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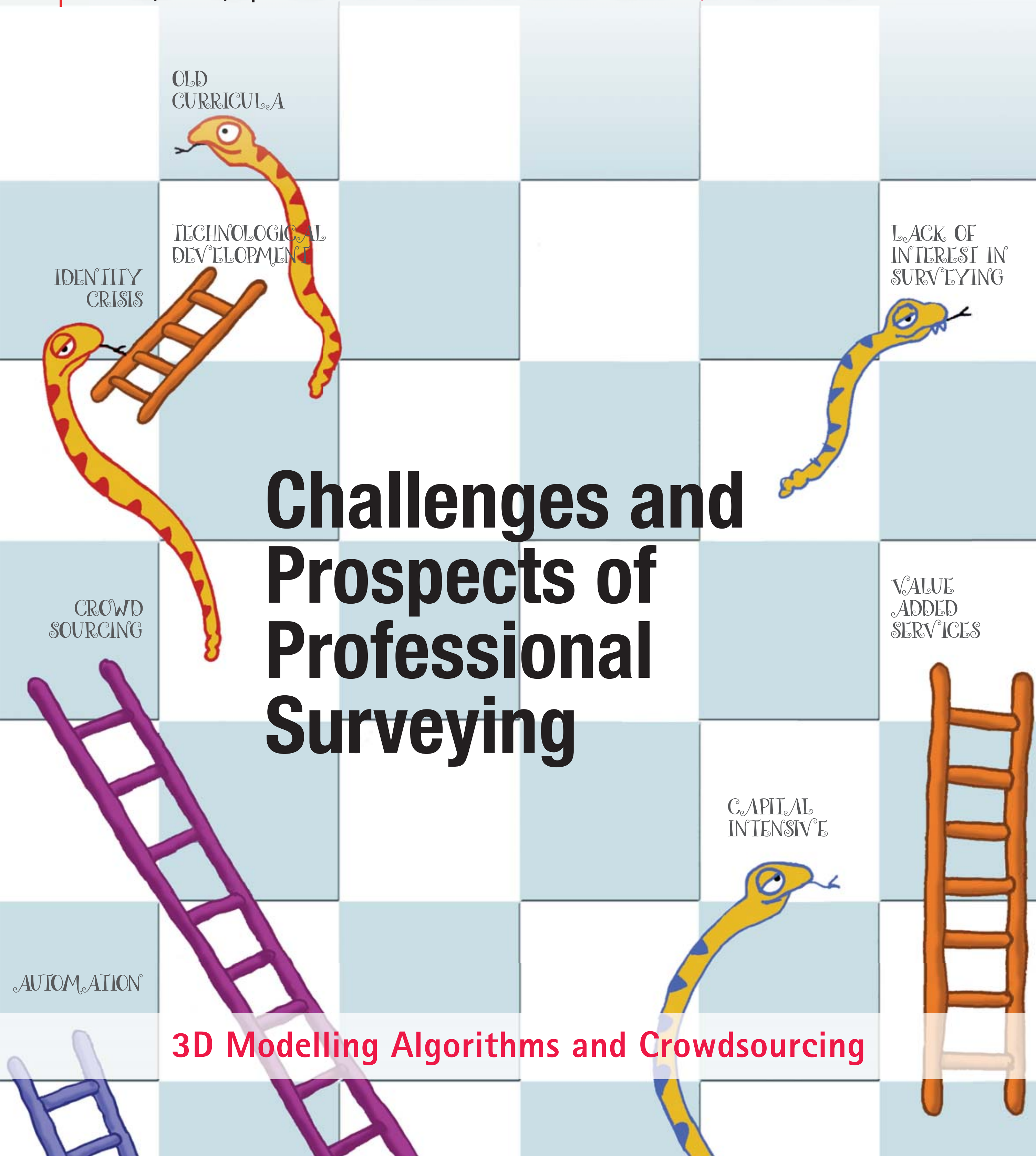

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3D Modelling Algorithms and Crowdsourcing

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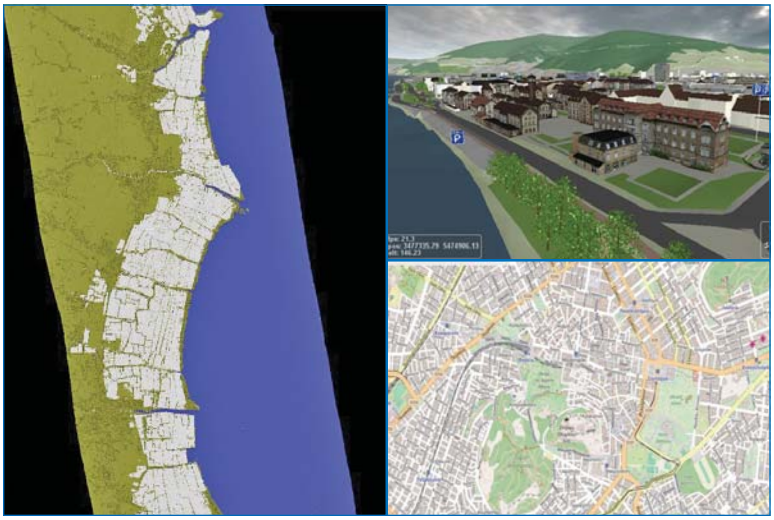

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Right to Privacy

Though in many countries,

Privacy enjoys a strong legal framework

India has been cautious.

On one hand the Government has the propensity

To encroach the private space of the citizens,

The citizens are, by and large, unaware and unmindful

Of the concepts and importance of privacy.

Given this, the Supreme Court of India judgment of August 24, 2017

That recognizes ‘right to privacy’

As intrinsic to life and liberty,

And protected under Indian Constitution,

May not only induce the course correction in Government polices

But also alter the discourse

On personal data (especially biometric) security and protection as well.

Bal Krishna, Editor
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3D Modelling Algorithms and Crowdsourcing Techniques

This study presents an evaluation of the current state of the art of algorithms and techniques used for 3D modelling and investigates the potential of their usage for 3D cadastre. We present this paper in two parts. In this issue, the progress realated to utilize VGI data in visualizing the 3D world is presented. The algorithms and techniques in 3D reconstruction which may be used to provide accurate and detailed 3D models are also discussed. In the next issue, the potential of using VGI data in 3D reconstruction procedures, indicating the advantages and disadvantages of this approach will be published in addition to the potential of using VGI data for 3D cadastral surveys.

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Image-based 3D reconstruction of buildings and architectural monuments is a well-studied problem in photogrammetry and computer vision. Traditional photogrammetric mapping has been in the realm of industrial organizations collecting imagery from the air and developing maps and perhaps 3D information of urban spaces from these images (Leberl, 2010). In recent years, Volunteered Geographic Information (VGI) became popular, where VGI describes how an ever-expanding range of users collaboratively collects geographic data (Goodchild 2007a). Each volunteer acts like a remote sensor (Goodchild 2007b) by creating and sharing geographic data in a Web 2.0 community and thus, a comprehensive data source is created. Modern practices and requirements aim to the development of a VGI geo-data future and Internet-based automated photogrammetric solutions, in order to describe in detail and model the 3D world. Thus crowd and each internet-user may be defined as potential neo-photogrammetrists (Leberl, 2010).

As cities expand vertically, safeguarding of tenure requires a clear 3D picture in terms of property rights, restrictions and responsibilities. Current research in this field includes integration of the 3rd dimension to the traditional form of a 2D cadastre, the adoption of automated and low-cost but reliable procedures for cadastral surveys and data processing, the use of modern IT tools and m-services for cadastral data acquisition, as well as the integration of the "time" parameter in the cadastre. Much experience has already been accumulated on how a 3D Cadastre should be best developed. 3D cadaster has been attracting researchers throughout the world but 3D cadastral technology is newly emerging (Dimopoulou et al., 2016). The implementation of 3D cadastre may be accelerated utilizing the experience gained from 3D building reconstruction using crowdsourced data.

This paper presents a literature research reviewing the progress in techniques, methods and algorithms for 3D model reconstruction, as well as the experience gained from the use of crowdsourced data in 3D building reconstruction, and investigates the potential of combining this experience to design low-cost 3D cadastral surveys in urban and suburban areas. The main contribution of this paper is to identify the appropriate 3D reconstruction methods and techniques, introducing 3D-VGI data collection in order to develop a Fit-For-Purpose (FFP) 3D cadastre where the necessary cadastral surveys may be conducted in a fast, reliable and affordable way. A theoretical framework for how this can be achieved, is proposed.

VGI data in visualizing the 3D world

During the last decades research in the

field of VGI attracted a grown interest, resulting in the development of a large amount of 3D real world applications. One of the most successful and popular VGI projects started in 2004 in England is the OpenStreetMap (Figure 1 left) (OSM, 2016). Until now, there are more than two million registered members who contribute to the rapid growth of OSM (Fan & Zipf, 2016). A subsequent research by Over et al. (2010) investigated the possibility of creating a 3D virtual world by using OSM data for various applications, and concluded that OSM has a huge potential in fulfilling the requirements of CityGML LOD1 (Gröger et al. 2008), that is block models (Figure 1 right). Several years ago, Goetz & Zipf (2012) presented a framework for automatic VGI-based creation of 3D building models encoded as standardized CityGML model. The basic idea is the correlation between properties and classes of OSM and CityGML, respectively. The investigation concluded that it is possible to create LOD1 and LOD2 but not LOD3 and LOD4. The development of an algorithm to automate the process and manage the incorrect input data using several assumptions, is of a great necessity for the success of the proposed framework.

The earliest and most prominent example of encouraging the crowd to generate spatial 3D information is Google 3D Warehouse launched on April 24, 2006. This shared repository contains user-generated 3D models of both geo-referenced real-world objects, such as churches or stadiums, and non-geo-referenced prototypical objects, such as trees, light posts or interior objects like furniture. Users must have a certain level of 3D modelling skill in order to voluntarily contribute (Uden & Zipf, 2013). The recent development of 3D modelling software such as SketchUp and ESRI CityEngine (Figure 2) that makes 3D editing more easy and effective leads to an increase of 3D building modelling production. In about 2007, Microsoft Virtual Earth and Google Earth integrated VGI and crowdsourcing techniques in their projects. 3DVIA (Virtual Earth) and Building Maker (Google Earth), provide a model kit to create buildings. Both of them exploit a set of oblique (and proprietary) birds-eye images of the same object from different perspectives, in order to derive the 3D geometry. The latter ones aim to create geo-referenced 3D building models and refer to people who do not have technical skills in 3D modelling, but still want to contribute (Fan & Zipf, 2016). Even though the above mentioned projects are based on collaboratively collected data, they are far away from been open source or open data. Hence, there are several free-to-use 3D object repositories on the internet, such as OpenSceneryX6, Archive3D7 or Shapeways8. Their contents usually lack connection to the real world but can nonetheless be useful to enrich real 3D city model visualisations (Uden & Zipf, 2013).

A 3D reconstruction can also be performed using 2D vectors and images derived from crowdsourcing strategies (Spanò et al., 2016). Over the years several projects appeared that generate and visualize 3D buildings from OSM; OSM-3D, OSM Buildings, Glosm, OSM2World, KOSMOS Worldflier, etc., are some of the most popular projects of that kind. The major limitation of these projects is that the majority of buildings are only modelled at coarse level of detail. In OSM-3D, a number of buildings are modelled in LOD2 if there are indications for their roof types (Figure 3).

The integration of more detail is conducted usually manually (LOD3 / LOD4) using other sources via OpenBuildingModels (OBM) (Uden & Zipf 2013). OBM is a web based platform for uploading and sharing entire 3D building models. More specifically, users can: (i) upload a 3D building model which is associated with a footprint in OSM, and (ii) browse, view and download an existing model in the repository. At the same time, one can add attribute information referred to the building model (Fan & Zipf, 2016).

A wide range of tools and algorithms is required in order to support a motivated mapper to collect the various 3D information in all levels of detail. Data collection for 3D modelling of simple building properties does not always require the use of high accuracy sensors since most data can be measured with the eye. More complex models can only be created by means of various sensors such as laser meters, terrestrial and/or aerial imagery,

Figure 1: Representation of Open Street Map (OSM) (left); Geometrical representation of a building in CityGML LOD1 (right) (source: Goetz & Zipf, 2012).

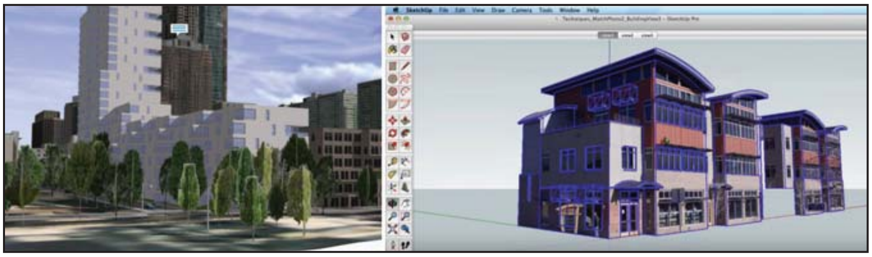

Figure 2: Examples of Parametric models creates with 3D modelling computer programs ESRI CityEngine (left) (source: ESRI, 2017) and SketchUp (right) (source: SketchUp, 2017).

GPS or even terrestrial laser scanners. Many of these sensors are nowadays included in modern smartphones, transforming them into a multi-sensor-system which is pretty well-suited for crowdsourced 3D data capturing. In the future, further sensors like barometers, stereo cameras such as Microsoft Kinect (Elgan, 2011) and maybe also laser meters and little laser scanners will possibly be included into smartphones, making them even more all-round tools for 3D-VGI. Obviously, the creation of 3D models requires a well-suited modelling software.

Figure 3: OSM-3D overview of Heidelberg in XNavigator (source: Fan & Zipf, 2016).

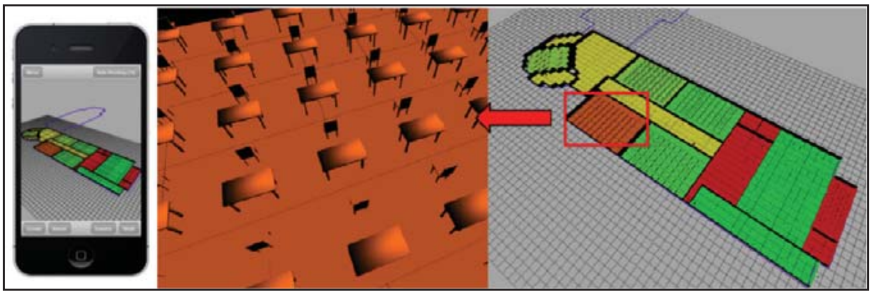

Figure 4: Mobile application for the creation, submission, and voting on 3D models of building inside components (left); Model of the first floor of an academic building with furniture (middle); Coloring corresponds to approval of the model components (red has the fewest and green the highest number of votes) (right). (source: Eaglin et al., 2013)

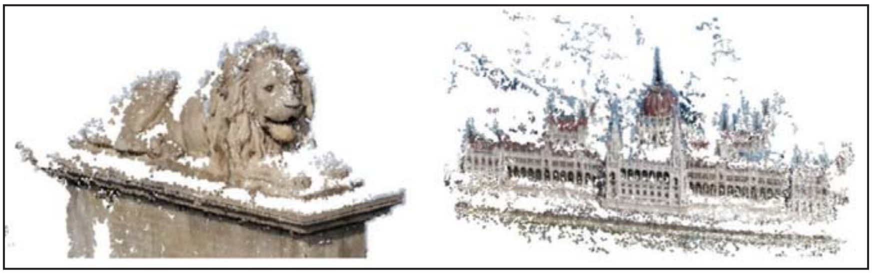

Figure 5: Reconstruction from smart phone images (left), Dense point cloud of the Parliament building after reconstruction from images (right) (source: Somogyi et al., 2016).

There are several 3D graphics modelling software but different tools need different skills. Kendzi3D JOSM-plugin (Kendzi, 2011) is a widely used editor which is specialised for advanced OSM 3D-building modelling, makes it easier for the users to assemble parametric 3D models without caring about the rather complicated and cumbersome tagging itself. Such an editor could also avoid incorrect modelling and ensure topological consistency in complex 3D objects (Uden & Zipf, 2013). Another example of such a software is presented by Eaglin et al. (2013); the proposed system exploits the power of current mobile devices (smartphones, tablets) and their 3D graphics rendering capabilities to present a mobile application (Figure 4).

This system is based on a client-server architecture, where users of a mobile application create, submit, and vote on 3D models of building inside components; the server collects and uses votes pertaining to accuracy and completion of the model to determine if an object may be approved.

The mobile application allows users to create geometry (such as chair, table etc.) through a simplified toolset and an editor. This system leads to satisfactory results.

Reconstruction of 3D buildings from terrestrial photographs can traditionally be accomplished using complex and expensive photogrammetric software. Currently, free-to-use assisted 3D modelling software like Autodesk 123D Catch or My3DScanner offer an alternative for this task.

With the rapid development of technology, image sharing sites and social networks, such as Flickr, Instagram, Panoramio, Picasa, Pinterest, the finding and exploitation of crowdsourced amateur images for 3D reconstruction is enabled (Figure 5). Research has been performed over time to explore the potential of crowdsourced data in 3D reconstruction procedures (Hadjiprocopis et al., 2014; Somogyi et al., 2016; Hartmann et al., 2016).

