," said Chai Jinzhu, an official with the ministry's north China sea maritime insurance centre.

Galileo update

Galileo satellites set for year-long Einstein experiment

Europe's fifth and sixth Galileo satellites - subject to complex salvage manoeuvres following their launch last year into incorrect orbits - will help to perform an ambitious year-long test of Einstein's most famous theory. Galileos 5 and 6 were launched together by a Soyuz rocket on 22 August 2014. But the faulty upper stage stranded them in elongated orbits that blocked their use for navigation.

ESA's specialists moved into action and oversaw a demanding set of manoeuvres to raise the low points of their orbits and make them more circular.

"The satellites can now reliably operate their navigation payloads continuously, and the European Commission, with the support of ESA, is assessing their eventual operational use," explains ESA's senior satnav advisor Javier Ventura-Traveset.

"In the meantime, the satellites have accidentally become extremely useful scientifically, as tools to test Einstein's General Theory of Relativity by measuring more accurately than ever before the way that gravity affects the passing of time."

Although the satellites' orbits have been adjusted, they remain elliptical, with each satellite climbing and falling some 8500 km twice per day. It is those regular shifts in height, and therefore gravity levels, that are valuable to researchers.

Albert Einstein predicted a century ago that time would pass more slowly close to a massive object. It has been verified experimentally, most significantly in 1976 when a hydrogen maser atomic clock on Gravity Probe A was launched 10 000 km into space, confirming the prediction to within 140 parts in a million.

Atomic clocks on navigation satellites have to take into account they run faster in orbit than on the ground - a few tenths of a microsecond per day, which would give us navigation errors of around 10 km per day. This new effort takes advantage of the passive hydrogen maser atomic clock aboard each Galileo, the elongated orbits creating varying time dilation, and the continuous monitoring thanks to the global network of ground stations. "Moreover, while the Gravity Probe A experiment involved a single orbit of Earth, we will be able to monitor hundreds of orbits over the course of a year," explains Javier.

"This opens up the prospect of gradually refining our measurements by identifying and removing systematic errors. Eliminating those errors is actually one of the big challenges.

"For that we count on the support of Europe's best experts plus precise tracking from the International Global Navigation Satellite System Service, along with tracking to centimetre accuracy by laser."

The results are expected in about one year, projected to quadruple the accuracy on the Gravity Probe A results. *http://www.spacedaily.com/reports/*

Under an arrangement made by the Maritime Safety Administration, the north China sea maritime insurance centre has been working on the construction and operation of the surveillance centre. *http://economictimes.indiatimes.com*

Magnetic protein may provide animals with navigation information

Although the ability of biological entities to register magnetic fields is fairly well accepted, the means by which they do so hasn't been definitively identified. A lot of attention has focused on cases where small clusters of iron are formed within cells. But researchers in China figured that a protein might exist that could act as a magnetic sensor. So they screened the Drosophila genome for one that fit the bill—and found it.

A couple of different models have been postulated to explain the biological basis of magnetosensing. Cryptochromes (Cry) are light-sensing proteins used by birds to orient and navigate using the Earth's magnetic field. Although these can sense the inclination of the geomagnetic field, they cannot detect polarity and thus cannot function as a compass.

Scientists thus assumed that another protein must be involved, likely one that binds to iron (which can detect polarity and thus can function as a compass). So they scanned a database of the Drosophila genome for genes encoding proteins that (a) bind to iron; (b) are expressed in the head (where Cry is); and (c) are found within the cell, rather than on the cell membrane (again, that's where Cry is). They identified nine candidates in this in silico search, but only one bound to the Drosophila cryptochrome. Bingo: the Drosophila magnetoreceptor protein, dMagR.

Like cryptochromes, genes for MagR are found in all animal species. In addition to Drosophila, Cry/MagR complexes were found in butterflies, pigeons, mole rats, minke whales, and humans. Further examination of the complex purified from pigeon retina revealed that it consists of a linear core of iron-containing MagR

proteins surrounded by a sheath of Cry proteins. As a unit, the complex acts as a light-dependent biocompass, capable of detecting the polarity, intensity, and inclination of the Earth's geomagnetic field. It has an intrinsic magnetic moment, as verified by the fact that it orients parallel to an enhanced external magnetic field. *http://arstechnica.com/science/*

GPS Ground System security upgraded

The ground system for the U.S. Air Force's PNT satellites recently received a software update and security upgrade under a two-year-old contract with Lockheed Martin. Known as the GPS Intrusion Protection Reinforcement, the updates enable greater data protection within the Air Force's current Operational Control Segment, which serves as the ground system for the Air Force's GPS satellites. The updates also resolve equipment obsolescence issues.

ULA drops out of GPS III launch competition

The United Launch Alliance (ULA) send-off of the 12th GPS Block IIF satellite scheduled for next February 3 may turn out to be the last GPS launch for the Boeing/Lockheed Martin joint venture — at least for a while.

ULA did not submit a bid to launch of GPS III

In a statement released on November 16, ULA said that it would be "unable to submit a compliant bid for GPS III-X launch services." The company blamed its decision on the lack of Atlas rockets due to restrictions imposed by the 2015 National Defense Authorization Act, which continued a ban on Russian-built RD-180 engines imposed following Russia's annexation of Crimea.

Russia's Glonass-M navigation satellite planned for launch in late December

The Russian navigation satellite Glonass-M is planned for launch from the Plesetsk space center in north Russia in late December. The satellite will be orbited by a Soyuz-2 carrier rocket with the Fregat booster. The Glonass-M satellite, which has No. 51, will replace the satellite that has operated for three years above the warranty term in the Russian navigational orbital grouping. *http://tass.ru/en/science/*

Azerbaijan can join Russia's GLONASS system

Azerbaijan doesn't rule out the possibility of joining Russia's GLONASS satellite navigation system in the future, head of Azercosmos JSC Rashad Nabiyev said.

Azerbaijan's participation in this project is not currently on the agenda, but it is well possible if the sides reach a corresponding agreement, he added. *http://en.trend.az*

Russia to Install 48 Glonass Navigation Stations in 36 Countries

"The installation of 48 GLONASS measurement stations are in Russia's plans in the country and abroad and it's planned that 36 countries will begin in cooperation," Oleg Gorshkov said recently during an innovative technologies forum in Moscow. *http://sputniknews.com*

Karutin Named General Designer of GLONASS Program

Russian President Vladimir Putin has approved the appointment of Sergey Karutin, deputy director of the Central Research Institute of Machine Building and head of its PNT Center responsible for GLONASS operations, to serve as the new general designer of the Russian GNSS program.

In his new role, Karutin will undertake the "comprehensive work of further developing the system," according to Russian Deputy Prime Minister Dmitry Rogozin in charge of the nation's defense and space industry.

His position is one of 21 supervisors of key Russian scientific and military projects who will be included in the Military-Industrial Commission of the Russian Federation.

GPS for autistic boys during school in the US

The Long Island parents of two autistic boys have outfitted their sons with GPS tracking devices to wear at school in case they run away.

Brian and Dayann McDonough say their sons have wandered from home and school repeatedly. The Merrick parents initially were met with resistance from school officials who were concerned about how the GPS devices would affect other students' privacy.

North Merrick school officials now say they're allowing the use of the devices as long as there's no audio element that could jeopardize confidentiality to special education students.

The devices can send a text and email notification of a location change. *http://www.fox5ny.com*

Air Force launches 11th GPS IIF satellite

The Air Force successfully launched the 11th GPS IIF satellite into orbit Oct. 31, according to Air Force Space Command.

The Boeing-built satellite was launched at 12:13 p.m. Eastern Time from Cape Canaveral Launch Station 41 in Florida using an Atlas V 401 launch vehicle.

In addition to the GPS IIF satellites, Space Command has GPS IIAs, 12 GPS IIRs and seven GPS IIR-Ms in orbit. These satellites are operated by Air Force Space Command's 50th Space Wing at Schriever Air Force Base, Colorado. Space command plans to launch one more GPS IIF satellite. Testing is underway for the GPS III satellite, which prime contractor Lockheed Martin vows will have three times better accuracy and eight times improved anti-jamming capabilities, and it should be the first GPS satellite that will be interoperable with other global navigation satellite systems. But the launch of the first GPS III satellite has been delayed until 2017 because of problems with the satellites' navigation system, which is being built by subcontractor Exelis. *http://www.airforcetimes.com*

In Coordinates

10 years before...

mycoordinates.org/vol-1-issue-7-december-05/

GEODESY

Measuring geopotential difference between two points

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

W B Shen

PERSPECTIVE

Geodetic infrastructure in India

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

N K Agrawal

Indian Grid

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

HIS COORDINATES

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

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

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

NAVIGATION

Multiple reference station GPS networks for airborne navigation

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

Ahmed El-Mowafy

NSDI

NSDI in India: The reality behind the dream

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

Enhanced mapping system for 911 emergency dispatchers

Two computers sat side-by-side at a recent demonstration showing the mapping available to Kane County Emergency Communications (KaneComm) dispatchers before and after the county's GIS department completed enhancements to better serve people calling 911 for help. Emergency dispatchers now see what the caller sees, Deputy Director Michelle Guthrie said.

The equipment is the same but the software now provides detailed maps along with aerial photos showing where a 911 call is made from a cell phone, Guthrie said. Emergency dispatchers no longer have to jump from screen to screen to find maps pinpointing locations, saving a lot of time, Guthrie said. The software also provides closer locations to cell towers for first responders to find anyone who needs help, she said. *www.chicagotribune.com*

OGC and ASPRS to collaborate on geospatial standards

The Open Geospatial Consortium (OGC) and the American Society for Photogrammetry and Remote Sensing (ASPRS) have agreed to work together more closely in the application and promotion of standards and best practices for the location and geospatial industries.

"The advancement of standards and best practices in areas such as point clouds benefits from the partnership of key organizations," said Mark Reichardt, OGC's president and CEO. "We are deeply appreciative of the alliance recently established between ASPRS and OGC. This alliance encourages our respective members to join forces in collaborative activity that will result in benefits for the whole global community as photogrammetry and remote sensing grow in importance."

"Both the OGC and the ASPRS have long-established roles in the expanding field of location and geospatial technologies," said Michael Hauck, ASPRS's Executive Director. *www.spacedaily.com*

The Swedish Hydrographic Office chooses CARIS

The Swedish Maritime Administration (SMA) has chosen CARIS Hydrographic Production Database (HPD) as the new system to meet the Hydrographic Office's current and future requirements. With HPD the Hydrographic Office will have the latest and most efficient system for the management of spatial data and the efficient production of paper and electronic charts. Efficiently and securely migrating data and transitioning the work force to a new system while continuously ensuring safety at sea is vital for the Hydrographic Office, who represents Sweden as a member of the International Hydrographic Organization (IHO).