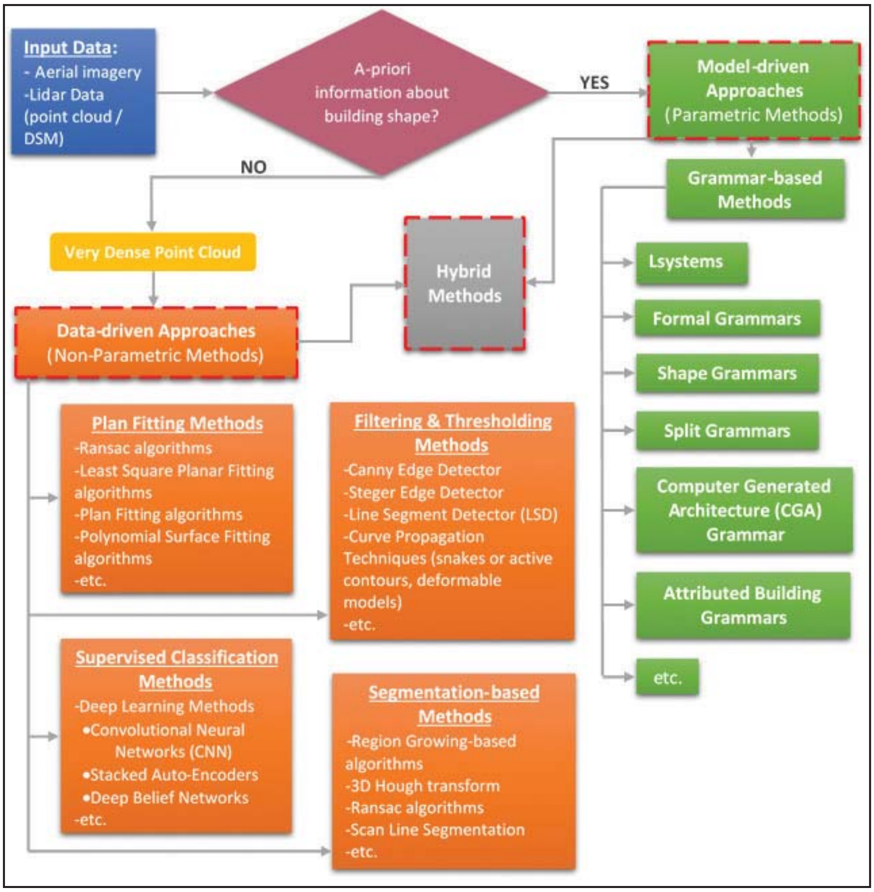

Figure 6: Classification of 3D reconstruction methods.

Current algorithms and techniques in 3D reconstruction

Over the last twenty years, the automatic extraction and reconstruction of 3D buildings has been a major research focus, trying to replace the manual reconstruction of buildings from aerial imagery via stereoscopy or from lidar data, which are time consuming and laborious tasks. Research has exploited both aerial imagery and lidar data for the reconstruction of 3D models at varying levels of detail. Through the various approaches that have been proposed so far only semi-automation has been achieved (Brenner, 2005). Studies which compare proposed reconstruction methods have suggested that in order to achieve full automation, aerial imagery and lidar data need to be used in synergy in order to utilize their superior positional and height resolutions respectively (Brenner, 2005). In recent years several methods have been developed for building detection, recognition and reconstruction. These methods can be divided into three general categories based on the degree of the contexual knowledge:

- Model-driven methods (parametric modeling),
- Data-driven methods (non-parametric modeling), and
- Hybrid methods.

Each one of these methods include several algorithms and techniques aiming to achieve a successful 3D building reconstruction (Figure 6).

Model-driven methods

Parametric methods or top-down approaches are based on a priori known information about the shape of the buildings. A library of parametric shapes consists of a set of predefined patterns, which are described by a number of parameters. An appropriate combination of these parameters is needed, in order to evaluate the best 3D model. The main advantages of parametric methods are the robustness in the case where the original data (exported buildings points) are incomplete and weak, and the topologically correct model output.

However, each library may not include information about all kinds of buildings geometry. That is, in case of buildings with complex geometry the reconstruction may not be complete. One of the most popular category of parametric methods is Grammar-Based methods. Grammar-Based Methods are based on a structure, called Grammar. They use a language L (Gb), which includes all possible models (components of the building - Building Grammar). Based on Gb, a segmentation process starts, where every component is checked against a set of rules. Each building consists of individual parts, which cannot undergo a further segmentation. As such elements can be considered doors, windows, walls, etc.

Grammar-based methods have been extensively used in architecture modelling. The most well-known examples are Lsystems (Lindenmayer-systems), Shape Grammars, Split Grammar, Computer Generated Architecture (CGA) Grammar, Formal Grammars and Attributed Building Grammar (Yu et al., 2014). Lsystems, were developed for modelling plants, so they are not appropriate for the modelling of individual buildings. Shape grammars include shape rules and a generation engine that selects and processes rules.

Shape rules define how an existing shape can be transformed. Shape grammars have been successfully used in architecture (McKay et al., 2012); however, their applicability for automatic generation of buildings was limited. Karantzalos & Paragios, (2010) proposed a different approach, which utilizes the methodology of Shape Grammars. The proposed method refers to a Grammar, which is composed of a three-dimensional (3D) shape priors. According to this methodology, the choice of the most suitable model is via the optimal selection of parameters which form the shape of the building part. Wonka et al. (2003) employed a split grammar to generate architectural structures based on a large database of split grammar rules and attributes. In this approach, a split grammar is introduced to allow for dividing the building into parts, and also a separate control grammar is proposed to handle the propagation and distribution of attributes. However, due to the requirement of an excessive amount of splits for complex models, the proposed split grammars have limitations to handle the complexity of architectural details. Following this idea, a new Computer Generated Architecture (CGA) grammar (Müller et al., 2006) is presented to generate detailed building architecture in a predefined style, which is demonstrated by a virtual reconstruction of ancient Pompeii. They solely use context-sensitive shape rules to implement splits along the main axes of the facades. More recently, formal grammars have been applied in building facade modelling (Becker & Haala, 2009) to reconstruct building facades from point cloud data. Depending on the structures of facade, the façade model is defined by a formal grammar. Each grammar rule subdivides a part of the facade into smaller parts according to the layout of the facade. However, facade modelling does not consider the entire building and is limited to certain type of structures in some cases, e.g., symmetric structures. Yu et al., (2014) proposed an automated reconstruction method in order to reconstruct completely building structures.

This method was called Attributed Building Grammar. The next years, Yu et al., (2016) proposed another automated method of reconstruction of buildings using an Attributed Building Grammar, which starts with the segmentation of the initial point cloud in order to extract planar, cylindrical, and other types of surfaces, by methods such as PCA (Principal Component Analysis). The segmented data transformed into 3D shapes which represent the 3D building structures. Subsequently a Grammar engine, lead the reconstruction process, ensuring the enforcement of appropriate rules, for the further subdivision into elementary shape structures. The division is described by a tree structure, wherein the body represents each shape and the leaves represents the elementary objects. Finally, the 3D model composed of individual elementary objects which occurred through the combined use of Grammar and the corresponding rules. This methodology can be used to produce 3D models in various forms (e.g., CAD, BIM).

Data-driven methods

> Modern practices and requirements aim to the development of a VGI geo-data future and Internet-based automated photogrammetric solutions, in order to describe in detail and model the 3D world

In the data-driven or bottom-up approaches, the points related to the roof top are extracted based on a set of building measurements and are grouped into different roof planes with 2D topology and are used for 3D modelling. The main advantage of the data driven approach is that there is no need to have a prior knowledge of a specific building structure; however, this method requires very dense collection of building's points to reconstruct the 3D models correctly. They tend to be more flexible as they use the extracted data in order to create a roof model. The geometry of a roof can be described by the number and the shape of roof faces, thus most methods aim to classify roof planes from the input dataset. Current methodologies and algorithms on building detection and extraction problem can be divided into 4 groups as: Plan fitting based methods, Filtering and Thresholding based Methods, Segmentation based Methods (Shadow based Segmentation, Region Growing based algorithms, etc) and Different Supervised Classification Methods.

In the literature there is a variety of approaches, which apply Plan fitting based methods to data from active sensors (e.g., LIDAR Digital Surface Model - DSM) or point clouds obtained through photogrammetric processes. The algorithms widely used to achieve this goal include RANSAC algorithms, Least Squares planar fitting algorithms (Omidalizarandi & Saadatseresgt, 2013) and Plan fitting based algorithms (McClunea et al., 2016). Wang (2016), proposed an automated Semi-Global Matching (SGM) method (Hirschmüller, 2008) in order to produce a dense cloud of points and the extraction of the outline of buildings utilizing high-resolution aerial imagery. Then the extraction of the ground surface using a polynomial surface adaptation method (polynomial surface fitting) was attempted. The volumes of the buildings identified by the production of nDSM (normalized DSM) using a seed area approach with radiometric criteria or other characteristics for the further categorization of all the elements located on each building roof. The outline of the roof was extracted in vector form with the split-and-merge method. It is noted that the proposed methodology can be applied in areas with complex types of buildings but not in densely urbanized areas.

In recent literature, Filtering and Thresholding based methods, especially in case of aerial images for extracting building outlines utilizing edge detectors, are widespread. Dal Poz & Fernandes (2016) proposed a method for extracting groups of straight lines that represent roof boundaries and roof ridgelines from high-resolution aerial images using corresponding ALS (Aerial Laser Scanner) - derived roof polyhedrons as initial approximations. The proposed methodology consists of two sub-stages: (i) the boundaries of the ALS - polyhedrons used to limit the search area of candidate straight lines, and (ii) Steger line detector and Canny edge detector are applied to the images, to identify lines within the limited area of the interior of the polyhedrons.

Köhn et al. (2016) proposed a method for the detection and reconstruction of the building roof, using aerial images. A high resolution DSM was derived based on the SGM algorithm. The exterior and interior orientations of all images were estimated by a bundle adjustment using the GNSS/IMU measurements. In a first step, the DSM was normalized based on morphological grayscale reconstruction. The derived nDSM includes the volumes above the ground, identifying the potential building positions. Then the operator Line Segment Detector (LSD) is applied which identifies straight line segments using the region growing method among the pixels that exhibit similar intensity and orientation. An assumption about the buildings shape (rectangular) was made, in order to identify them. Then, a RANSAC-based plane fitting procedure is applied to the pixels in each segment by which the 3D building roofs are reconstructed. Apart from the above, Curve Propagation Techniques (snakes, geometrical snakes or active contours, deformable models) have shown encouraging results both to identify buildings and roads (Karantzalos & Argialas, 2009) and thus at the reconstruction procedures.

As concluded by Rottensteiner et al. (2014), in summarizing the outcomes of the recent ISPRS benchmark assessment of 3D building reconstruction, area-based reconstruction tends to favor the use of lidar data in the form of point clouds or raster DSMs. Segmentation based methods are widely used. Points can be clustered into planes based on similar attributes, such as: normal vectors, distance to a localized fitted plane or height similarities. This clustering is performed using methods such as: region growing based algorithms, 3D Hough-transform or the RANSAC algorithm. While many approaches have tried to fit planes to extract surfaces, an alternative and under-explored approach is the use of cross sections for segmenting planar features. This approach is called scan line segmentation. However, these tend to be more computationally expensive compared to the planar detection due to the number of points being tested for clustering. Planar segmentation results depend on the correct determination of threshold parameters, such as the neighborhood used to calculate the attribute, and incorrect results may arise in areas with low point density and complex structures (Rottensteiner et al., 2014). While surface extraction and planar fitting approaches may accurately detect planes and perform well in the presence of noise, they tend to lead to over and under segmentation. Research has shown that planes can be extracted by segmenting along cross sections of a surface and then performing region growing. McClune et al. (2014) proposed a methodology to derive the geometry of building boundaries using aerial images. At first the roof level is identified using the DSM. By means of along cross sections method, the 2D sections height differences are examined using the DSM. The parts with intense height differences are usually sections of roof boundaries. Canny edge detector used in order to find additional roof features. Omidalizarandi & Saadatseresgt (2013) performed region growing on image based point clouds to form planar segments. However, it was found that errors from planar segmentation may arise at the location of the planar boundaries. These boundary errors can be overcome by combining feature-based and area-based methods, with the extraction of edges from imagery tending to form a post-processing step to refine the boundary of planes from lidar data. Besides aerial or LIDAR data, mobile-phone images are recently used for photogrammetric reconstruction.

Supervised classification methods, such as Deep Learning methods (Makantasis et al., 2015) are a class of machines that can learn a hierarchy of features by building high-level features from low-level ones, thereby automating the process of feature construction for the problem at hand. As examples of Deep Learning models the Convolutional Neural Networks – CNN, the Stacked Auto-Encoders and the Deep Belief Networks may be mentioned. CNNs consist a type of deep models, which apply trainable filters and pooling operations on the raw input, resulting in a hierarchy of increasingly complex features. Generally, there are two common approaches for training a CNN model, such as training from scratch with random values of weights, as well as fine-tuning of a pre-trained model. CNN is a kind of feed-forward neural network with the multilayer perception concept which consists of a number of convolutional and subsampling layers in an adaptable structure and it is widely used in pattern recognition and object detection application. In literature, there is a limited number of studies on the detection and identification of 3D structures based on CNNs using remote sensing data. Alexandre (2016) developed a 3D object recognition method based on CNNs by using RGB-Depth data. In this method, a CNN is trained for each image band (red, green, blue and depth) separately such that the weights vector for each CNN will be initialized with the weights vector of the trained CNN for another image band; that is, the knowledge is transferred between CNNs for RGB-D data.

Many researchers have used multi-class Support Vector Machine (SVM) classification for land use detection of urban areas from aerial or high-resolution satellite images. SVM is a supervised non-parametric statistical learning technique (Vapnik, 1995; Burges, 1998). SVM need training data that optimize the separation of the classes rather than describing the classes themselves. Training the SVM with a Gaussian Radial Basis Function (RBF) requires setting two parameters: regularization parameter that controls the trade-off between maximizing the margin and minimizing the training error, and kernel width. SVM classifier provides four types of kernels: linear, polynomial, RBF, and sigmoid (Sarp et al., 2014). The RBF kernel works well in most cases. Tuia et al. (2010) performed SVM classification using composite kernels for the classification of high-resolution urban images and concluded that a significant increase in the classification accuracy was achieved when the spatial information was used. Sarp et al. (2014) proposed a method for the automatic detection of buildings and changes in buildings after an earthquake, utilizing orthophoto images and point clouds from stereo matching data. In the first step the classification of the high-resolution pre- and post-event Red-Green-Blue (RGB) orthophoto images (ortho RGB) conducted, using SVM classification procedure to extract the building areas. In the second step, a normalized Digital Surface Model (nDSM) band derived from point clouds and Digital Terrain Model (DTM) is integrated with the SVM classification (nDSM + orthoRGB). Finally, a building damage assessment is performed through a comparison between two independent

As cities expand vertically, safeguarding of tenure requires a clear 3D picture in terms of property rights, restrictions and responsibilities. Some of the current research trends in this field include integration of the 3rd dimension to the traditional form of 2D cadastre; the adoption of automation and low-cost but reliable procedures for cadastral surveys and data processing; the usage of modern IT tools and m-services for cadastral data acquisition; as well as the integration of the "time" factor in the cadastre.

classification results from pre- and post-event data. The main conclusion was that using the spectral information as well as the elevation information from point cloud as additional bands, leads to a significant accuracy increasment. Vakalopoulou et al. (2015) developed a method of locating buildings from high resolution satellite images. In this process vector features used to train a binary SVM classifier to separate building and non-building objects. Then, a MRF model was used to extract the best classification results. Zhang et al. (2015) proposed two search algorithms to localize objects with high accuracy based on Bayesian optimization and also a deep learning framework based on a structured SVM objective function and CNN classifier. The results on PASCAL VOC 2007 and 2012 benchmarks highlight the significant improvement on detection performance.

Alidoost & Arefi (2016) proposed a new approach for the automatic recognition of the building roof models (such as flat, gable, gabled, hipped, etc) based on Deep Learning methods using LIDAR data and aerial orthophotos. In the last group of modelling approaches, the combination of model-driven and data-driven algorithms is used to have an optimal solution compensating the weakness of each method. Occasionally multitude investigations about Hybrid methods are conducted, resulting in satisfactory results (Nguatem et al., 2016)

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Mapping beyond boundaries

Challenges and prospects of professional surveying practice in Nigeria

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Advances in digital technology and globalisation have imposed a multi-disciplinary approach on survey and mapping. The advent of globalisation has also brought about the collapse of professional boundaries. It is no longer possible to easily define clear-cut professional boundaries. In other words, it is not easy to say where surveying for example ends and civil engineering starts. It can safely be said that professional boundaries, that is boundary lines demarcating one profession from another, are collapsing.

The traditional parcel boundary demarcation which had been the preserve of surveyors is being turned into a major pre-occupation. Technology has changed the instrumentation for surveyors much to the exclusion of those practicing in traditional ways. There is now less emphasis on data quality, while data processing and management is gaining more ground. The surveying profession in Nigeria therefore has lots of challenges to grapple with in order to ensure its future and survival. Challenges such as a poor professional image, collapse of professional boundaries, training and lack of interest in surveying by prospecting students must be overcome by concerted effort aimed at self-promotion and clear vision.

Another cause for great concern is the rate at which newly-registered surveyors open up their own firms and break away without consideration of the fact that professional survey practice requires large measures of team work, while equipment outlay is highly capital intensive.
The above scenario sets the stage for unhealthy competition and rivalry, leaving most practicing surveyors with the last option of cutting corners or indulging in unethical practices in order to survive.