Gateway to maps for Europe takes centre stage at EC

National Mapping, Cadastral and Land Registry Authorities have demonstrated how their maps and land information can help the European Commission to achieve the EU's priorities.

Recently concluded two-week Maps for Europe event in Brussels focused on the use of geospatial data to better understand information related to people and places. It was organised by EuroGeographics, the membership association for European National Mapping, Cadastral and Land Registry Authorities in collaboration with Eurostat, the statistical office of the European Union, under the patronage of European Commissioner Marianne Thyssen.

According to Director General of Eurostat, "The goal of the European Location Framework is to deliver authoritative, interoperable, cross-border data to benefit both the public and private sectors. It builds upon the success of the INSPIRE Directive and will clearly have a positive impact upon policymaking within the Commission."

Marine airgun noise could cause turtle trauma

Scientists from the University of Exeter are warning of the risks that seismic surveys may pose to sea turtles. Widely used in marine oil and gas exploration, seismic surveys use airguns to produce sound waves that penetrate the sea floor to map oil and gas reserves.

The review, published in the journal Biological Conservation, found that compared to marine mammals and fish, turtles are largely ignored in terms of research attention and are often omitted from policy guidelines designed to mitigate the environmental risks of seismic surveys.

Possible ramifications for turtles include behavioural changes and exclusion from critical habitats as well as potential auditory damage, as turtle hearing ranges overlap with airgun frequencies. In addition, turtles are known to become entangled in gear towed behind the survey vessel, which can lead to drowning.

Lead author Sarah Nelms from the Centre for Ecology and Conservation at the University of Exeterís Penryn Campus in Cornwall said: ìBy talking to oil and gas companies, seismic operators and on-board Marine Mammal Observers, as well as academics and conservationists, we had a great opportunity to gather a broad spectrum of opinions, not just one side of the story. This allowed us to access information that was not available in the published literature.

The researchers also examined policy guidelines for the mitigation of risk to marine life in seismic surveys and assessed peer-reviewed literature on the topic.

Our study reveals the potential for seismic surveys to cause behavioural changes and physical harm to turtles and we are calling for more research to urgently fill the crucial knowledge gaps that were highlighted during our review, said Ms Nelms.

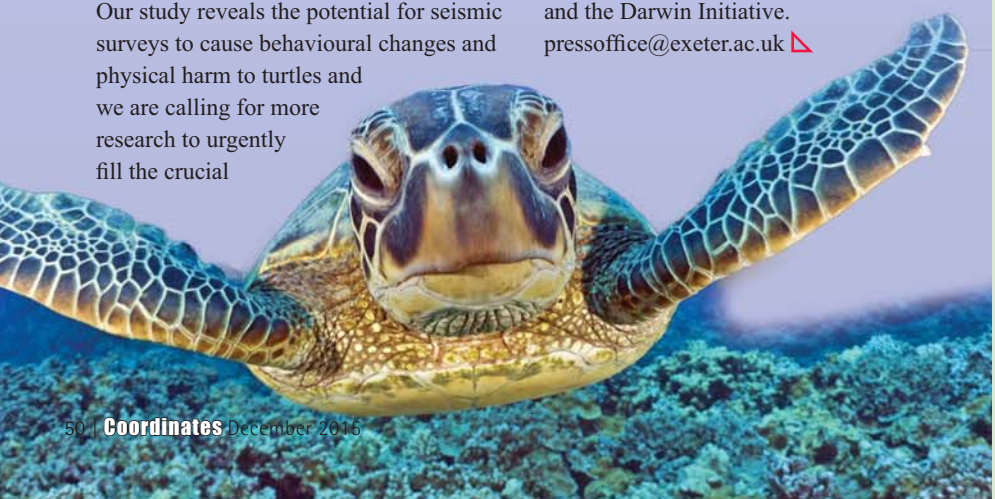
During a survey, specialised ships simultaneously fire multiple airguns while towing multiple hydrophone streamers, which can cover an area up to 700m wide and 12km long, to capture the returning sound waves. Researchers involved in the study received reports of turtles becoming entangled in the trailing tail buoys and developed a turtle guard which has been voluntarily installed by some operators. Further research could help make such preventative measures mandatory in the future.

Senior author Professor Brendan Godley, also from the University of Exeterís Centre for Ecology and Conservation, said: ìSeismic surveys are occurring in the waters of at least 50 countries in which marine turtles are present and they are becoming increasingly widespread. Given the conservation status of turtles, we feel that it is important and timely to assess the level of threat posed by this global activity and highlight knowledge gaps to direct future research efforts.

There is a great deal that could be done proactively to help improve the status quo. We are standing by to work with seismic companies and others in the oil and gas sector to this end.

The researchers hope that their findings will assist with the development of policies to minimise the impact of seismic surveys on marine turtle populations, for example ensuring that they are not carried out during sensitive times or in critical areas, such as during breeding seasons or in foraging grounds.

This work was supported by NERC and the Darwin Initiative.
pressoffice@exeter.ac.uk



At a Glance

- Mr Paul Verhoef has been appointed as Director of Galileo Programme and Navigation-Related Activities.
- Russia and Peru strategic partnership treaty signed
- Rolta OnPoint enhances emergency response capabilities
- Nokia Networks helps Zain address the digital transformation
- Bundeswehr Acquires TanDEM-X Global Elevation Model
- Beta version of European Data Portal launched
- exactEarth invests in Australian SIoT startup
- Massachusetts launches Wildlife Climate Action Tool
- NASA to develop FireSat to locate wildfires across the globe
- €26.5 million for GMES & Africa initiative
- Hera Systems to launch 9 CubeSats
- Hexagon, Huawei join forces for smart city solutions
- Trimble plans to acquire AGRI-TREND
- GSAT-15 Communications Satellite Successfully Launched
- Canada to access Sentinel data
- Garmin Quickdraw Contours to improve existing fishing maps
- HERE partners with Oracle for logistics service providers
- Cardno introduces remote sensing data analytics services in the US

Uber Signs a mapping deal with TomTom

TomTom has signed a global, multi-year agreement to provide maps and traffic data for the Uber driver app. It will be implemented in more than 300 cities around the world. *http://fortune.com*

Singapore Tourism Board launches digital services for Chinese tourists

Chinese visitors to Singapore can now explore the city with the help of WeChat and Baidu Connect, with the launch of the Singapore Tourism Board's (STB) suite of digital and mobile services for this market on Oct 21.

The launch comes as Internet penetration reaches 668 million people in China, of which 89 per cent of these users access the Internet from their mobile devices.

The digital and mobile services launched by STB include the new YourSingapore WeChat and Baidu Connect that will provide consumers with real-time location-based services to help them explore Singapore. *www.channelnewsasia.com*

Ola partners MapmyIndia for better navigation

Taxi aggregator Ola has partnered with MapmyIndia by acquiring a multi-year licence. This "first-of-its-kind" partnership in the country would also enable consistent map updates from MapmyIndia to Ola, making the data rich and relevant, he said. *http://gadgets.ndtv.com*

Google maps now available offline in india

Google India has announced that its Maps app will be available offline with features such as voice-based turn-by-turn navigation while in offline mode. At Google I/O 2015, the company had revealed plans to bring offline search to its Maps app and had stressed it was aimed mainly for "emerging markets" where Internet connection was spotty, and data charges were expensive, as navigation via GPS was independent of mobile networks.

The launch of offline Maps in India comes just days after Google officially introduced the feature on Android. While offline Maps were available previously on the app, features including offline navigation and search features are some of the additions. For using an offline map, users will need to download the map of an area on the device, and it will continue to work when there's no connectivity. Once an area has been saved for offline access, users can also enable turn-by-turn driving directions as well as search for specific destinations even when there is no Internet connection.

The company explains that when a connection is found, Maps will switch to online automatically and will allow users to access the full version of the app such as live traffic conditions for the current route. It's worth noting that Google Maps will only download offline areas on the device when on a Wi-Fi connection. *http://gadgets.ndtv.com/*

Drone flight over Lingaraj temple creates a flutter

A drone capturing images of the 11th century Lingaraj Temple drew attention of servitors of the shrine and led to suspicion over motive behind the photography.

Some of the temple officials also registered a complaint with the police but eventually, it turned out to be part of a Smart City Project work of the Bhubaneswar Municipal Corporation in India.

The photographer, Ranjit Kamble who represents Goregoan-based IBI Group, was questioned and the firm's authorisation to capture images was verified by Lingaraj Police. After the authentication, Kamble was allowed to go along with his photography devices. *www.newindianexpress.com*

Indian student bags Germany's Green Talents Award

Arun Prasad Kumar currently pursuing a PhD in Earth Remote Sensing and Geo-Information, Technology from the department of earth and space sciences of the Indian Institute of Space Science and Technology is the only Indian among the 27 winners from more than 90 countries to bag a 'Green Talents Award' at the 7th Green Talents 2015.

Green Talents - International Forum for High Potentials in Sustainable Development, hosted yearly by the German federal ministry of education and research (BMBF), calls for applications from all over the world from young visionaries to come up with innovative concepts to make the planet sustainable.

Kumar's thesis focuses on 'species-level classification and biophysical characterisation of mangroves using hyperspectral remote sensing'. The thesis also incorporates socio-economic awareness initiatives to give more insight to the local community regarding the benefits of mangroves and to implement conservation activities in the study area. *www.hindustantimes.com*

ViviSat remote sensing license approved

ViviSat LLC has announced that the Commercial Remote Sensing Regulatory Affairs Office of the National Oceanic and Atmospheric Administration, an agency of the Department of Commerce, has granted it a license to provide space based remote sensing on up to 10 of its Mission Extension Vehicles (MEVs).

ViviSat's MEV will utilize these remote sensing capabilities to visually image its clients' satellites during rendezvous and docking operations while providing on-orbit life extension services. The MEVs will operate in geostationary orbit. *www.businesswire.com*

China launches latest remote sensing satellite

China has successfully launched a remote sensing satellite, Yaogan—29 which will focus on experiments on survey of land, crop yields and disaster relief.