Furthermore, it is now painfully obvious how big the divide is between surveying experts on the one hand politics and society on the other. Politics is needed to consolidate or to expand new fields of professional activities, and to provide a firm legal basis for new surveying products (e.g. GIS reference data).

The various geospatial techniques (geodesy, cadastral, photogrammetry, remote sensing, hydrography, GIS etc.) used by surveyors in acquiring information has a common ground with other professionals within the built environment. The world over, Geomatics (surveying) curricula keep changing to reflect the current technology and recent developments within the field and allied professions. There is a need to expand from time to time, and modify the course contents to reflect technological and societal changes. The educational margin should be expanded to strengthen the core.

Moreover, our education should increasingly focus on the global market place rather than on the national scene, so that our products will be on the move. New courses should reflect both technical and managerial skills. This will be in line with the post-industrial society's view of itself as a society which will be information and knowledge based, in which brain work and information handling will dominate every facet of life, and most workers will become managers.

Modern definition of surveyor (Geomatician)

At its meeting in Morocco in November 2003, the FIG Council (International Federation of Surveyors) approved a proposal for an update on vision or the definition of a "surveyor" originally, adopted by the general assembly in 1990. The reason for updating the definition is the rapid change in technology and

> Challenges such as a poor professional image, collapse of professional boundaries, training and lack of interest in surveying by prospecting students must be overcome by concerted effort aimed at self-promotion and clear vision.

environment of the surveying professions. The new definition better covers all aspects (techniques) in geospatial data acquisition, such as modern instrumentation and technology and their use (e.g acquisition and use of spatial information from close, aerial and satellite imagery and the automation of this process). It also better covers cartography and the use of GIS. This proposal was adopted by the FIG general assembly in Athens in May, 2004.

According to the new definition, a surveyor or geomatician is a professional person with the academic qualifications and technical expertise to conduct one or more of the following activities:

- To determine, measure, evaluate and represent land, three dimensional objects, point fields and trajectories.
- To assemble and interpret land, geographically and economically related information.
- To use the information for the planning and efficient administration and management of the land, the sea and any structures thereon.
- To carryout urban and rural development as well as land management.
- To conduct research into and develop such practices.

In the listing of detailed functions, a surveyor's professional tasks are further described as possibly involving one or more of the following activities, which may occur either on, above or below the surface of the land or sea and may be carried out in association with other professionals:

- The determination of the size and shape of the Earth, the measurement of all data needed to define the size, position, shape and contour of any part of the Earth, and monitoring any change therein.
- The positioning of objects in space and time, as well as positioning and monitoring of physical features, structure and engineering works on, above or below the surface of the Earth.
- The development, testing and calibration of sensory instruments and systems for the above mentioned and other surveying purposes.
- The acquisitions and use of spatial information from close range, aerial and satellite imagery and the automation of these processes.
- The determination of the positions of the boundaries of public and private land, including national and international boundaries, and registration of those lands with the appropriate authorities.
- The design, establishment and administration of geographic information systems (GIS) and the collection, storage, analysis, management, display and disseminations of data.
- The analysis, interpretation and integration of spatial objects and phenomena in GIS, including the visualisation and communication of such data in maps, models and mobile digital devices.
- The study of the natural and social environment, the measurement of land and marine resources, and the use of such data in the planning of development in urban, rural and regional areas.
- The planning, development and redevelopment of property, whether urban, rural, land or building.
- The assessment of value and the management of property, whether urban or rural, whether land, buildings or landed interests.
- The planning, measurement and management of construction works, including the estimation of costs.

In the application of the foregoing activities, surveyors take into account the relevant legal, economic, environmental and social aspects affecting each project. From the above definitions, one would see the high expectations and the multi-disciplinary nature of surveying/geomatics.

Drivers for development in geomatics

Societal developments

Throughout history, we have witnessed an expansion of a number of societal phenomena, not only world population, but also mobility, local conflicts, size and number of cities, food production, exploration of natural resources and the seas areas, and trade and communication. These developments did not take place at the same rate through space and time. Sometimes a society or nation deteriorates due to bad governance and powerful groups prioritising their own interests, which inevitable results in another society taking the lead. Well-known examples are Portugal corroding the hegemony of India and China in the 15th century, while Spain took over world leadership in the 16th century. Holland subsequently replaced Spain, Great Britain succeeded Holland and the USA superseded Great Britain. Who will be next?

Technological development

All advancements in the geomatics discipline rely heavily on a few general developments in technology, including:

- Increased computer power and storage capacity

- Broadband and wireless communication

- Exploration of the electromagnetic spectrum, both for sensory and point positioning.

- High-speed platforms including cars, aircrafts and satellite processing speed and memory capacity of computers, the number and size of pixels in digital cameras and pulse rates of lidar systems.

They all are expanding at exponential rates. Their development roughly obeys Moore's Law. In 1965, Intel co-founder Gordon Moore noticed that the number of components in integrated circuits had doubled every year since their invention in 1958 and predicted in 1970 that there would be a doubling every two years. So far, that growth has proven to be valid for all digital electronics. It is a too modest a forecast when considering communication systems bandwidth which, as Gilder observed at the end of the 1980s, triples every year.

Crowdsourcing

The surveyor's main task is acquiring, processing and disseminating geodata, particularly its geometric component today. However, the public hold in their hands smartphones that are equipped with GNSS positioning, GIS/mapping functionality and a wireless connection, meaning any layman can collect and retrieve geodata. These communication technologies products are widely available nowadays, not only in megalopolis, but also along coastlands.

Even in tropical rainforests, Web 2.0 downloadable maps, aerial and satellite imagery, GNSS and GIS, on smartphones enable educated users to wirelessly transfer geodata to dedicated services such as WikiMapia and OpenStreetMap without any intervention from professional surveyors. The buzzword "crowdsourcing" or "volunteered geographic information" has been coined for data generation methods in which the general public use informal social networks to collect and share data that is stored centrally using the internet and online tools. New ideas for how mapping and land administration agencies may benefit from crowdsourced data are emerging all the time. Using today's technology, a community without education in map making can collaborate to uncover past and present land rights and uses, voluntarily and without requesting financial compensation. Crowdsourcing can thus help to improve adjudication and dispute resolution processes at low costs.

Challenges facing professional surveying practice

Collapse of professional boundary

As a result of globalisation and information and communication developments, the wall demarcating one profession from another are fast collapsing. Surveying is worst hit because, as earlier stated, what drives surveying is partly advances in technology and societal changes. Technology has

> Using today's technology, a community without education in map making can collaborate to uncover past and present land rights and uses, voluntarily and without requesting financial compensation. Crowdsourcing can thus help to improve adjudication and dispute resolution processes at low costs

made crowdsourcing very simple and easy. Surveying operations can now be carried out by those who are not educated in the field. To stay afloat, surveying must continue to move with the needs of society and technological advancement. Educational institutions must structure their curricula to give students a balance of vocational demands of work within the discipline, and need to give students sufficiently broad educational knowledge that enable them to develop and adapt over time with the rapid changes in our modern world.

Professional image

Surveying as a profession is having an identity crisis. It is not an overstatement to say that the public image of the surveyor has dropped sharply. This does not mean that the importance of surveying to the nation has decreased in stature. In fact, it can be said that the task that the surveyor performs has grown tremendously in quality and technicality. This is why many writers have described this as an "identity crisis". It is worth noting that the status and the respect which the public gives to any profession depends upon the value and scope of work performed and the recognition given to it. As a matter of fact, what the public sees of surveying in Nigeria is a fellow pulling chains, tapes, or carrying a camera-like instrument (theodolite or level) with little or nothing left behind at the end of the day to show for their activities.

There is the urgent need for Surveyors Council of Nigeria (SURCON), the body regulating the practice of surveying, and the Nigerian Institution of Surveyors (NIS), the professional institution that promotes and develops professional practice and techniques in Nigeria, to come up with a public enlightenment programme on radio, television, newspapers and other media platforms to boost the image of the profession – knowing full well that surveyors provide services that are fundamental to sustainable development and nation building. The image problem in the survey family must be faced squarely, drastically, and decisively. When its professional image goes through a spiral fall, the public begins to reckon less and less with the real professional, takes him for granted, and shows reluctance in paying him his fees.

Training

Training in our universities and polytechnics at present emphasises the core traditional surveying courses. There is the need for curricula updates to take into account recent technologies and development within the field of Geomatics. There is the need to expand the margin to strengthen the core. Moreover, our education should increasingly focus on the global market place rather than on the national scene, so that practicing surveyors will be on the move. Courses such land information and management, oceanography, hydrology, geophysics, programming, web mapping, data mining, and big data analytics should be reflected in the new curriculum for training of surveyors. Other courses such as entrepreneurship and professional practice should touch on such areas as principles of corporate/partnership practice, reports and proposal writing, marketing and public relations. These courses will ensure that graduates of surveying are not only technically proficient but also corporate managers. This will go in line with the post-industrial society's view of itself as a society that is information and knowledge-based; brain work and information handling will dominate every facet of life and most practicing surveyors will become managers.

Professional development

Surveyors are supposed to be experts in spatial and time dependent systems, but many lack the interest to venture into these emerging areas. Many of them are generally conservative and do not respond fast to changing situations. As surveying products are becoming more and more sophisticated, the role of the surveyor needs redefining. There is a need for a new approach to training surveyors if they must meet the need of present dispensation. This has also led to the need to retrain the already-trained manpower. It is in the light of the above that educational institutions have to modify their curricula to reflect current developments and take care of recent advances in data acquisition and data analysis. The two bodies responsible for regulating surveying practice in Nigeria need to develop and expand the routine, mandatory professional programme to reflect current development in the profession.

Surveying and politics

In Nigeria, there is a big divide between surveying and politics. It is difficult to find any Nigerian surveyor who is a member of parliament. Making contact with politicians are regarded as somewhat disreputable and is not favoured by Nigerian surveyors. How can we then succeed in carrying out the necessary lobbying, now indispensable in democratic societies, for sensible funding of our universities and training institution, or for the abolition of professional or market structures which are obsolete or biased? It is no surprise that the Nigerian National Mapping law has not sailed through after 17 years since it was proposed. Politics is needed to consolidate and expand new fields of professional activities, to provide a legal framework for new surveying products (e.g. GIS reference data), or to regulate a sensible relationship between the public and private surveying profession. Holger Magel (2002) posited that surveying services are not neutral or free of value judgement. Surveying organisations must seek to have contact with political life – politicians as representative of society – to convince them of the indispensable services offered to the society by surveyors. That means that surveyors must begin to invite politician to their meetings, conferences and give them the opportunity to speak and take part in discussions. There is an urgent need for critical dialogue between politics and surveying where a relationship of mutual benefits will emerge.

Future and prospect for surveying

Nigerian surveyors must not stop at collecting data. What brings money the world over is the value added services. Surveyors need to have broad sets of skills to enable them go beyond data collection and management of data – they should be able to create several secondary uses and meanings out of a particular set of data. Buckner (1981), writing on the future of surveying in the United States of America, enumerated the content of the special body of knowledge which the future surveyors in that country needed to acquire in order to ensure their relevance to society. Buckner's view is: "The modern version of a land surveyor should know how to measure expertly for any purpose. He would understand error propagation; know how to control this error to the extent feasible for each job; and estimate his probable error for statements on plans of survey. To do this he needs not to be a highly educated statistician. He would understand photogrammetry enough to make maps or coordinate the efforts of other specialist; but he needs not be a research scientist in photogrammetry, nor would he want to be. He would be a geodesist to the extent necessary for performing control surveys within limited areas, but he needs to be involved in research concerning the Earth's size and shape or gravity. He would be a planner and designer to the extent necessary to lay out safe, efficient, and appealing new communities, but would not be a landscape architect or urban planner and would work with such professional for extensive urban planning problems. He would know how to determine accurate directions but would not be an expert astronomer. He would take pride in preparing maps and plans to make them portray the intended message in an appealing manner; but he needs not be a higher educated cartographer. He would know how to programme computers for surveying and land subdivision problems, but he needs not to be a mathematics or computer science specialist".

The surveying profession in Nigeria has a future, but to ensure its future survival, the surveying profession needs to keep under review the social and economic environment in which it operates and to take account of perceived external changes which may impact on it. Again, the surveyors in Nigeria must recognise that its old skills are now almost redundant and obsolete, and accept the challenges of taking on new roles.

Professional surveyors in Nigeria must re-educate themselves in the direction of the new technology. The surveying profession must as a matter of urgency work on its image and status. This is because the status and respect which the public gives to any profession depends on the value and scopes of work performed and the recognition given to it. The profession's future will be assured if in the judgement of the public, the surveyor exhibit expertise and competence and performs a service that no one else can provide better and faster economically.

Conclusion

Within the past 30 years, there has been a shift from electro/optical/mechanical tools to software solutions, enabled by reduction in prices of computer chips, digital storage media and the intensive exploration of electromagnetic signals both for positioning and imaging, further accelerated by orbiting platforms and wireless communication.

The main benefit resulting from these developments is the high degree of automation in acquiring and processing geodata. By exploring the capabilities of Web 2.0 technology, the general public is becoming increasingly aware, resulting in participatory acquisition and dissemination of geodata, a process which is denoted by the buzzwords "crowdsourcing or VGI" (Volunteer Geographical Information).

These developments place huge responsibilities and expectations on survey students and professionals in terms of catching up with these developments and again adding value to geodata collected in order to meet the needs of our today society.

The secret to the future is not to think only in terms of standard solutions, but to develop solutions adapted to the needs of the customers and keep an eye open for new customers and demand. The surveying profession in Nigeria has a future, but to ensure its future survival it needs to keep under review the social and economic environment in which it operates and to take account of the perceived external changes which may impact on it. Again Nigerian surveyors must recognise that its old skills are now almost obsolete and accept the challenges of taking on new roles. The professional surveyor in Nigeria must re-educate themself in the direction of new technology. The surveying profession has exciting prospect. This must be the reason why many non-traditional surveying companies are buying into survey-based companies. Examples of this are Hexagon taking over Leica, Microsoft taking over Vexcel Imaging (now it is Vexcel Imaging again) and Shah Capital taking over Thales Navigation. Totally new players are coming into the industry like Google Earth and Oracle, bringing new opportunities and prospect. The need for geospatial information is tremendous and growing; spatial data has to be up to date, more 3D, and more accessible over the internet etc.

Climatic and economic changes still point to the need for spatial data. As the sea level rises, cities become mega cities and energy consumption increase drastically across the world, therein lies the need for more spatial data and services of surveyors. Other dramatic and sudden phenomena like hurricane, tsunamis and earthquakes demands direct action on the part of Surveying and GIS professionals and companies.

> Surveyors are supposed to be experts in spatial and time dependent systems, but many lack the interest to venture into these emerging areas. Many of them are generally conservative and do not respond fast to changing situations. As surveying products are becoming more and more sophisticated, the role of the surveyor needs redefining.