The satellite will be used for experiments, land surveys, crop yield estimates and disaster relief. However, western analysts believe the series of satellites are of a military nature, using electronic intelligence, electro—optical and synthetic aperture radar sensing equipment. *www.thehindu.com*

Correlator3D™ version 6.3 by SimActive

SimActive has announced Correlator3D™ version 6.3 with an expanded UAV enterprise offering. A new floating licensing option allows computers on the same network to seamlessly borrow licenses from a pool, increasing transferability for enterprise requirements. Multi-language support is also introduced with this version. *www.simactive.com*

Phase One Industrial Releases Software Development Kit 8.3.3

Phase One Industrial has released Phase One Software Development Kit (SDK)

ISRO-ASI initiative for remote surveillance of heritage structures

Indian Space Research Organization (ISRO) and Archeological Survey of India (ASI) have joined hands to create a repository of satellite-based surveillance photographs on 3,000-plus nationally protected monuments initially and later add 1,50,000-odd heritage structures across the country.

ISRO has also been entrusted with the job of filing high resolution digital images of each site and its peripheral areas to spot illegal structures that have mushroomed in the neighbourhood of protected monuments and heritage buildings in the last 50 years. These satellite pictures will come handy for ASI to identify the worst affected areas and take corrective action. The ISRO-ASI combine will be carry out remote sensing surveillance of all the monuments and prepare maps that clearly demarcate the prohibited and regulated zones around these monuments.

A standard operating procedure (SOP) using high resolution satellite data as primary source and employing state-of-the-art geo-spatial technology and open source tools has been developed for operational use by ASI. The project is already in advanced stage of completion in the state of Karnataka and soon will be extended to the rest of country. Data from Cartosat-1, Cartosat-2 and Resources at LISS IV are being used to create the database on heritage sites and monuments. Three management zones (protected, prohibited and regulated) around the heritage site are delineated using GIS tool after locating the site or monument on the satellite image. All land use features within each zone are precisely mapped. *http://timesofindia.indiatimes.com/*

8.3.3 in Linux, Windows and Mac OS versions. This SDK provides tools that enable users to build custom applications to control the way Phase One aerial cameras capture and process images. It enables users to precisely control which parameters to apply -- such as capture frequency, exposure values and white balance while capturing or processing images from a Phase One aerial camera. The Phase One SDK includes interface components for custom applications to work with the Phase One cameras in a production set up. *http://industrial.phaseone.com/*

Govt requests Japan to extend minerals surveying project

Remote sensing is a minerals prospecting technique using aircrafts or satellites.

Deputy permanent secretary in MMEWR, Obolokile Obakeng made the appeal at a seminar on sustainable development of mineral resources in Botswana's mining sector.

The seminar was co-hosted by MMEWR and the Japanese Ministry of Economy, Trade and Industry (METI), through the Japan Oil, Gas and Metals National Corporation (JOGMEC).

The remote sensing project started in July 2008 after the signing of a memorandum of agreement between Botswana Geological Survey and JOGMEC, as well as the establishment of the JOGMEC Geological Remote Sensing Centre in the Department of Geological Survey (DGS) premises in Lobatse and another one in Gaborone for use by SADC member states. *www.mmegi.bw*

Gwinnett commissioners renew aerial photography contract

Gwinnett Commissioners agreed earlier this month to the renewal of digital oblique aerial photographic imagery and viewing software on an annual contract with Pictometry International Corporation for $173,527. *www.ajc.com*

GAIL launches Bhuvan– GAIL Portal

In order to address the pipeline security concern, GAIL (India) Limited in collaboration with National Remote Sensing Centre (NRSC), a unit of Indian Space Research Organization (ISRO, has launched an innovative surveillance geo-portal called "Bhuvan-GAIL portal" utilizing space technology for its pipeline application. Despite all challenges, GAIL has proved that the space technology can be efficiently used for monitoring the pipeline Right of Use (RoU). GAIL has over 13000 Km of Pipeline network wherein monthly monitoring of pipeline ROU at present is being carried out through Helicopter surveys. GAIL will start live satellite monitoring of the pipeline RoU by January 2016 and is also looking for alternative methods like advance Unmanned Ariel Vehicle (UAV) which can also be integrated with this system.

GAIL also developed an innovative mobile application, from which the

pictures of the exception taken locally from any mobile describing the actual scenario can be uploaded instantly to the portal. A report system integrated with this Bhuvan-GAIL portal can send alerts to the relevant executives via SMS and email regarding the changes noted along the ROU and also arrival of any new satellite imagery. To establish the technical feasibility of utilizing space technology for its pipeline applications, GAIL started the study with Imageries from Indian Satellites and later shifted to very high resolution foreign satellites. *www.gailonline.com/*

FAA recommends drone registration

The US Federal Aviation Administration (FAA) has released a list of recommendations for how to better monitor recreational use of the machines.

Under the proposal, most drone owners would have to register the machines with the federal government, which would place the information in a national database in what would be the first time for such requirements. *https://nakedsecurity.sophos.com*

DJI Introduces Company's First Agriculture Drone

DJI has announced the launch of a smart, crop-spraying agricultural drone.

The DJI Agras MG-1 is dustproof, water-resistant and made of anti-corrosive materials. It can be rinsed clean and folded up for easy transport and storage after use.

The eight-rotor Agras can load more than 10 kilograms of liquid for crop-spraying and can cover between seven and 10 acres per hour. It is over 40 times more-efficient than manual spraying. The drone can fly up to eight meters per second and adjusts spraying intensity to flying speed, ensuring even coverage.