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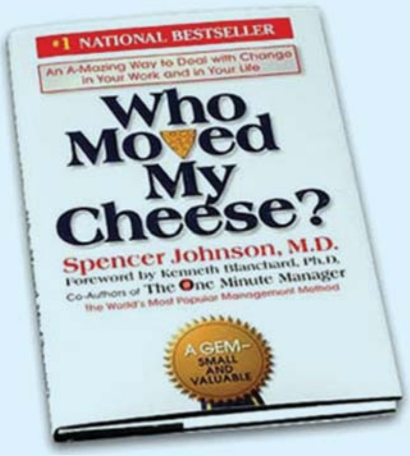

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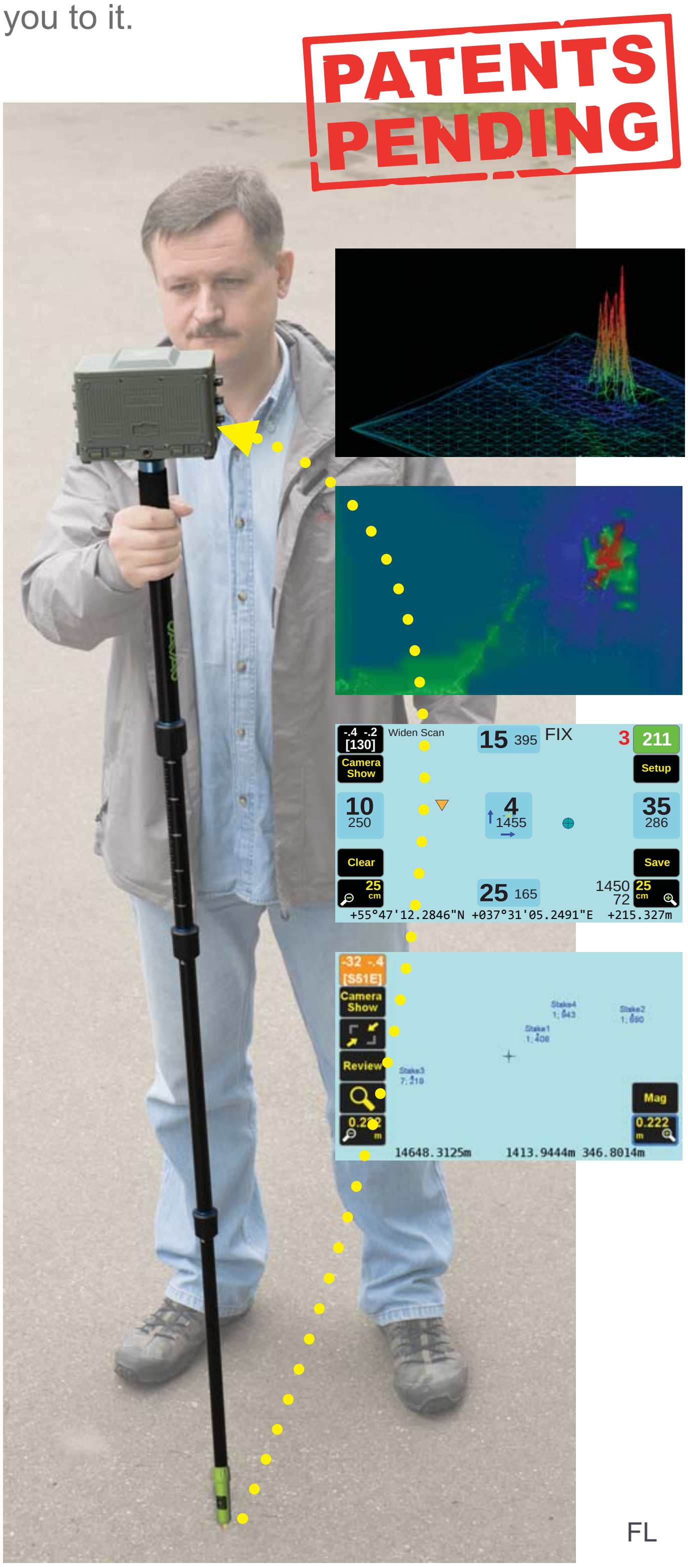
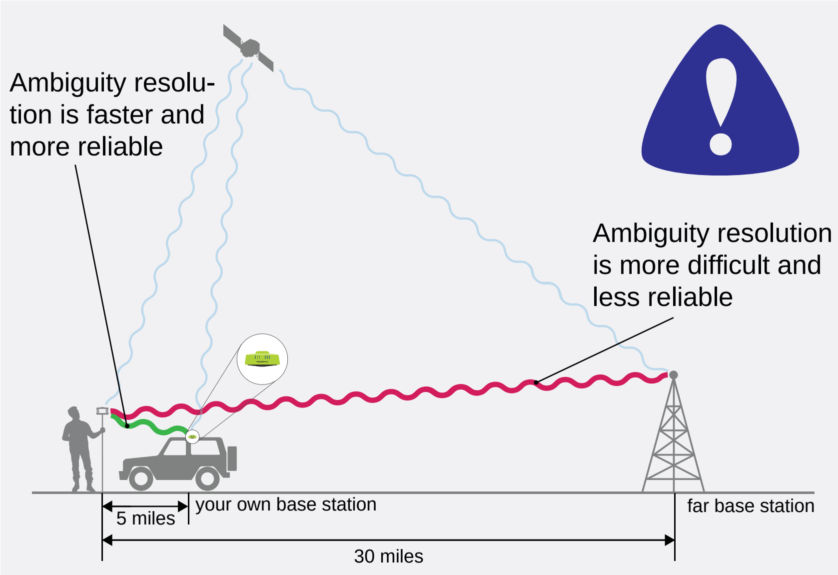
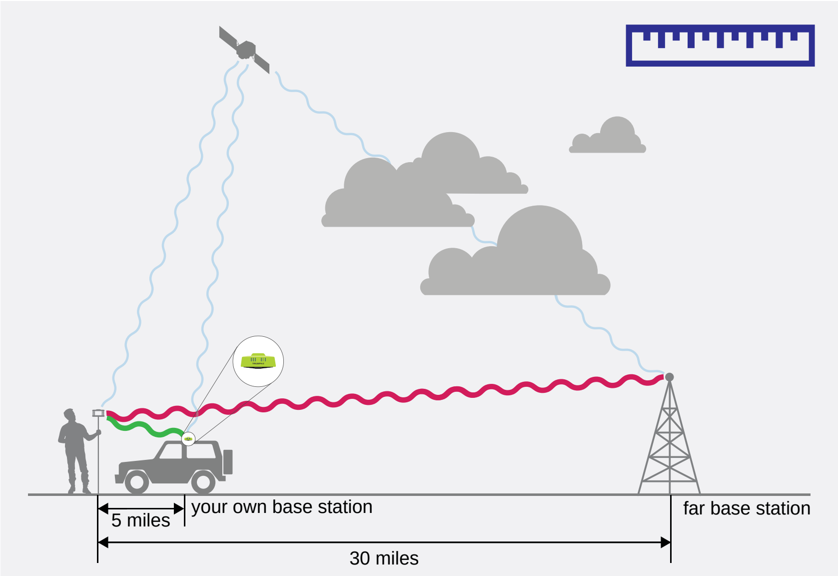


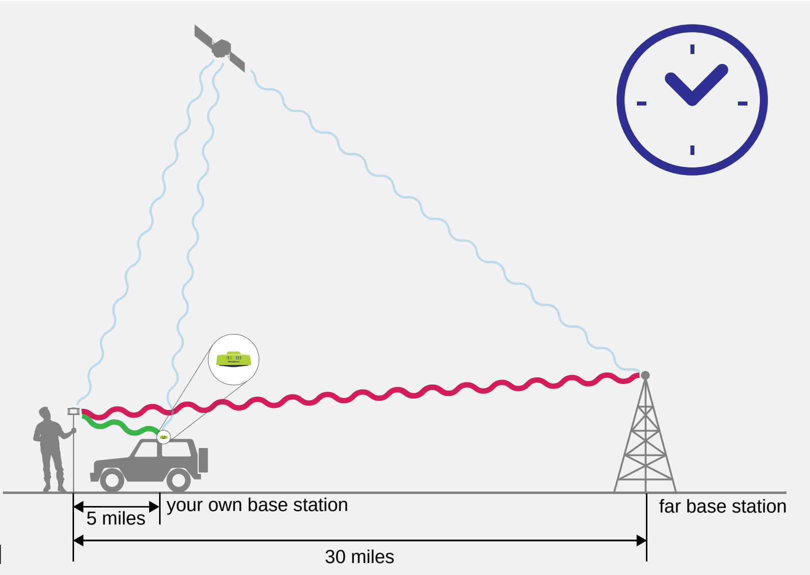
Advantages of your own base station...



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



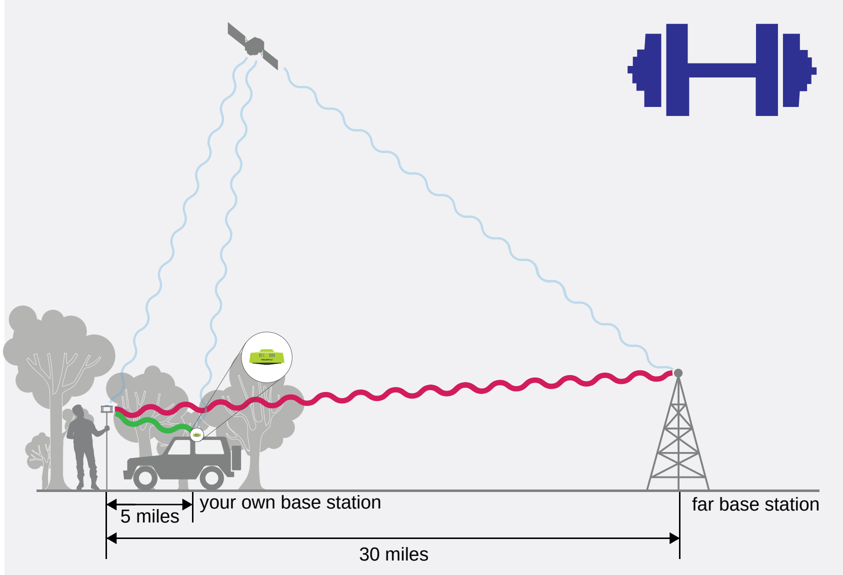
2. Shorter baseline has better **accuracy** because most of errors (like atmospheric and tropospheric effects) are common and cancel.



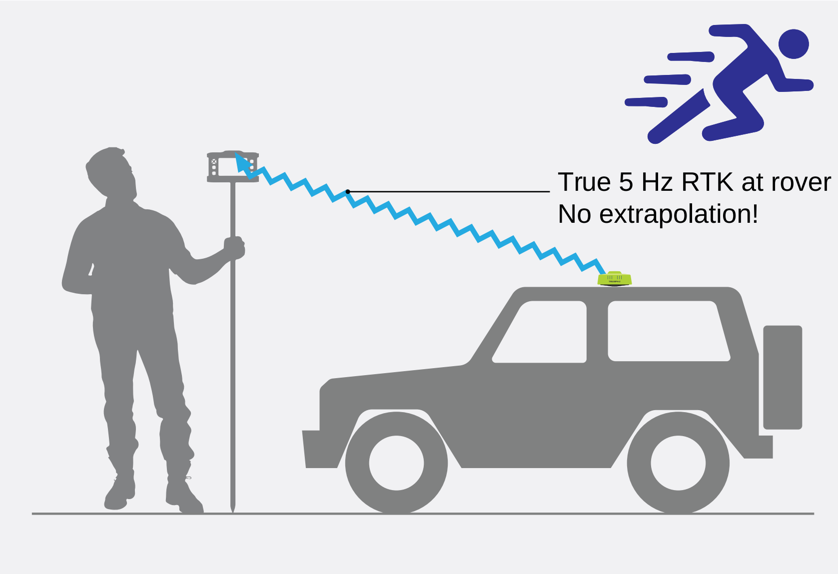
3. Shorter baseline ambiguities are resolved much **faster**. In longer baselines, incorrect ambiguities may pose as being correct in the statistical evaluations and it takes longer to isolate incorrect ambiguities.

...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.

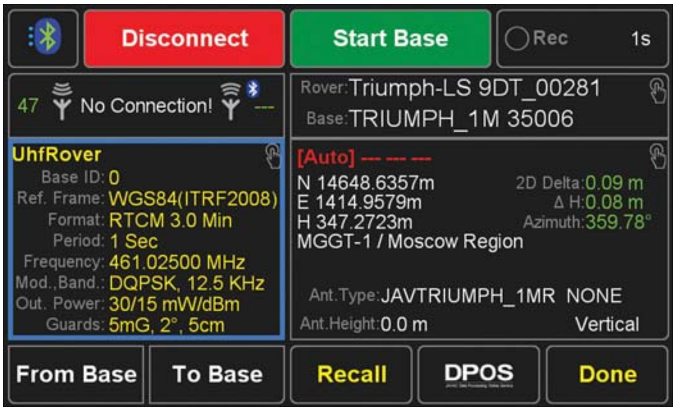


5. **Beast Mode RTK** is available only via our TRIUMPH-2 and TRIUMPH-1M base station. It makes ambiguity resolution up to 5 times faster because base station transmits base data 5 times per second. 5-Hz Beast Mode RTK is totally different from the up to 100-Hz RTK that is done by extrapolating the same 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.

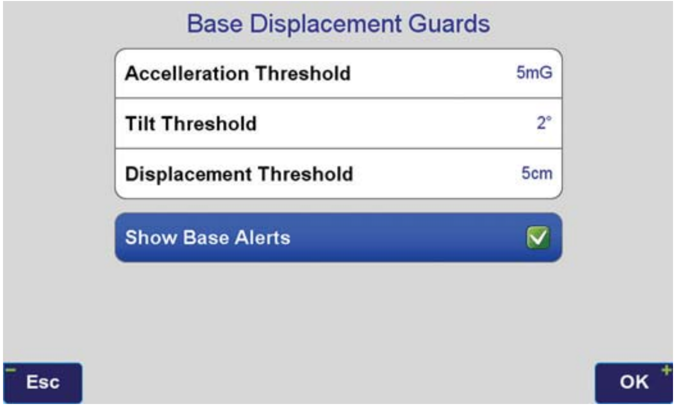


6. In addition to savings due to speed and reliability, it saves you RTN and communication charges. A complete system, Base + Rover + Radio + Controller & Controller Software, starts at $19,990. 0% financing available ($1,537.69 per month for 13 months) to active license US Professional Land Surveyors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

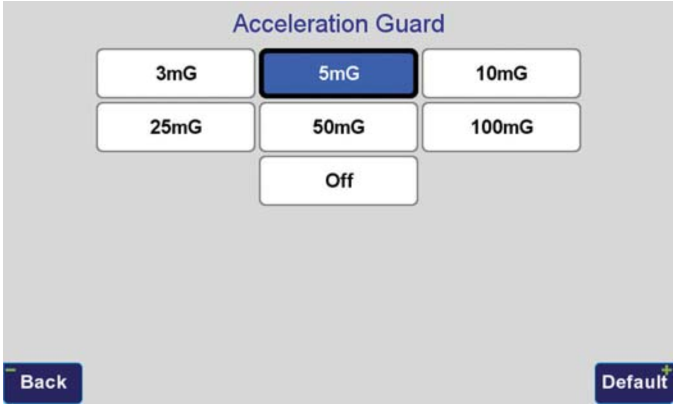
...and ensure that your base has not moved



To setup for base movement alert, go to base rover setup screen and click on the left side of the screen



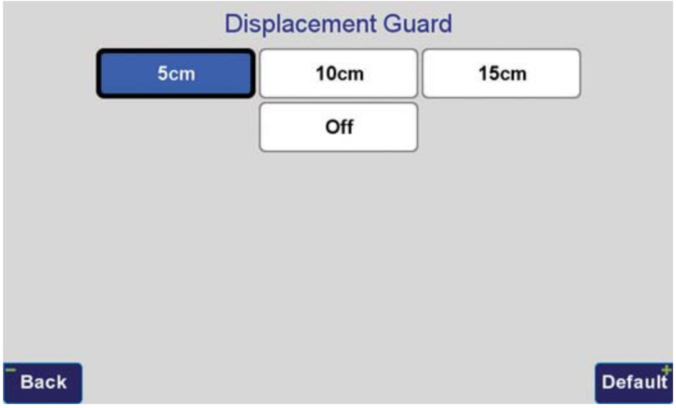
You can set up threshold limits for accelerometer, inclinometer (tilt) and displacement values to create alert when these thresholds are exceeded..



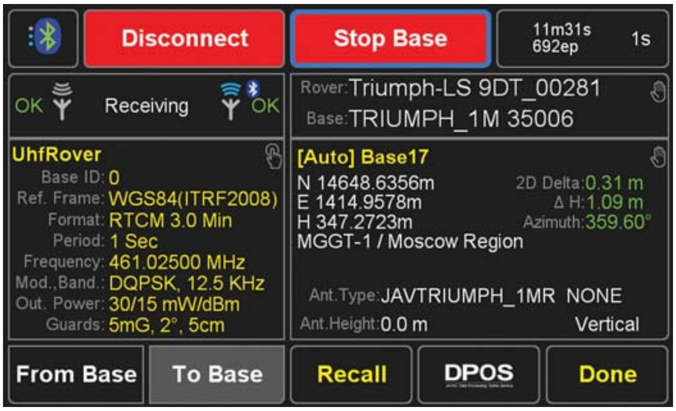
Set Acceleration limit here. The units are in milliG (mG). G is acceleration in free fall. “Off” means ignore this sensor.
Our default is 5 mG

Set the tilt threshold here. Units are in degree. “Off” means ignore tilt.
Our default is 5 degrees.

...or be alerted immediately if it did.

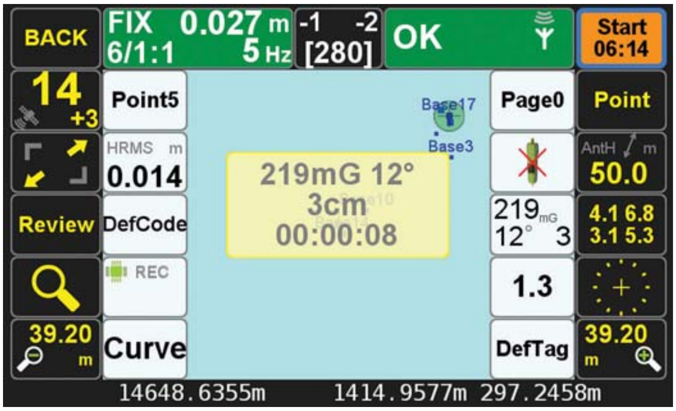


Set the displacement threshold here. “Off” means ignore displacement.
Our default is 5 cm.

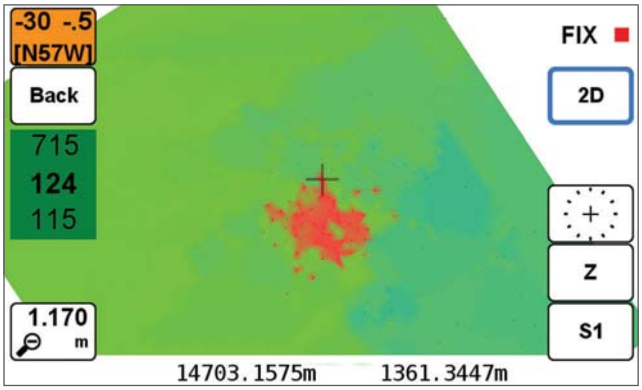


Click the “Start Base”. it will change to “Stop base.”
RTK corrections as well as motion values will be transmitted to the rover.
Maximum values of the motion parameters will be kept at all time.