The Agras features DJI's industry-leading flight-control system and microwave radar to ensure centimeter-level accuracy. *www.dji.com*

Netherlands donates U.S.$7 Million

The Netherlands and FAO are expanding their collaboration in the area of water management with a $7 million donation by the Dutch government to support the use of remote sensing technology in helping water-scarce countries in the Near East and Africa monitor and improve the way they use water for crop production. *http://allafrica.com*

NDRF inks pact with NRSC to get satellite data

In order to obtain the vital "third eye" to tackle disasters, the NDRF has inked a pact with the National Remote Sensing Centre which will provide the force with geo-spatial and other satellite data for sharpening its relief and rescue operations.

A MoU was signed in this regard by National Disaster Response Force chief O P Singh and senior NRSC Scientist Bhanumurthy.

The new partnership will allow the force to access the NRSC, Hyderabad and the Indian Space Research Organisation's (ISRO) technical database on disaster management support to not only prepare for the onslaught of a natural disaster but also while preparing the physical response to such calamities. *http://newsworldindia.in*

Drone register features app detailing permitted flying areas

Every drone or remotely piloted aircraft (RPA) over one kilo in weight would be required to sign up, with the legislation also applying to model aircraft, Mr James, formerly Defence Forces deputy chief of staff, told the Drones, Data X conference in Westport, Co Mayo. The new drone register, which will be one of the first of its kind in Europe, will be up and running soon, according to Irish Aviation Authority director of safety regulation Ralph James. *www.irishtimes.com*

DOST eyes rice sufficiency via remote sensing technologies

During the recent 2015 Asian Conference on Remote Sensing, Dr. Enrico Paringit, explained that through the said technology, experts can make an inventory of the agricultural resources and immediately discover any irregularities in the crops before these spread. Paringit is the program leader of the Department of Science and Technology's (DOST) Disaster Risks Exposure Assessment for Mitigation (DREAM), Philipines.

"The El Niño phenomenon was detected using remote sensing technologies," says Paringit while explaining the benefits of remote sensing technologies in the areas of agriculture, forestry, and disaster mitigation.

Remote sensing is the technology used in getting information on an object or phenomenon without making any physical contact. It is done through aerial scanning of a location or through satellite images. "We can say that remote sensing is more like feeling without touching," says Paringit.

Under the DREAM program which Paringit heads, DOST will be sending two microsatellites in two years starting 2016 to enable the remote transmission of data. These images will be verified using data coming from other sources.

A deal at UN meet paves way for satellite tracking of aircraft

A deal reached at a U.N. meeting opens the way for satellite tracking of airliners, a major breakthrough motivated by the mystery disappearance of a Malaysia Airlines jetliner last year.

The agreement allows nations to set aside radio frequencies so that airplanes can be tracked by satellite - not just from the ground.

Under current radar-based systems, the movement of planes is monitored by land-based systems, leaving around 70 percent of the world's surface uncovered, according to the International Telecommunications Union, the U.N. communications agency. Modern planes that can send what are known as Automatic Dependent Surveillance-Broadcast, or ADS-B, signals to the ground are now on track to send signals to satellites too — with implementation expected by 2017.

The accord to set aside the 1087.7-1092.3 MHz radio frequency for satellite tracking of planes came at the World Radiocommunication Conference, an international gathering organized every four years by the ITU. International civil aviation regulator ICAO has pushed for satellite tracking of aircraft, as long as current safety measures aren't jeopardized. *www.asianage.com*

NISAR mission biggest collaboration of ISRO and NASA

The NASA-ISRO Synthetic Aperture Radar (NISAR) mission will be the biggest collaboration between the two space agencies yet, said a senior scientist from NASA recently. The mission involves building a 2,600 kg satellite that will "effectively make a time-lapse movie of the earth" while keeping a close eye on disturbances in the ecosystem, ice-sheet collapses and natural hazards. *http://indianexpress.com*

Rapidlasso receives "Green Asia Award" at ACRS 2015

At the Asian Conference on Remote Sensing 2015 (ACRS 2015) held in Manila, rapidlasso GmbH was honored with the "Green Asia Award" by the Chinese Society of Photogrammetry and Remote Sensing (CSPRS). This award is given to a paper that directs Asia towards a greener future using remote sensing technology. This year's award commends rapidlasso GmbH on advancing the area of LiDAR processing through their PulseWaves effort. PulseWaves is a vendor-neutral full waveform LiDAR data exchange format and API that simplifies access to full waveform data and allows researchers to focus on algorithms and share results. In the future this technology may prove valuable to improve biomass estimates for carbon credit programs such as the TREEMAPS project of WWF. *http://rapidlasso.com*

NovAtel to Develop WAAS G-III

U.S. Federal Aviation Administration (FAA) and NovAtel have exercised a bi-lateral option to produce a Wide Area Augmentation System (WAAS) G-III – Galileo prototype receiver to advance research on multi-GNSS constellation operation.

The new receiver will operate in the WAAS reference station test environment while maintaining core NovAtel WAAS G-III functionality for GPS and the U.S. satellite-based augmentation system (SBAS) signal processing. The prototype receiver will also add functionality to support tracking and demodulating associated navigation data for Galileo satellites including:

- Galileo E1 and E5a tracking
- ephemeris and almanac reporting/ processing from E1 or E5a
- automatic channel assignments
- time solution computed from Galileo
- correlator information for signal deformation on Galileo signals

The WAAS G-III – Galileo prototype receiver will be built on NovAtel's existing WAAS G-III receiver hardware and application software and delivered as a field-loadable firmware package.