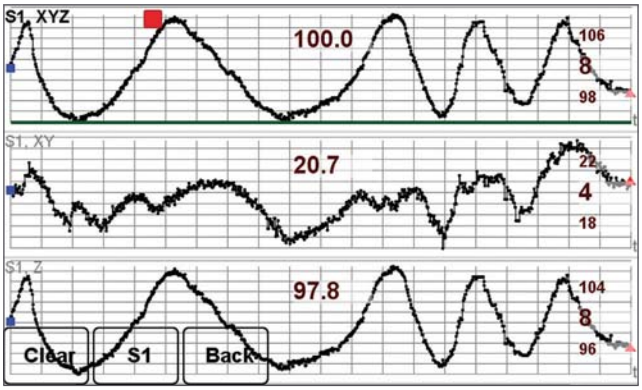
Maximum values of the three sensors can be shown in a white box in the action screen. Top left is the acceleration in milliG, bottom left is tilt and bottom right is displacement in centimeter.



If any of the threshold values exceeds, a pop up will alert you and shows the maximum value of the sensors since you started the base. The bottom number is time since the threshold(s) exceeded.



2D magnetic view of the field



Time view of magnetic variations

Unlike conventional magnetic detectors which sense magnetic values only in one direction, J-Tip has three dimensional magnetic sensors. You can view magnetic values in **XY** (horizontal), **Z** (vertical), and **XYZ** (combined) directions.

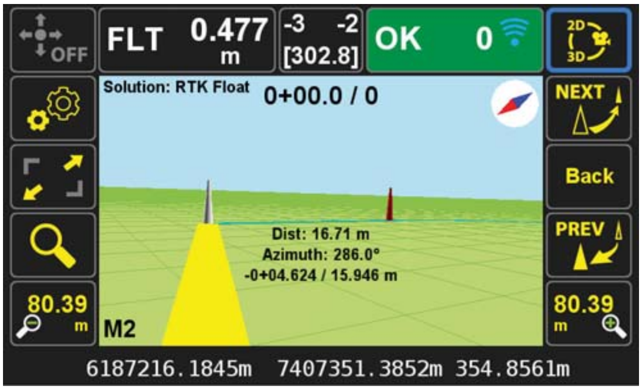
In addition to the audio notifications, J-Tip shows magnetic values in “**Time View**” (always), and in “**Spatial Views**” (**Mag**, **2D**, and **3D** views) when you have RTK solutions.

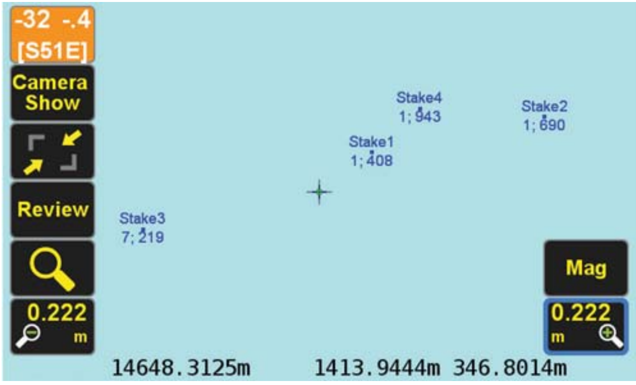
When you have fixed RTK, hold the monopod vertical (within 5 degrees) to tag mag values with their coordinates. J-Tip scans the area 100 times per second and stores the highest mag values and shows them in a large grid. In Spatial Views, the **graphs are centered on the cell with the highest mag value**. Only points that fit in the grid will be shown. The number of such points is shown above the progress bar. The “Clear” button restarts the process.

In Mag mode, pole tilts are corrected automatically and RTK is set to extrapolation mode.

The calculated coordinates of the object is shown in the bottom of the Mag screen.

Time graphs (above) show the magnetic values of the selected sensors in Z, XY and XYZ directions during the past 100 seconds. It also shows the Min and Max values since the Start/Rest. Click on any of the three graph component to expand it.





When you scan a large area, you can save all possible peak points, view them on the map and select the point with the highest peak to dig.

When you save a point, you can also save all the raw Mag sensor data for future view and research. We also plan to give you the ability to share that data with us by transferring it directly to our server for analysis and improvement.

We have not only integrated a sophisticated magnetic locator in the TRIUMPH-LS, but we have also streamlined the whole process. First the “Stakeout” screen will guide you toward the target.
Then the “Mag” screen locates your underground target and gives you its estimate of the coordinates of the underground target and a button to save it “as staked”.
And finally in the “Collect” screen you can survey the target point which you have dug up and exposed. This is also the time to use the built in camera of the TRIUMPH-LS to photograph and fully document the evidence which you have recovered.

TRIUMPH-1M

864 channel chip, equipped with the internal 4G/LTE/3G card, easy accessible microSD and microSIM cards, includes “Lift & Tilt” technology.

TRIUMPH-2

Total 216 channels: all-in-view (GPS L1/L2, GLONASS L1/L2, SBAS L1) integrated receiver.

The one and the only Digital Radio Transceiver in the world!

Unique adaptive digital signal processing, which has benefits: the full UHF frequency range and all channel bandwidths worldwide • the best sensitivity, dynamic range, and the highest radio link data throughput • embedded interference scanner and analyzer • compatibility with another protocols. Cable free Bluetooth connectivity with GNSS receivers and Internet RTN/VRS access via embedded LAN, Wi-Fi, and 3.5G

And all this with competitive prices!

HPT435BT/HPT135BT/HPT225BT*

35 W UHF/VHF Transceiver

HPT404BT/HPT104BT/HPT204BT*

4 W UHF/VHF Transceiver

HPT401BT/HPT101BT/HPT201BT*

1 W UHF/VHF with internal battery

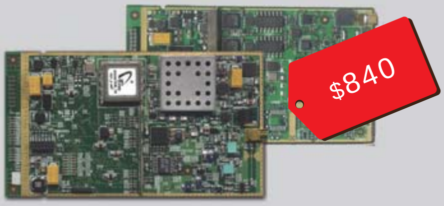
L-Band/Beacon*

Receivers for multiple applications

JLink 3G LTE BAT*

Web-interface Wi-Fi, Ethernet, 3.5 G, UHF/VHF/FH915, internal battery

OEM Solutions



902-928, 360-470, 225-255, 138-174 MHz

*Power, data cables and antenna are included.

Low cost GNSS and Geo-referencing

This paper presents challenges faced by surveyors in Jamaica to geo-reference small rural cadastral surveys. An interim solution to the problem is provided. We present here the first part of the paper. The concluding part will be published in the October 2017 issue

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A recent amendment to the Land Surveyors Regulations (1971) of Jamaica made by the Land Surveyors Board requires that all Cadastral Surveys must be tied to the National Grid. For surveys done in urban areas, a minimum of two (2) boundary points must be used to tie surveys to the National Grid to a positional accuracy of plus or minus 0.1 metre. In the case of surveys done in rural areas, a minimum of two (2) boundary points must be used to tie surveys to the National Grid to a positional accuracy of plus or minus 0.5metre. A temporary exemption, subsequently implemented, allows for surveys done in rural areas, where the Virtual Reference System is not functional and ground control is beyond four hundred metres (400m) of the subject of survey, that such surveys may be geo-referenced to a positional accuracy of plus or minus 3 metres. This presents a problem to define the orientation of the survey, and is one of the aspects of this new requirement which caused some concern to surveyors.

The Surveys and Mapping Division of the National Land Agency has embarked on the production of an island wide digital cadastral map, which will support a myriad of applications, and is one of the reasons why it has become necessary to require surveys to be tied to the national grid, so that this project can be executed more efficiently. Another reason is to support reliable land registration by eliminating dual registration of land.

The implementation of the new amendment will dictate that surveyors acquire Global Navigation Satellite System receivers in order to efficiently meet the new requirements. On the other hand, the cost of survey grade receivers (Scott, Jones, and James 2016) can be an impediment for some practitioners, who may have to resort to the option of using low cost receivers. However, can these low cost receivers meet the required accuracies as outlined in the Land Surveyors (Amendment) Regulations, 2013? The purpose of this study is to investigate the effectiveness of low cost GNSS in geo-referencing small rural cadastral surveys, by looking at costs and positional accuracy characteristics, using data collected in the field by members of the University of Technology, Jamaica, Surveying & Geographic Information Sciences final year students, the National Land Agency and a private practitioner Mr. Earle Spencer.

Background

Cadastral surveying is that branch of surveying which is concerned with the adjudication, demarcation and survey of land boundaries for the purpose of defining parcels of land for registration in a land registry. The traditional cadastral survey practice typically involve the use of terrestrial survey equipment such as a total station, theodolites and/or a tape/chain, and very often requires the re-establishment of previously existing boundaries points that has gone missing. However of major concern in the current survey practice is the fact that most cadastral surveys are carried out and cadastral plans prepared and lodged at the Surveys and Mapping Division for certification without any requirement for tying the surveys to the National Grid. As a result of this traditional approach, surveys cannot be related reliably to each other, and as a result problems may arise such as dual registration, slow pace of cadastral mapping, and heightened complexity in the re-establishment of land boundaries.

GNSS refers to several constellations of satellites providing signals from space, transmitting positioning and timing data, which when processed, produces positional information for the location of the receiver. The technology is being used in other jurisdictions for the survey of property boundaries and the geo-referencing of land parcels, through adherence to strict legal guidelines and best practices.

Key considerations

The motivation for this study is driven by the following key considerations.

New LS Regulations

According to the Land Surveyors (Amendment) Regulations of 2013, Section 3 subsection C1, surveys are to be tied to the National Grid System. In urban areas, positional accuracy of minimum of 2 boundary points used to connect the urban survey to the Jamaica Datum 2001 shall not exceed, plus or minus 0.1metre, relative to the Jamaica Datum 2001.

Section 3 subsection C2 states that, in rural areas, positional accuracy of minimum of boundary points shall be used to connect the survey to the Jamaica Datum 2001, but shall not exceed, plus or minus, 0.5metre, relative to the Jamaica Datum 2001.

In accordance with the regulation found in under Part IV, section 35D, subsection 3 of the Land Surveyors Act which states "Any Global Positioning System equipment used for the purpose of cadastral mapping, shall be considered inaccurate, if the position it has determined for a point in the National Calibration Network differs by more than plus or minus 0.5 metre from the listed position on the Jamaica Datum 1969 (JAD 69), Jamaica Datum 2001 (JAD 2001) or World Geodetic System 1984 (WGS 84) available in the records of the Surveys and Mapping Division, National Land Agency."

Where surveys are executed in an area where the VRS not functional and ground control is beyond four hundred metres (400m) of the subject of survey, such surveys may be geo-referenced to a positional accuracy of plus or minus 3metres, by virtue of a temporary exemption. As the ground control is densified and the VRS becomes more accessible, the need for this provision will gradually diminish.

GNSS

Several Global Navigation Satellite System (GNSS) constellations transmit signals which are freely available to users. Some of these constellations are: Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), BeiDou Navigation Satellite System (BeiDou), Galileo, Indian Regional Navigation Satellite System (IRNSS), Quasi-Zenith Satellite System (QZSS), Precise Range and Range Rate Equipment (PRARE), Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS).

The Global Positioning System is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. The first GPS was launched in 1978. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use.

GPS works in any weather conditions, anywhere in the world, 24 hours a day. The GPS position of reference is WGS84. GPS receivers are extremely accurate; however, certain atmospheric factors and other sources of error can affect the accuracy.

Global Navigation Satellite System (GLONASS) was initially developed in the mid 1970's by the former Union of Soviet Socialist Republics (USSR) based on the experiences with the Doppler satellite system Tsikada. It is made up of 24 satellites, and is operated by the Russian military forces which make it a military system. GLONASS terrestrial reference system is referred to as PE-90.

The People's Republic of China carried out space activities since the1970s, when it launched its first satellite. China decided to implement an independent navigation system called Beidou. The name Beidou denotes the seven-star constellation also known as Ursa Major, Great Cart, or Big Dipper. This constellation has been used for centuries to identify the Polaris star, which indicates the north direction on the northern hemisphere. The Beidou-2 satellite constellation will consist of 27 MEO satellites with their position of reference been CGCS200.

The Quasi-Zenith Satellite System (QZSS), developed by Japan, provides a regional satellite navigation service in East Asia and Oceania. Although QZSS is primarily an augmentation and a complementary service to GPS, it also has the potential to operate in stand-alone mode providing a regional service. The QZSS coordinate system is known as the Japanese geodetic system (JGS). In May 2006, India approved the implementation of the Indian Regional Navigation Satellite System (IRNSS) to provide an autonomous navigation

The Surveys and Mapping Division of the National Land Agency has embarked on the production of an island wide digital cadastral map, which will support a myriad of applications, and is one of the reasons why it has become necessary to require surveys to be tied to the national grid, so that this project can be executed more efficiently.

system for the Indian subcontinent. The space segment consists of seven (7) satellites. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorized users. The IRNSS System is expected to provide a position accuracy of around 20 m over the Indian Ocean Region (1500 km around India) and less than 10 m accuracy over India.

The French system Doppler Orbitography by Radio positioning Integrated on Satellite (DORIS) is a one-way uplink system mainly used for the orbit determination of satellites. DORIS became operational in 1990. DORIS instruments are currently in service, and 60 reference stations are operational. The receiver on board the satellite measures the Doppler offsets of these signals every 10 seconds. Based on the measurements, the satellites determine their position with an accuracy of 1m and velocity with an accuracy of 2.5 mms^{-1} in real time.

The German Precise Range and Rate Equipment (PRARE) is used for orbit determination of satellites like DORIS. It is a two-way system measuring ranges and range rate between the ground segment and the satellites. The master station determines the satellite position in post processing mode with an accuracy of 5 cm and the velocity with an accuracy of 1 mms^{-1}. The system is operational since January 1, 1996.

Low Cost GNSS Receivers

There are many different types or configurations of GNSS equipment ranging from as low as US$150 to US$3,500 or as high as US$ 25,000. Some of the low cost brands of GNSS receivers are manufactured by companies such as Eos Positioning (Arrow), Garmin, Magellan, South, Trimble, Columbus and Wintec and may be used in autonomous mode or differential and single frequency post processed after attaching an external antenna, which adds to the cost of the receiver.

Magellan Navigation, Inc. is an American producer of consumer and professional grade global positioning system receivers. Some of the products by Magellan Inc. are the Pro-Mark 3 which is a survey grade system that performs centimetre-accurate static, stop and go, and kinematic surveys, as well as GIS and mapping. There is also the Pro-Mark 500 which does the same thing plus real time kinematic procedures. The Ashtech Pro-Mark is one of the most versatile post-processing solution equipment, designed for easy and efficient land survey applications. It includes a rugged GNSS handheld receiver running a version of the Windows operating system. Magellan also produces a small commercial grade receiver which is targeted at the recreational market.

One of the most common hand held GNSS devices is manufactured by Trimble and called the Geo-Explorer. It is described by the company as a high accuracy handheld device packed full of features that enable fast geospatial data collection anywhere. It may be used in autonomous mode and also in differential mode after attaching an external antenna and post processing the collected data.

Garmin Ltd. is the Swiss parent company of a group of companies founded in 1989. One of the most popular of the Garmin handheld GPS receivers is the compact e-Trex series which was introduced in 2000.

Orientation

The new provisions require that:

Initial orientation of any survey may be obtained by means of observation of control marks:

a. In the National Grid System, Jamaica Datum 2001; or
b. In an adjoining survey, the initial orientation of which was obtained using controls established in the National Grid System, Jamaica Datum 2001.

All other previous provisions, including the use of magnetic north as a means of orienting surveys have been deleted from the regulations. A major consideration now is whether grid north can be achieved to an acceptable degree of accuracy given the temporary relaxation of the standard for rural surveys.

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To be concluded in next issue.

Monitoring of the interference environment on large vehicles

In this paper we propose a jamming and spoofing detection test system comprising one or two jamming detectors and a network of record and replay systems, triggered centrally by a high precision timing unit, plus a time and frequency monitoring card. The monitoring card detects time jumps and thus spoofing.

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In traffic applications, where critical situations can occur, it is increasingly important to monitor the signal environment of GNSS (Global Navigation Satellite Systems) signals to detect the jamming and spoofing and other potentially disruptive signals, capable of degrading or denying the reception of GPS/GNSS signals and thus impairing a key element of navigation on board of large vehicles, like commercial and military ships and trains.

Several test campaigns in Europe in the last 2 years suggest that the amount of jamming events has increased in recent years, e.g. by the widespread use of private privacy devices generating intentional interference to GPS signals to prevent vehicle tracking, with a high density on highways. Other GPS/GNSS vulnerabilities include multipath, for instance reflections of GNSS signals on large sea vessels from the metal parts on board, and unintentional interference by different transmitter antennas installed on top of roofs of large sea vessels for a variety purposes, e.g. for mobile satellite communication and RADAR. Some of the antennas transmit very strong signals which overpower the very weak GNSS signals arriving from space. These vulnerabilities are also relevant on large airports and test ranges.

Thus, detection and monitoring of interference signals is necessary to notify the navigation crews of large commercial vehicles and operators and controllers of test ranges in real–time to ensure that the navigator stops relying on the GNSS part of his navigation system, in case of a serious denial of GNSS signals. At the same time this satellite navigation signal environment should be recorded to enable analysis at a later time, or in near-real time, to be able to gain a better understanding of the nature and direction of arrival of the interference on board and systematically improve signal GNSS reception, e.g. by seeking and finding a suitable location for the GNSS antenna(s). Recently, new GNSS (GPS, GLONASS and Galileo) interference detectors have been developed, which monitor the signal environment 24 h / 7 days a week and send alerts to the users, in case of strong interference. In addition, record and replay systems with the ability to record all signals in view: GNSS and multipath, jamming and spoofing signals, have been improved with 8 or 16 digitization bits, instead of 1 or 2 per I and Q signal sample. The increased number of bits leads to better resolution and better representation of the dynamic range (jammer/signal ratio).

Here we propose a test system setup consisting of 4 such record and replay systems combined with 2 GPS/GNSS interference detectors. The network of record and replay systems is triggered centrally by a high precision timing unit, so that the trigger pulse arrives at each recording system within 10 nsec, enhancing the accuracy of the recording of the complete test setup. The signal quality of GNSS test systems depends directly on the quality of the timing reference. We propose to further enhance the quality of the recording by input of a highly precise external 10 MHz frequency with better stability and accuracy than the internal OCXO (Oven controlled crystal oscillator), to compensate for various drift and aging effects of the oscillators. This allows to replay the GNSS signals, either on board the vehicle within a few minutes delay after the detection of a GPS/GNSS denial or later in the laboratory and thus to reconstruct a 3D view of GNSS signals and other signals in the L-Band on the large vehicle. This allows localization and analysis of all received signals, including the multipath, jammed and spoofed signals.

In this way navigators are alerted to critical events in real-time, they have access to a concise overview of critical events in a database table on a screen, and gain the ability for an in-depth analysis of the complex signal environment by replaying the recorded signals either in near-real-time after the alert or later for post-processing in the laboratory.

Introduction

Many military and civilian traffic applications are highly dependent on satellite navigation, mainly GPS – Global Positioning System – but also other countries' Global Navigation Satellite Systems (GNSS), like GLONASS, Beidou by China and Galileo. GNSS satellites provide Radio frequency (RF) signals which arrive at the surface of the Earth with a very low signal power of -120 to -130 dBm, so low that it is buried inside the thermal noise. The GPS/GNSS signals are thus easy to interfere with by other signals in the same band of moderate strengths, and vulnerable to different types of effects, including atmospheric disturbances, multipath and malicious spoofing.

Interfering radio signals in the L-band can be emitted and generated unintentionally, e.g. by defect devices or different transmitter antennas installed on top of roofs of large sea vessels, e.g. for mobile satellite communication. Intentional interference is caused by jammers, which are devices designed with the purpose to disrupt GNSS signals. They produce stronger RF signals in the same RF band, and simply overwhelm the GPS receiver by sheer noise [2, 4]. When a receiver is disrupted by a jammer, it is clear to the receiver and to the user that there is a signal problem. Several test campaigns in Europe in the last 2 years suggest that the amount of jamming events has increased in recent years [1,7].

Spoofing on the other hand is a hidden attack misleading the receiver with erroneous information, to make it believe it has different position, velocity or time than it actually has. In this case it is not clear to the receiver and the user, that there is a signal problem. Spoofing has been observed rarely so far. [3]

Jamming can be detected due to the strong power of the signals. Spoofing can be detected, because the spoofing signals differ from the real ones by several parameters, e.g. there is usually only one direction of transmission and all satellites are received twice [18].

Spoofing and jamming signals can be detected in the Automatic gain control of the Receiver, as they both add a high amount of signal power to the signal environment [17], thus less gain is required in the receiver. Relevance

GNSS plays a key role in applications such as in-car navigation systems, advanced driver assistance systems, and autonomous driving systems, timing in mobile phone networks and on military boats and trucks, ground based augmentation systems (GBAS) on airports to provide differential corrections and integrity information of GPS/GNSS signals for approaching aircraft, and diverse purposes on military test ranges.

Correct and uninterrupted information is crucial, because many of these applications involve safety of human lives, e.g. during a landing approach of an aircraft close to the ground, even short interruptions [13] can endanger safe operations or even have fatal consequences. [15, 16].

Thus, the ability to recognize and analyze threats to GNSS reception in near-real time is fundamental, to gain an understanding of the RF environment and to quickly react to threats.

Here, we propose a concept for a network of test systems for the detection of jammers and spoofers, involving both monitoring and recording of the RF signal environment synchronized by a very precise timing unit, which allows to compensate for loss or manipulation of GNSS signals affecting timing, and maintain precise timing for up to 30 days. In addition the system sends and shows alerts in case of strong GNSS signal interference and spoofing. We outline the example of a military ship or boat.

Test System

Overview

We propose to use 2 detectors and 4 Record and Replay systems, together with a very precise GPS timing receiver, containing a high quality Rubidium oscillator, and a frequency and time monitoring card.

Jamming Detector

The GNSS Interference DETECTOR constantly monitors the live GPS and Galileo RF signal environment at L1 at +/- 8 MHz around Center Frequency (CF) and the GLONASS L1 RF signal environment at L1 at +/- 4.5 MHz, in a signal power range of -95 dBm to -25 dBm. It detects jamming events, classifies the impact of a jamming event, characterizes the waveform and type of interference, notifies the user via E-Mail about serious events and stores snapshots of 160 ms lengths of spectrum and spectrogram, +/-80 ms from the peak. The DETECTOR is a detector and an analyzer, analyzing the jamming signals frequency properties, signal strengths and potential impact on a GPS receiver. In addition, the snapshots can be converted into test cases for a GNSS and interference simulator system, enabling repeated and controlled testing of real jamming events in the laboratory [citations from 1, 5, 6].

The access to the jamming event data is enabled via a web based service: all events are sent to a central webserver via internet, allowing the user to access an overview over all events listed in a table on a web portal. This can be either a Spirent web portal PT Cloud or a user specific private network. The web portal table allows viewing of the spectrum and spectrogram snapshots. The online table grants an easy access to the data and a fast impression about the amount and severity of jamming events at the test location of the active DETECTOR or even at several test locations, without a need for the user to manually sort and look through a huge amount of recorded data and without extensive computations. In addition to the online table there are analysis and visualization tools enabling monitoring over time and in-depth trend analysis [6].

"The detection function is accomplished using a fusion of complementary pre- and post-correlation techniques. ….

After the first level signal classification at the GSS200D Detector Probe hardware, the captured interference event is then transferred to the server for further characterisation.

The classification approach used assigns a threat level severity metric to the event. Events are automatically ranked according to a priority score based on the likely impact to GNSS services. *This takes into account the signal power, its frequency and whether this frequen*cy varies over time, e.g. high priority events are assessed as likely to prevent all receivers in the vicinity from acquiring and tracking satellites." [6]

Even though the GSS200D is not intended to be used for operational decision making in real time, information about high priority interference events and alerts can be used as input for a central navigation system, e.g. on a ship or boat.

Record and Replay System

In order to be able to capture and analyze the Jamming or Spoofing Events, we suggest to utilize 4 Record and Replay Systems synchronized by a precise timing unit, and triggered centrally either by an automatic alert or manually, via a central remote control computer, sending a trigger pulse. This yields up to 4 RF recordings of the GNSS and jamming signal environment, including fading, obscuration, atmospheric effects and multipath.

This allows to capture the true signal environment in near real-time, to gather more information about the nature of the interference, to quickly analyze the different signal elements and the direction the signal comes from, and take immediate measures against the interfering signal and reestablish correct positioning, navigation or timing with a fall-back solution or work-around.

The record replay system GSS6450 is a portable unit capable of recording 4 GNSS bands simultaneously at all L band frequencies, including IRNSS (Indian Regional Navigation Satellite System), SBAS, Inmarsat, QZSS (Quasi Zenith Satellite System), B3, and Galileo E6. On record, the RF signals, are downconverted, digitized and stored at IF and can later be faithfully replayed with minor losses of 1-2 dB. "On playback, the IF signal is recreated and then up-converted to RF at the relevant GNSS frequency using the same built-in oven controlled local oscillator (OCXO) as used to record the data for minimum phase noise." [8]. RF signals can be recorded at 4, 8 or 16 bit for quantization and at 10, 30 and 50 MHz bandwidth. There are throughput limitations at 8 and 16 bits and 50 MHz, limiting the amount of channels that can be recorded simultaneously to 1-2. [8]. The GSS6450 contains an OCXO for record and playback for high frequency stability. It is very small at 2.2 kg and a size of 21*20 cm, with a large storage capacity of 2-4 TB internal and external SSD.

The disadvantage of recording at 8-16 bits and 50 MHz is a very high data volume, resulting in short maximum recording times of about 1 hour/TB. This recording time can be extended, by using larger storage media, for example recording externally via USB 3.0. [8].

At the same time, the major advantage of this record and replay system is the 16 bit depth for quantization of I and Q each, allowing to capture GNSS signals even at high jamming powers. Most other portable record and replay systems have a 2 bit quantization, which is suitable for general GNSS signals with a 12 dB dynamic range. Greater bit depth allows better resolution of GNSS signals and greatly increases this dynamic range both for jamming and for multipath and fading effects, to 21 dB at 4 bit I and 4 bit Q, to 45 dB at 8 bit I and 8 bit Q and to 80 dB at 16 bit I and 16 bit Q.

Sampling rates are 10.23, 30.69 or 51.15 MHz, synchronous recording rate for external data is 300 kbps at 10.23 MHz, 900 kbps at 30.69 MHz and 1500 kbps at 51.15 MHz, asynchronous recording rate for external data is 4800-115200 baud. [8] The reference oscillator is an OCXO with a frequency of 10.23 MHz, to allow direct generation of the wanted GNSS frequencies. There are two RF outputs: one normal RF output with a standard

Fig. 1 Front view of GSS6450 by Spirent

Fig. 2: LL-3760 GPS Timing Receiver by Lange-Electronic GmbH

GNSS RF signal strength (nominal -130 dBm for GPS L1), and one high power output at the back of the test system with around -80 dBm nominal [8]. In addition there is a 10 MHz Reference IN port, allowing to input a source of precise timing. The better the timing, the better the accuracy of the GNSS Position, Navigation and timing solution.

"The GSS6450 is fully integrated and can be controlled from the front panel, over WiFi, from the webserver or via scripts. Remote control is possible via a VNC (Virtual Network Computing) server and HTTP (Hypertext Transfer Protocol) messages. [9].

"External data can be recorded synchronously and asynchronously. The wide range of external data sources includes: 4 video streams per webcam, audio, CAN (Controller Area Network) bus data, timing pulses, NMEA (National Marine Electronics Association) data, IMU (Inertial Measurement Units) and other sensors. [9]

Timing Systems

The signal quality of GNSS test systems depends directly on the quality of the timing reference. To improve the accuracy of the complete test setup, the network of record and replay systems is triggered centrally by a high precision timing unit, so that the trigger pulse arrives at each recording system within 10 ns. It is possible to further enhance the quality of the recording of the GSS6450 units by input of a highly precise external 10 MHz frequency with better stability and accuracy than the internal OCXO, to compensate for various drift and aging effects of the oscillators.

We propose to use the LL-3760, a precision GPS Timing Receiver, with a basic accuracy of +/- 5 ns, based on a high quality OCXO [14]. This accuracy was verified in experiments in the AviationGATE (Aviation Galileo Testbed) at the Technical University of Braunschweig [14]. The unit outputs 10 MHz and 1 pulse per second synchronized to the GPS system.

Originally, the unit was designed to provide time and frequency to Spirent Pseudolite Simulators (Galileo) [12]. It provides "three capabilities to shift the system time independently, with a programmable shift of the 1 PPS and frequency outputs in ~25 ps steps, phase locked [12]. On the one hand, this enables triggering of the 4 record and replay systems within 10 ns, on the other hand it allows provision of a very stable 10 MHz frequency to keep the record and replay systems precisely synchronized, and on the third hand it provides very precise timing for one day with 500-600 ns drift per 24 hours, even in case of a loss of GPS/GNSS signals due to jamming or spoofing. An even higher accuracy can be achieved with a Rubidium standard instead of the OCXO.

In order to detect spoofing, it is also possible to integrate a timing and frequency monitoring card KL-3360 [19] by Lange Electronic for the detection of time jumps and offsets. This time and frequency unit monitors and compares time and frequency systems, it controls up to eight frequency signals from 4-40 MHz and up to eight 1 PPS Input Signals. It is programmable via PC (personal computer), with the Grafical User Interface "DataMon". When the preset limits of permissible errors are exceeded the software releases an alarm, which is displayed and can be distributed via email and SNMP-trap (Simple Network Management Protocol) [19]. It offers three types of alarm messages: optical, via e-mail and SNMP trap. All data are stored on the PC and can be played back in different speeds in the „DataMon" Software or analyzed in spreadsheets. This allows retrospective analysis of time- and frequency anomalies through stored data.

System Interconnections

The DETECTORS work independently of the other test system components and provide their information via webserver or local data base to the central data processing or navigation system. The timing receiver and the record and replay units are connected via coax cable providing 1 PPS and 10 MHz reference. This is possible for a length of several hundred meters. With an additional effort, the four 1 PPS outputs can be adjusted to the different cable lengths, so that the pulses will arrive simultaneously. The cable lengths must be known for this adjustment. The central data processing unit or navigation system can send a trigger pulse to the record and replay systems via the precise GPS timing receiver. Or the precise GPS timing receiver LL-3760 can send the trigger on its own.

Use cases

The proposed concept can be used in any traffic applications involving safety critical operations, where human lives are at stake, on large vehicles or vessels, both in the civilian and the military domain.

Here we want to highlight the use case of timing on military ships, which is crucial for several important subsystems and is maintained with great effort. Military ships and vessels are usually equipped with several GNSS receivers on-board, used both for timing and positioning. During field operations a jamming or spoofing attack is more likely than in civilian ships. Communication is based on frequency hopping and all parties taking part in the communication need to stay synchronized within 100-200 µs.

With our proposed GPS timing reference, timing drifts 500-600 ns in 24 hours, and timing of about 15 µs accuracy can be maintained for 30 days, even in case of long-lasting jamming and spoofing attacks, as the internal Rubidium oscillator(s) continues to operate with a high stability, independent of external RF signals. The requirement of 100-200 µs timing accuracy is still met after 4-5 months of free running Rubidium oscillator without any GNSS reception. Depending on the quality of the oscillator, an even higher accuracy can be achieved (Cesiums, Masers or multiple Rubidiums).

Commercial container ships transport freight of high value, and are sometimes kidnapped and robbed. It is useful to have an early warning system for jamming and spoofing on-board, indicating that an attack might be imminent.

Timing and integrity monitoring is critical on test ranges and airports, both military and civilian, where quick alerts are required for secure operation, e.g. an approaching aircraft needs to receive integrity information within 6 s according to ICAO (International Civil Aviation Organization) require-ments.

Benfits and Drawbacks

Advantages

- The overall system outputs a fast alert in case of interference and spoofing, so that immediate action can be taken, e.g. fallback on backup systems.
- With 2 DETECTORs the direction of arrival of the jammer can be determined
- This system enables a 3D spatial recording and capturing of the GNSS and interference signal environment.
- The GNSS and interference signals are captured immediately following the alert, giving a better chance for classification, identification of nature of inter-ference, multipath and repeated patterns, and finding the root cause of GNSS reception problems.
- The RF signals are recorded and can be replayed repeatedly, so that a deeper analysis can be carried out in the laboratory.
- The data allow conclusions about quality of the location of the GNSS antenna on the shell of the vehicle
- The LE 3760 keeps operating and providing a very precise time during a jamming or spoofing event. The precise time is maintained by the internal oscillator:
- This precise time can be used on-board military and other ships to continuously synchronize all devices and systems
- It allows monitoring of the time with a precise timing receiver, or a time and frequency monitor. Unusual shifts or offset in the time, indicate the presence of a spoofing attack, so that an alert can be triggered by the software of the frequency monitor.

Drawbacks

- High effort and a significant investment initially
- It takes more than one detector and Record and Replay unit to determine the direction of the interfering signals
- It takes time to analyze signals – unless there is an algorithm capable of automatic evaluation of signals
- Interference can be caused by different phenomena from different sources: Multipath, spoofing, atmos-pheric effects and jamming, and more. They can be recorded with the same Record and Replay system. The analysis method and recognition algorithm needs to be different for each of them

Conclusion

Positioning, Navigation and timing with satellite navigation, is an important component of many safety critical applications, e.g. timing on military ships, boats and trucks to enable secure and complex communication schemes. Due to their low signal power, GNSS signal reception can easily be degraded and disrupted by interfering signals, like jamming and spoofing.

In this paper we propose a jamming and spoofing detection test system comprising one or two jamming DETECTORS and a network of record and replay systems, triggered centrally by a high precision timing unit, plus a time and frequency monitoring card. The monitoring card detects time jumps and thus spoofing.

Jamming detectors work independently and are able to monitor the signal environment non-stop, to detect jamming events, classify them and send alerts, in case of strong interference. 4 record and replay systems can be triggered by a central unit and faithfully record the RF of both the GNSS signals and the interference signals with high bit depth and fidelity.

The central high precision timing unit ensures that the trigger pulse arrives at each recording system with a time difference of less than 10 ns, enhancing the accuracy of the recording of the complete test setup. It is possible to improve the quality of the recording even further by input of a highly precise external 10 MHz frequency with very high stability and accuracy.

The overall setup allows to replay the GNSS signals, either on board the vehicle within a few minutes delay after the detection of a GPS/GNSS denial or later in the laboratory and thus to reconstruct a 3D view of GNSS signals and other signals in the L-Band on the large vehicle.

In this way, navigators are alerted to critical jamming and spoofing events in real-time, they have access to a concise overview of critical events in a database table on a screen, and gain the ability for an in-depth analysis of the complex signal environment by replaying the recorded signals in near-real-time after the alert. The main advantage is that precise timing can be maintained for many days, the duration depending on requirements. In the case of the military communication the duration is up to 4-5 months with the OCXO.