SANDIS upgrades with Leica

Engineering and surveying company SANDIS has upgraded its capabilities with the purchase of 15 Leica Geosystems CS20 Controllers powered by Leica Captivate software. The Leica CS20 Controller, coupled with a Leica Geosystems total station, enables accurate electronic distance measuring and displays the 3D data captured on its screen. The controllers include an integrated BT module designed for long-range robotic total station communication, a 5-megapixel internal camera and an integrated DISTO for accurate distance measuring.

Satlab SL600 & SL-55

The Satlab SL600 configuration incorporates several eye-catching features. The receiver board is the same as found in the latest Trimble receivers on the market: the BD970, utilizing the 220-channel Maxwell 6 ASIC. This is a very good, proven receiver board. As tested, the integrated radio modem is a PacCrest XDL, with a maximum output of 2 Watts. On-board power is supplied by two hot-swappable 10,000 mAh batteries. A reasonable 1Gb of internal memory is good for many days of recording raw GNSS data for post processing.

SL-55 data collector with the ever-popular Carlson SurvCE software. The SL-55 is a Windows Mobile handheld with an 806MHz processor, 256MB of RAM and an 8GB internal Flash drive, with a micro-SD card slot. It's equipped with WiFi as well as Bluetooth communications, which the latter allowed me wireless accessibility to the SL-600 base and rover. The battery life is a little less stunning as compared to the SL-600 at only 8 hours, but the battery is user accessible and field replaceable for long days.

M12M Concurrent GNSS PNT Replacement Receiver Module

Jackson Labs Technologies, Inc has announced the availability of the M12M Replacement Receiver GNSS module. The module uses an 8th generation GNSS timing-enabled receiver allowing 72 GNSS channel reception with any two GNSS systems being received simultaneously, is form-fit-function compatible to the very popular legacy Motorola M12M and M12+ Timing and Navigation receivers, and adds easy configurability via USB ports as well as DIP switches and various status displays. GPS, GLONASS, BeiDou, QZSS, and SBAS signals can be received.

The M12M Replacement Receiver supports NMEA, Motorola Binary, uBlox Binary, as well as SCPI (GPIB) communication protocols for easy configuration and monitoring, and is designed to allow plug-and-play retrofit of equipment designed for the legacy Motorola receivers, as well as provide an easy design-in for new customer applications. *www.marketwire.com*

OriginGPS Introduces the Smallest Multi-GNSS Modules

OriginGPS has announced the launch of a new family of products, the first of which is the ORG1510-MK, the world's smallest fully integrated multi-GNSS (GPS, Glonass and BeiDou) module. The miniature low-power architecture supports an update rate of up to 10Hz and contains onboard flash, making it the perfect GNSS component for devices that require fully-featured components with small footprints, such as UAVs designed to follow action sports and other fast-moving activities or wearables. It contains the MediaTek MT3333 chip, which supports the fastest update position calculation rate of all leading modules. The chip also contains an onboard flash memory that does not erase when power is off. *http://m2mworldnews.com*

Telit secures $220 million supply contracts with tier-one automotive OEMs

Telit Communications PLC has recently secured supply agreements for its cellular modules with two tier-one automotive suppliers, with expected revenues of up to $33 million.

These agreements are the 5th and 6th such supply agreements Telit has secured over the past 12 months representing in aggregate up to $220 million of revenues over the life of the agreements. Supply periods range from four to six years with shipments on one contract already begun and peak volumes being reached in 2018, with deliveries into the U.S., Germany, Japan, China and Korea. *http://m2mworldnews.com*

Trimble Field Link Adds GNSS Capabilities

Trimble has announced that its mechanical, electrical, and plumbing (MEP) construction layout software, Trimble® Field Link, can now be used

with the Trimble R8s GNSS receiver. This addition extends Trimble's portfolio of positioning and scanning solutions for MEP contractors. The solution enables MEP contractors to take advantage of GNSS technology when performing outdoor construction layout tasks including utility, open deck, or long distance field layout, while using software designed for the MEP construction layout process. The Trimble Field Link software offers an easy-to-use interface for MEP contractors to view and locate their layout points with a robotic total station, a GNSS receiver or both. *buildings.trimble.com*

Hexagon Geospatial to develop information services using OS data

Ordnance Survey and Hexagon Geospatial have announced a new agreement, with a shared focus on enabling Hexagon Smart M.Apps to support key initiatives such as Smart Cities. Through the new agreement, Ordnance Survey content, including aerial imagery, will be a part of the Hexagon Smart M.App experience, delivering a wide range of innovative information services.

This provides geospatial solution providers with an opportunity to develop Hexagon Smart M.Apps to address targeted industry concerns.

3-D indoor mapping; 007 Spectre series

Kozo Keikaku Engineering Inc. has signed a partnership agreement with Munich-based NavVis GmbH to sell and market NavVis's products, services and value-added services in Japan. One of the products is the M3 Trolley, a 3-D indoor mapping system that captures and digitalizes all details of a building with high-resolution images (16 megapixels) and 3-D point clouds. Applicable to any type of building or underground mall, indoor digitalization automatically processes the captured data and a 3-D map can be opened in any web browser using IndoorViewer. *www.japantimes.co.jp*

Trimble Acquires Telog Instruments

Trimble has acquired privately held Telog Instruments, Inc. based in Victor, New York. The acquisition extends Trimble's smart water strategy by adding advanced water management technology and productivity solutions to the portfolio.

Telog, founded in 1984, manufactures a suite of wireless remote monitoring, analytics and data acquisition systems that are used by thousands of water, wastewater and stormwater management utilities and private contractors throughout North America. *www.TrimbleWater.com*

Story Map Navigates Cause and Effects of Climate Change

Esri, released an interactive map illustrating the earth's natural and human systems and how they have changed—and will change—over time. With the *Atlas for a Changing Planet* Story Map, scientists, policy makers, planners, and activists can examine detailed spatial information that is critical for adapting to a warmer future.

Atlas for a Changing Planet explores a sample of maps, imagery, and data from Esri ArcGIS Online. The Story Map covers five themes: understanding natural systems, mapping human systems, mapping ocean impacts, predicting the future, and international cooperation.

The Story Map also models data from the National Center for Atmospheric Research (NCAR) in three scenarios. With this data, users navigate the Story Map to see projected changes in temperature and precipitation based on the level at which greenhouse gas emissions increase or decrease over time.

FARO® launches new FOCUS3D X 30 Laser Scanner

FARO Technologies, Inc has announced the release of the new FARO Focus3D X 30 Laser Scanner. With a scanning range of up to 30 meters, the Focus3D X 30 is ideal for a variety of short-range scanning applications such as architectural preservation, as-built documentation, building information modelling (BIM), engineering, facility management and forensics. The ultra-portable Focus3D X 30 enables fast, straightforward and accurate measurements of interiors, such as small architectural façades, complex structures, crime scenes, mechanical rooms, and production and supply facilities.

OPAL-ECR 3D LiDAR by Neptec Technologies

Neptec Technologies Corp. has announced the OPAL-ECR (Enhanced Close Range), a new addition to its OPAL™ 2.0 family of rugged, obscurant-penetrating 3D LiDAR scanners. It is specifically designed for real-time applications in low-reflectivity target environments (like coal or iron ore), for distances up to 240 meters. It is well suited for use in automation and collision avoidance applications on stacker/reclaimers, shiploaders, excavators, haul trucks and other heavy machinery, and for applications where reliable and predictable detection of targets, even with low reflectivity, is essential. *www.neptectechnologies.com*

HERE powers connected navigation for Volvo Cars

Volvo Cars has chosen HERE to power connected navigation for the next-generation in-car control system for new and future Volvo models as part of a multi-year agreement between the two companies.

Volvo's in-car system, called Sensus, offers customers a fully connected experience and incorporates advanced maps and services enabled by the HERE location cloud to provide drivers with smart guidance both in and out of the car. The first model featuring the new Sensus system is the XC90, Volvo's new luxury SUV which started shipping earlier this year. *https://company.here.com*

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January 2016

International Remote Sensing Conference
17 - 20 January
Saudi Arabia
www.irsc-sa.org

February 2016

NRSC User Interaction Workshop
3 - 4 February
Hyderabad, India
http://www.nrsc.gov.in/uim2016/index.html

EuroCOW 2016 Workshop
10 - 12 February
Lausanne,Switzerland
www.eurocow.org

March 2016

Munich Satellite Navigation Summit 2016
1 - 3 March
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2016

IGRSM 2016
13 - 14 April 2016
Kuala Lumpur, Malaysia
http://www.igrsm.com/igrsm2016

Interexpo GEO-Siberia-2016
20 - 22 April
Novosibirsk, Russia
www.expo-geo.com

May 2016

XPONENTIAL 2016
2 – 5 May
New Orleans, USA
www.xponential.org/auvsi2016/public/enter.aspx

FIG Working Week 2016
2 - 6 May
Christchurch, New Zealand
www.fig.net/fig2016/call.htm

10th Annual RIN Baska GNSS Conference
8 - 10 May
Baska, Krk Island, Croatia
www.rin.org.uk

NAVITECH 2016
10 - 13 May
Moscow, Russia
www.navitech-expo.ru/en/

GEO Business 2016
24 - 25 May
London, UK
http://geobusinessshow.com

European Navigation Conference
30 May - 02 June
Helsinki, Finland
www.enc2015.eu

June 2016

HxGN LIVE
13 - 16 June
Anaheim,USA
http://hxgnlive.com/anaheim

6th International Conference on Cartography & GIS
13-17 June
Albena, Bulgaria
www.iccgis2016.cartography-gis.com

2016 Esri International User Conference
27 June to 1 July
San Diego, USA
www.esri.com

July 2016

ISPRS – PRAGUE 2016
12 - 19 July
Prague, Czech Republic
http://www.isprs2016-prague.com/

September 2016

ION GNSS+ 2016
12 - 16 September
Portland, Oregon USA
www.ion.org

EUROGEO 2016
29 - 30 September
University of Malaga,Spain
www.eurogeography.eu/conference-2016-malaga/

October 2016

INTERGEO 2016
11 - 13 October
Hamberg, Germany
www.intergeo.de

37th Asian Conference on Remote Sensing (ACRS)
17 - 21 October
Colombo, Sri Lanka
www.acrs2016.org

November 2016

Trimble Dimension 2016
7-9 November
Las Vegas, USA
http://www.trimbledimensions.com/

INC 2016: RIN International Navigation Conference
8 - 10 November
Glasgow, Scotland
http://www.rin.org.uk/Events/4131/INC16

GSDI 2015 World Conference
28 November - 2 December
Taipei, Taiwan
http://gsdiassociation.org/index.php/homepage/gsdi-15-world-conference.html

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