Acknowledgment

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Fishponds extraction using rule based classification and support vector machine of LiDAR data

The objective of the study is to extract large scale fishponds using Object Based Image Analysis.

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Mapping of fishponds are valuable to achieve proper monitoring and inventory of fish production. Due to yearly changes in the fishpond structures and operation, inventory of these aquacultures tend to become time consuming laborious. On the other hand, the possibility of using remotely sensed data to generate maps of aquatic resources must be explored considering that remote sensing data were proven to be useful in generating high accuracy maps of land covers.

LiDAR data is one of the remotely sensed data that were frequently used in mapping which has 0.5m x 0.5m resolution. LiDAR data is produced by projecting laser that transmits very short pulses in optical or near infrared part of the electromagnetic spectrum (Rees, 1999). Using LiDAR data, different raster layers can be produced and used in mapping of land covers in various ways of classification processes. "Support Vector Machine" and "Rule Based Classification" are some of the classification processes that are commonly used in mapping purposes. Support Vector Machine (SVM) on the other hand, is one of the best machine learning algorithms in which a given set of training examples, the machine also analyzed the data and create new examples based on the similarities of patterns and categories in the given set of training samples (Pradhan, 2012). "Rule Based Classification" is a process that is highly expressive as decision trees which is easy to interpret, generate and can immediately classify objects (www.mimuw.edu.pl).

Table 1: Layers used in the study.

LAYER	DESCRIPTION
DSM and DTM	Digital Surface Model: Earth surface objects Digital Terrain Model: Earth surface without any objects
nDSM	DTM grid subtracted from the DSM grid to obtain the height of objects above the ground
Slope	Steepness of certain straight line.
Slope of slope	Slope of DSM undertaken another slope computation to amplify levees.
Curvature	Degree to which a curve deviates from a straight line, or a curved surface deviates from a plane.
Surface area to planar Area (SAPA)	Ratio between the 3D surface area and the planar area of the surface, and optionally also provides the surface area itself.

Mapping aquatic structures can also be performed with good accuracy and at regular intervals by satellite remote sensing, which allows observation of vast areas and even areas of difficult accessibility at a fraction of the cost of traditional surveys (Travaglia et. al, 2004). This study was conducted to develop a protocol in extracting large numbers of fishponds by combining the SVM and "Rule Based Classification" using LiDAR Data.

Objectives

The objective of the study is to extract large scale fishponds using Object Based Image Analysis by combining with SVM and Rule Based in classification approaches.

Materials and methods

Data and study area

The data used in this study are LiDAR data from the Phil-LiDAR 1, Data Acquisition Component, University of the Philippines Diliman, Philippines. The selected study site was a 31.04km^2 land cover area in the municipalities of Samal and Abucay, Bataan. Both municipalities lies in coastal zone having numerous fishpond structures (Figure 1).

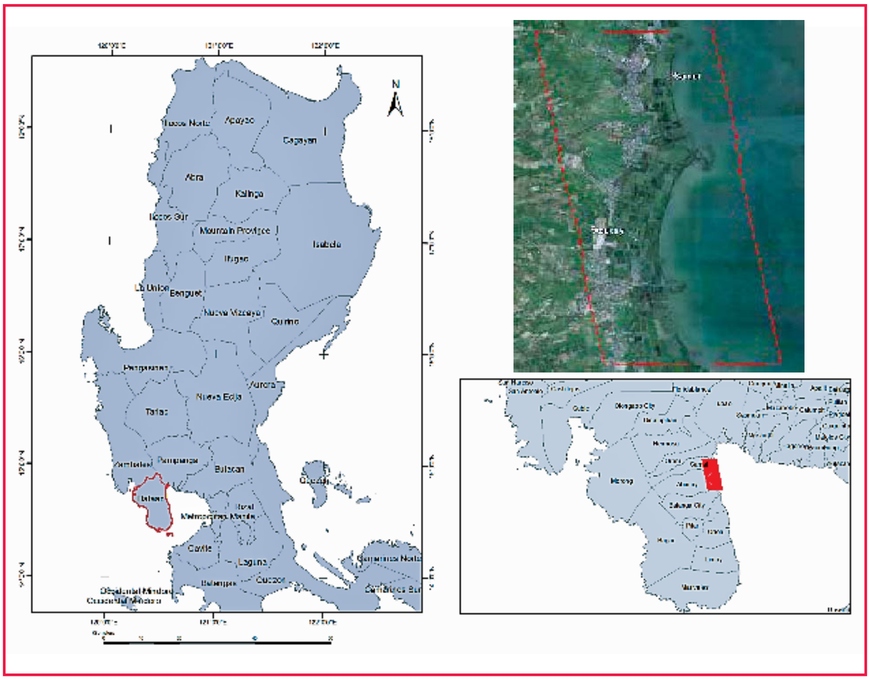

Figure 1: Aerial image of the study site

Table 2. Multi-resolution segmentation parameters

Criteria	Value
Scale Parameter	60
Shape	0.2
Compactness	0.8
Layers	**Weights**
Curvature	0
DSM	1
DTM	0
nDSM	0
Slope	1
Slope of slope	1
SAPA	0

General Methodology

The methodologies used in this study are the same methods used in classification processes for mapping land covers using various remotely sensed data. Some modifications in the methods were carried out to achieve the objectives of the study. Figure 2 shows the flow chart of the general methodology of the study.

Derivation of Layers

LiDAR data was used to generate layers using LasTools and ArcGIS softwares. Digital Surface Model (DSM) and Digital Terrain Models (DTM) were derived using Blas2Dem and processed in ArcGIS to generate various layers. All layers produced were mainly height dependent to magnify fishpond levees. Description of all layers used in classification is shown in Table 1.

Image Segmentation Method

Two pronged approach in image segmentation were used in the classification process using eCognition developer. Multi-threshold was used in separating large objects based on pixel/layer values and this segmentation approach was used in separating ocean bodies from the land cover mass through DSM layer. Using Rule Based classification, objects were classified as higher ground, ocean bodies and fishpond areas based in the DSM and geometric features (Figure 3).

Multi-resolution segmentation (MRS) was used to compensate the fishpond areas which were incompletely segmented. Objects of interest typically appear segmented from the other objects by controlling the scale parameter and layer weights (Baatz and Schape, 2002). In eCognition software, three criteria must be satisfied to have a good set up and these are: scale parameter, shape and compactness. These three criteria are very vital in having a good segmentation. Therefore, height dependent layers were used in the segmentation process to properly dissect fishpond levees. Table 2 shows the parameters and layer weights used in segmenting the levees from the classified fishpond areas.

In Multi-resolution segmentation, the values and weights dictates the degree or influence of the criteria and layers in the segmentation, thus, trial and error are needed in the process to choose the best results. Figure 4 shows the result of the MRS by applying the values and weights in the fishpond areas.

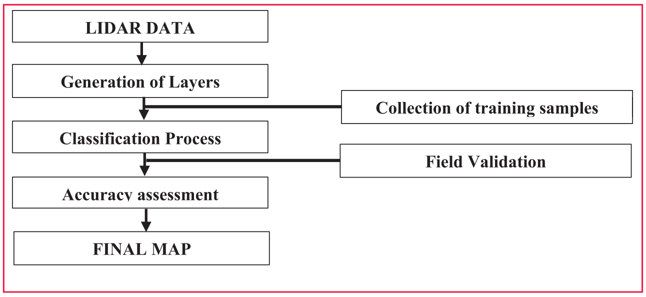

Figure 2: Flow chart of the general methodology of the study.

Figure 3: Image segmented using multi threshold segmentation

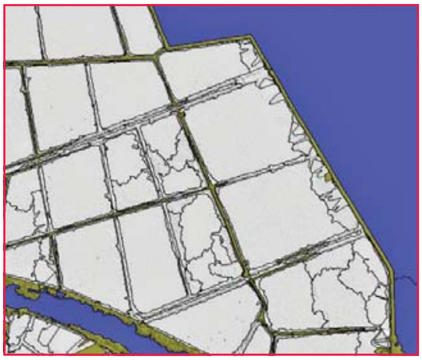

Figure 4: Segmented fishpond levees

Support Vector Machine (SVM) Classification Process

Support Vector Machine (SVM) is one of the best machine learning algorithms that automatically classify segmented objects. SVM is a technique suitable for binary classification tasks, which is related to and contains elements of non-parametric applied statistics, neural networks and machine learning (Auria et.al, 2008). From the segmented objects of the fishpond areas, this approach can classify the fishpond levees from the water bodies. Given the height dependent layers generated from the LiDAR data, classification of levees, water bodies, unwanted triangulations and other water artifacts e.g. boats, bamboo, *kubo* will be much better. Layers used in the SVM classification process have undergone trial and error to select the best results. Table 3 shows the layer values and geometry assigned for the SVM classification process.

Rule Based Classification Process

Extraction of fishpond levees and other water artifacts was carried out using SVM. The remaining water bodies e.g. fishponds, river ways and small water reservoir were further classified using "Rule Based Classification" which function as decision trees that is easy to interpret and quick to execute. Table 4 displays the geometrical features used in the classification process.

Table 3: Layer values and geometry used in the SVM classification process.

Layer Values	Layers
Mean	Curvature DSM DTM Slope Slope of slope
Standard Deviation	Curvature DSM DSM (hillshade) Slope Slope of slope
Geometry	Features
Extent	Length (pxl) Length/Width

Table 4: Geometrical features used in the classification process

Geometry	Features
Extent	Number of Pxls
Shape	Compactness Elliptic fit

Geometrical features are vital for extracting fishpond structures from other water bodies because of their polygonal shape. On the other hand, river or water ways were observed elliptical and linear, while small water embankment has an indefinite or irregular in shape. Therefore, the rule based classification approach was observed as effective way to extract fishpond structures and be classified individually. Flow chart for the classification process is shown in Figure 5.

Results and discussion

Results of segmentation and classification

In image segmentation, Multi-threshold segmentation was found to be the best way to separate different classes in large homogenous object. On the other hand, generated layers such as slope, DSM, and slope of slope were observed to have the highest influence to dissect the fishpond levees in Multi-resolution segmentation, thus these layers are vital in the classification process. Geometrical features such as: number of pixels, compactness and elliptic fit were observed to be useful in separating fishpond areas from the other water bodies.

Accuracy assessment report

Accuracy assessment was done to evaluate the classification process was carried out in extracting fishponds structures. It was observed that the classification process obtained high accuracy of 98.22% with a kappa coefficient of 0.94. Results of the accuracy assessment is shown in Table 5.

Figure 6 shows the final classified map of fishpond structures using the combined approached of Support Vector Machine and Rule based classification.

Conclusion

Proper scaling and weighing values are vital in using Multi-threshold and Multi-resolution segmentation to separate different classes. “Support Vector Machine” and “Rule based Classification” effectively extracted large number of fishpond structures in Samal and Abucay, Bataan. The study shows that using the modified method for classifying fishpond structures, an accuracy of 90+ can be obtained putting only height dependent layers of the LiDAR data. Accuracy may vary by using different layers and remotely sensed data.

Acknowledgement

We would like to acknowledge the Department of Science and Technology (DOST) for funding support for the Phil-LiDAR 2 Program, and Philippine Council for Industry, Energy and Emerging Technology Research and Development (PCIEERD) as the program monitoring agency.

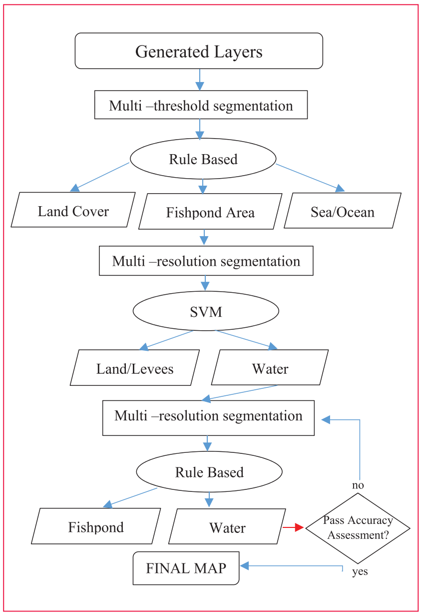

Figure 5: Flow chart for the modified method for classifying fishpond structures.

Table 5: Accuracy assessment for the classification process.

User/Reference	Land mass	Water 1	Fishpond	Sum
Confusion Matrix				
Land mass	21155	1603	0	22758
Water 1	0	17478	0	17478
Fishpond	0	2100	165932	168032
unclassified	0	0	0	0
Sum	21155	21181	165932	
Accuracy				
Producer	1	0.8251735	1	
User	0.9295632	1	0.9875024	
Hellden	0.9634960	0.9042138	0.9937119	
Short	09.295632	0.8251735	0.9875024	
KIA Per Class	1	0.8091579	1	
Totals				
Overall Accuracy	0.9822200			
KIA	0.9473286			

Figure 6: Extracted fishponds in Abucay, Bataan

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EarthSense to provide Real Time Air Quality Monitoring

EarthSense Systems is equipping commercial delivery vehicles with air pollution sensors as part of a project to test the performance and emissions of low-carbon lorries. Using their state-of-the-art Zephyr air quality monitoring sensors, it will collect real-time pollution measurements to help develop zero-emission running strategies for a range of environmentally friendly commercial vehicles and their cooling units.

The research is part of the Temperature-controlled Range-extenders and Integrated Urban Mapping of Pollution (TRIUMPH) project, led by logistics provider Kuehne + Nagel and supported by Cenex – the UK's first Centre of Excellence for low-carbon technologies. Working in partnership, Cenex will manage data collection and mapping for the trial, while Microlise develops a supporting telemetry system and Tevva provides zero emission running strategies – based on the real time air quality measurements captured by EarthSense. Finally, Emissions Analytics will be responsible for measuring trial vehicles' emissions and range capability. EarthSense Systems is a joint venture between aerial mapping company Bluesky and the University of Leicester. *www.earthsense.co.uk*

Teledyne CARIS releases new version of Bathy DataBASE

Teledyne CARIS™ has announced the release of Bathy DataBASE™ (BDB) 4.4. This new version addresses the important areas of feature generalization and automation of product generation for chart compilation, as well as the increasing emphasis on bathymetric Lidar surveys.

A collection of new techniques for generalizing bathymetry in chart compilation workflows can be found in BASE Editor™, which is part of the BDB suite. Point suppression and smoothing techniques help reduce the manual work associated with turning survey data into chart ready vector features. These techniques can be used in isolation or together with other bathymetric feature compilation tools to produce the best results possible. *www.teledyne.com*

TCarta Marine introduces Vector Shorelines

TCarta Marine has made the world's most dynamic environments easier to monitor and manage with the introduction of its new multi-scale Shoreline Products. Offered in GIS-ready vector format, the Shoreline data sets are derived from satellite imagery and accurately delineate mean sea level for the land-water interface at coastal areas around the world.

It is creating the Vector Shoreline Products at Global, National and Local scales for mapping applications as diverse as environmental protection, coastal infrastructure development and flood insurance rate calculations. Many of the Vector Shoreline Products are available off-the-shelf, while others are custom derived from archived or newly collected satellite imagery. *www.tcarta.com*

Japan launches navigation satellite

A Japanese H-2A rocket launched Japan's third Michibiki satellite to join a constellation of navigation aids to improve positioning services across the country. Weather pushed back the mission's initial Aug. 11 launch date, and a leaky helium pressurization system scrubbed a launch attempt Aug. 12, forcing ground crews to roll the rocket back to its hangar for repairs. The 174-foot-tall (53-meter) H-2A launcher, powered by a hydrogen-fueled main engine and four strap-on solid rocket boosters, headed east from the Tanegashima Space Center, a spaceport built on an island at the southwestern edge of the country. Climbing through a clear afternoon sky on 2.5 million pounds of thrust, the H-2A rocket quickly exceeded the speed of sound and left a twirling column of exhaust in its wake. The four solid rocket boosters let go from the launcher around two minutes after liftoff, and the shroud covering the Michibiki 3 spacecraft jettisoned a couple of minutes later. *https://spaceflightnow.com*

Project to densify GNSS/GPS Network

In A move to densify the nation's GNSS/GPS Network, the Geodetic Section of the Survey Department, Ministry of Development, Brunei conducted a simulation for a Field Reconnaissance Project at several key locations around the Sultanate.

The final list comprised 15 out of 19 proposed sites for the project using Primary Order Network which covers an area within 25 kilometres – two areas were delayed due to technical difficulties while the remaining two were ruled-out due to not meeting the quality criteria.

The survey was conducted by a project team led by the Geodetic Section of the Survey Department with testing procedures conducted using equipment based on the started regulations of geomatics (Work Instruction Geodetic 2016). The field reconnaissance project used levelling mount and GPS antenna secured to a stainless steel pin which is anchored within the top pillar which is generally simple and easy to construct almost in every terrain.

Results show that the most important factors for the successful survey focussed on collaboration to develop and improve the task standards in accordance with international standards applied consistently. According to Abdul Khaliq, the task design and implementation was "well-planned" using technological, spatial data computational and surveying viewpoints as well as consistent reviews and updates that were also factors to the success. *http://borneobulletin.com.bn*

Highly elliptical orbit segment for Glonass

The work to create a highly elliptical orbit segment for Russia's Glonass satellite navigation system will begin in 2019, according to the CEO of Reshetnev Information Satellite Systems Company Nikolai Testoyedov.

"The same concept envisages adjusting the Glonass target program and introducing a highly elliptical navigation segment of six satellites. This work will most likely start from 2019, if the concept is accepted and we are almost sure of that," the chief executive was quoted as saying in the company's corporate publication, Siberian Satellite. *http://tass.com*

Two more satellites join Galileo service provision

The European GNSS Agency (GSA) and the European GNSS Service Centre (GSC), have announced the commissioning of two additional satellites, bringing the total number of satellites available for the Galileo service provision to 18.

The GSA is pleased to announce the completion of in-orbit testing (IOT) of two new Galileo satellites, GSAT0212-SV ID 03 and GSAT0213-SV ID 04. Having passed all initial tests, the two satellites are now officially commissioned for operational use and are usable for the Galileo service provision. *http://www.gsa.europa.eu*

Icaros and Agrowing announce Integrated Drone product

Icaros Inc., a leading provider of aerial imaging software, and Agrowing, a leading supplier of multispectral sensors and analytics software, have announced an integrated drone product that bundles Icaros' OneButton software into Agrowing's solution stack, automating the entire workflow from image capture through generation of fully indexed orthomosaic maps for agriculture. *www.icaros.us/ob-software*

Volaero Drones and Geodetics sign agreement

Volaero UAV & Drones Holdings Corp., a Miami based Drone Tech Startup Company, has signed an Agreement with San Diego based Geodetics Inc., to integrate, deploy, and resell its advanced LiDAR and RGB imagery fusion technologies with the Geo-MMS, a Mobile Mapping System, for small UAS solutions. *www.volaerodrones.com*

Gryphon Sensors develops one-of-a-kind drone tracking system

Gryphon Sensors, an SRC Inc. company based in central New York, has developed a state-of-the-art mobile unmanned traffic management system called Mobile Skylight.

The development builds on the state's investments in the region's emerging unmanned aerial systems (UAS) industry. Mobile Skylight sets a new standard in drone security and UAS traffic management. Featuring an array of self-contained multispectral sensors, the system provides accurate 3D detection of low-flying, small UAS at a distance of out to 10 kilometers.

3DR Integrates Site Scan Mapping Software With DJI Drones

3DR has integrated its Site Scan aerial data capture software platform with DJI to make it compatible with their drones. This integration marks a significant expansion of the Site Scan platform, giving users more options for their data capture workflow.

The DJI drones will be compatible with 3DR's mobile app, Site Scan Field, and will work seamlessly with Site Scan, including its autonomous flight modes, multi-engine cloud processing, and suite of tools designed for construction, such as topographic surveys, calculating cut and fill volumes, measuring stockpiles, exporting native Autodesk file formats, and more.

CompassDrone launches CIRRUAS drone program

CompassDrone has launched CIRRUAS, a comprehensive drone-based mapping program designed specifically for Public Safety applications. The Complete Incident Response Recovery Unmanned Aerial System (CIRRUAS) is designed primarily for Accident Reconstruction and Crime Scene Mapping, but is also applicable to Search & Rescue and Reconnaissance missions.

U.S. Army halts use of Chinese-made drones

The U.S. Army has ordered its members to stop using drones made by Chinese manufacturer SZ DJI Technology Co Ltd because of "cyber vulnerabilities" in the products. An Aug. 2 Army memo posted by sUAS News and verified by Reuters applies to all DJI drones and systems that use DJI components or software. It requires service members to "cease all use, uninstall all DJI applications, remove all batteries/storage media and secure equipment for follow-on direction." The memo says DJI drones are the most widely used by the Army among off-the-shelf equipment of that type. DJI said in a statement that it was "surprised and disappointed" at the Army's "unprompted restriction on DJI drones as we were not consulted during their decision." The privately held company said it would contact the Army to determine what it means by "cyber vulnerabilities" and was willing to work with the Pentagon to address concerns. *https://www.reuters.com*

SpaceX notches 15th landing after launching overdue Formosat-5

A SpaceX Falcon 9 successfully launched a long-delayed remote sensing satellite for the government of Taiwan Aug. 24, executing another first stage landing in the process. Formosat-5 was built by Taiwan's space agency, the National Space Organization, known by the acronym NSPO. The 450-kilogram spacecraft was the first such satellite built domestically by Taiwan, and succeeds Formosat-2, retired a year ago. The spacecraft carries cameras capable of producing panchromatic images at a resolution of two meters and color images at a resolution of four meters. It also carries an ionospheric science instrument developed by a Taiwanese university NSPO awarded the launch contract for Formosat-5 to SpaceX in 2010, at the time intending to launch the spacecraft on SpaceX's smaller Falcon 1 rocket. SpaceX later discontinued the Falcon 1, moving Formosat-5 to a larger Falcon 9 vehicle.*http://spacenews.com*

Germany pumps €4 million in climate change research

The German government has pumped about €4 million in a project to conduct research in climate change and sustainable land management use in Zambia.

National Remote Sensing Centre (NRSC) technical expert Michael Phiri said the project is aimed at providing evidence-based advice for decision-makers and stakeholders to improve people's livelihood in the region. The project called Southern Africa Science Service Centre for Climate Change and Adaptive Land-use (SASSCAL) also aims to contribute to the creation of an African knowledge-based society. Under the project, the centre is expected to do seamless land cover mapping, produce records of national resources and land-use using remote sensing technology. He also said that NRSC is implementing the drought assessment project, which is coming to an end next month. *www.daily-mail.co.zm*

Latest ESA research leads to better cameras for precision agriculture

A new camera from Cubert, working in collaboration with VITO Remote Sensing and imec, based on research from the European Space Agency, is bringing high-resolution details to precision farming. Precision farming relies on *hyperspectral imaging to gather additional information about crops for making the best decisions on resource and field management. The ButterflEYES LS from Cubert can now provide these images with in focus details as minute as five centimeters. Also, since it weighs only 400g, it is easily carried by a drone over large and varied land masses. One of the key differences between previous hyperspectral cameras and the ButterflEYES LS camera is the use of an incorporated filter in imec's ultra-small sensor as opposed to the traditionally used prism that would make the camera too large for unmanned aircraft. Additionally, the image processor from VITO was developed after working on ESA remote sensing satellites. *http://trendintech.com*

Mouser – Tracker enables GPS-based IoT projects

Mouser is the Wio Tracker from Seeed Studio. It is an open source gateway that allows for faster GPS solutions for the IoT by tracking nearly any moving thing and uploading that data wirelessly. For added speed and flexibility, the tracker features 99 GNSS receiver channels for quicker lock times. *www.electropages.com*

'Self-driving' lorries to be tested on UK roads

Small convoys of partially self-driving lorries will be tried out on major British roads by the end of next year. A contract has been awarded to the Transport Research Laboratory (TRL) to carry out the tests of vehicle "platoons". Up to three lorries will travel in formation, with acceleration and braking controlled by the lead vehicle. *www.bbc.com*

Uber Movement's traffic data is now public

Uber Movement is now live. The website gives anyone the access to some of Uber's internal demand and usage data. Planners using Uber Movement will be able to search for average trip times between two points for specific times of day, days of the week, and months, information that could help cities improve traffic flow. Uber Movement's GPS-extracted information will help city planners to examine traffic patterns and monitor how infrastructure changes like road closures can impact congestion.

TomTom inaugurates Traffic Centre at Pune Centre of Excellence

TomTom inaugurated its latest Traffic Centre at its Centre of Excellence in Pune, India. It is a part of TomTom's global network of Traffic Centres, showcasing TomTom's intelligent technology for traffic and travel management. The Traffic Centre in Pune will demonstrate how TomTom turns data into actionable insights that can help traffic city planners and inhabitants make smarter decisions, reducing road congestion and enhancing mobility in cities.

Factory-Fit Machine Control Solution for Sumitomo Excavators by Trimble

Sumitomo Construction Machinery Co., Ltd. (Sumitomo) has announced selection of Trimble as Sumitomo's preferred technology provider for machine control solutions. Sumitomo will offer the Trimble® Earthworks Grade Control Platform for Excavators as a factory-fit machine control solution for the Japanese market.

Sumitomo will offer two options from the factory for grade control. The 2D Machine Guidance option will include a Sumitomo-designed user interface, using the integrated machine display panel in the excavator cab. The 2D Machine Control factory fit option includes a 10-inch Android™ tablet display running the Trimble Earthworks software application. *www.sumitomokenki.com.*

Sokkia GNSS receivers now integrated with TerraGo Magic

TerraGo Magic now offers advanced integration and support for the Sokkia line of GNSS receivers, including the new GCX3.

TerraGo Magic is a zero-code platform-as-a-service that enables customers to build their own custom mobile apps without writing any code by choosing from a menu of available, field-tested features. The GCX3 offers lightweight, compact and ergonomic benefits — along with centimeter-accurate positioning — now with expanded satellite tracking capabilities.

Garmin launches new range of smart watches in India

Garmin India has launched a wide range of smart watches and activity trackers, including its much-awaited 'Fenix 5' series, in India.The Wi-Fi-enabled 'Fenix 5' smart watches are packed with features like GPS with GLONASS support, 24-hour heart-rate monitoring, three-axis digital compass, barometric altimeter and several multi-sport activity modes and can be paired with smartphone.

PCTEL launches multi-band LTE/Wi-Fi/GNSS antenna

PCTEL, Inc has announced its new multi-band LTE/Wi-Fi/GNSS antenna with a sub-inch profile. The antenna combines PCTEL's high rejection multi-GNSS technology for precision timing and location tracking with high performance multi-band data connectivity, according to the company. The antenna is also designed to be rugged and easy to install, making it ideal for covert public safety operations, precision agriculture, and the Industrial internet of things (IoT).

New GNSS antenna for surveying and mapping by Harxon

Harxon has released the all-constellation GNSS antenna GPS1000, receiving GPS L1/L2/L5, BDS B1/B2/B3, GLONASS L1/L2, Galileo E1/E2/E5a/E5b and L-band signals. GPS1000 can be used in land survey, marine survey, channel survey, seismic monitoring, bridge survey and agriculture applications, providing consistent performance across the full bandwidth. The antenna has high gain and wide beam width to ensure the signal receiving performance of satellite at the low elevation angle, and the phase center remains constant as the azimuth and elevation angle of the satellites change.

HxGN Dynamic Haulage

Hexagon has introduced HxGN Dynamic Haulage for optimized truck movement. As part of the MineSight Schedule Optimizer (MSSO) platform, Dynamic Haulage ensures the best, most efficient path to destinations, regardless of changes in haul roads and routes between operational phases and between schedule runs. It's the closest thing to real-time "best path" from cut-to-mill or dump and back again. Dynamic Haulage appeals to large pit operations with significant fleet equipment assets.

Hexagon Imagery Program

The Hexagon Imagery Program (HxIP), the premier source for professional airborne imagery provided through the cloud, recently announced updates for 2017 airborne imagery collection plans of Wide Area Coverage (WAC) at 30-centimetre accuracy and Urban Area Coverage (UAC) at 15-cm accuracy. By the end of 2017, the HxIP will update its content for more than 3.9 million km² in North America. This includes a refresh of 18 previously captured U.S. states and completes the full coverage of the continental United States, Hawaii, Puerto Rico, the U.S. and British Virgin Islands, and select areas of Alaska.

In addition to the 30-cm program, the HxIP expands its 15-cm collection by 100 cities for a total of 347 U.S. urban areas covering more than 492,000km². The HxIP also includes 23 Canadian cities at 30 cm.

Robusta – by Antenova, launched

Antenova Ltd, manufacturer of antennas and RF antenna modules for M2M and the Internet of Things, has launchced Robusta part no. SR4G031, a new antenna for metal surfaces. The antenna operates in the 1559-1609 MHz bands and is designed for tracking metal objects and smart city applications. Antenova's takes antenna design a step forward with its REFLECTOR family, which answer to the challenge of operating on a metal surface or housing, where it is extremely difficult for an antenna to operate. The REFLECTOR antennas use a patented new technology where there are two layers, one electrically isolated from the other, so as to provide RF shielding to the second layer. *www.antenova-m2m.com*

Nikon NPL 322+ – new Reflectorless and Prism-only Total Station

Nikon-Trimble Co., Ltd. recently introduced a new version of the Nikon NPL-322+ Total Station, now available in both reflectorless and prism-only versions. It delivers an economic, versatile, and easy-to-use platform. The NPL 322+ allows you to see more detail and much less distortion, especially over longer distances. Using the same rechargeable long life Li-ion battery as the Nivo series, combined with low power consumption design, the NPL-322+ provides the longest possible time in the field. For convenience, the Nikon NPL-322+ total stations include two batteries and a dual charger, to support even the longest of working days.

New Joint Venture to Focus on GNSS Positioning Services

Bosch, Geo++, Mitsubishi Electric and u-blox announced the creation of Sapcorda Services, a joint venture that will bring high precision GNSS positioning services to mass market applications. According to the companies, existing solutions for GNSS positioning services do not meet the needs of emerging high precision GNSS mass markets. As a result, they decided to join forces to facilitate the establishment of a worldwide available and affordable solution for System Integrators, OEMs and receiver manufacturers. It will offer GNSS positioning services via internet and satellite broadcast and will enable accurate GNSS positioning at centimeter level. *www.satellitetoday.com*

Urthe Cast sign a for the delivery of a SAR-XL Satellite

UrtheCast Corp. has entered into a contract with a confidential customer for the development and delivery of a dual-frequency stand-alone Synthetic Aperture Radar (SAR) operational-class satellite as an "accelerator" for the OptiSARTM Constellation. The contract is for the delivery of the SAR spacecraft, key elements of the ground segment, namely the mission control and planning system and the SAR processor, and in-orbit operations support. *www.prnewswire.com*

FARO unveils FocusS 70 laser scanner in market

FARO has announced the latest addition of its FARO Focus Laser Scanner portfolio. Similar to FocusM 70, the FocusS70 also delivers industrial grade performance with an exceptional price/performance ratio. This includes an Ingress Protection (IP) Rating of 54 for use in high particulate and wet weather conditions, HDR imaging and extended temperature range.

Harris delivers navigation payload for GPS III Satellite

Harris Corporation has delivered the third of 10 advanced navigation payloads to Lockheed Martin, which will increase accuracy, signal power and jamming resistance for U.S. Air Force GPS III satellites.

The advanced navigation payloads feature a Mission Data Unit (MDU) with a unique 70-percent digital design that links atomic clocks, radiation-hardened computers and powerful transmitters – enabling signals three times more accurate than those on current GPS satellites. The new payloads also boost satellite signal power, increase jamming resistance by eight times and help extend the satellite's lifespan. *harris.com*

MARK YOUR CALENDAR

October 2017

GIS Congress-2017
2 – 3 October
Vienna, Austria
http://gis-remotesensing

The 9th Multi-GNSS Asia (MGA) Conference
9 - 11 October
Jakarta, Indonesia
http://www.multignss.asia

Year in Infrastructure Conference
10 -12 October
Singapore
https://www.bentley.com/en/yii/home

GeoAdvances 2017
14-15 October
Safranbolu, Turkey
http://geoadvances.org

INGEO2017
18 – 20 October
Lisbon, Portugal
http://ingeo2017.lnec.pt/index.html

ACRS 2017
23 - 27 October
New Delhi, India
www.acrs2017.org

Commercial UAV EXPO
24 - 26 October
Las Vegas,USA
www.expouav.com

6th International Colloquium — Scientific and Fundamental Aspects of GNSS/Galileo
25 – 27 October
Valencia, Spain
http://esaconferencebureau.com/2017-events/17a08/introduction

3D Australia Conference 2017
26 - 27 October
Melbourne, Australia
http://3dgeoinfo2017.com

ITS World Congress 2017
29 October – 2 November 2
Palais des congrès de Montréal, Quebec
itsworldcongress2017.org

November 2017

37th INCA INTERNATIONAL CONGRESS
1 – 3 November
Dehradun, India
http://incaindia.org

PECORA 20- 2017
14 – 16 November
South Dakota, USA
https://www.asprs.org

International Technical Symposium on Navigation and Timing (ITSNT)
14 – 17 November
Toulouse, France
http://www.itsnt.fr

Commercial UAV Show and GeoConnect Show 2017
15 - 16 November
London, UK
http://www.terrapinn.com

INC 2017
27 - 30 November 2017
Brighton, UK
http://www.internationalnavigationconference.org.uk

December 2017

International Symposium on GNSS (ISGNSS 2017)
10-13 December
Hong Kong
www.lsgi.polyu.edu.hk

Esri India User Conference
13-14 December
Delhi, India
www.esriindia.com/events/2017/uc

February 2018

18th Annual International LiDAR Mapping Forum
5 - 7 February
Denver, USA
www.lidarmap.org

GMA: Geodesy, Mine Survey and Aerial Topography
15 – 16 February
Moscow Novotel Center, Russia
http://www.con-fig.com/?lang=eng

March 2018

Munich Satellite Navigation Summit
5 - 7 March
Munich Germany
www.munich-satellite-navigation-summit.org

April 2018

The 7th Digital Earth Summit 2018
17 – 19 April
El Jadida, Morocco
http://www.desummit2018.org/

May 2018

Geoscience-2018
2-4 May
Rome, Italy
http://geoscience.madridge.com/index.php

GEO Business 2018
22 - 23 May
London, UK
http://geobusinessshow.com

June 2018

7th International Conference on Cartography & GIS and Seminar on Early Warning and Disaster Management
18-23 June
Sozopol, Bulgaria
www.iccgis2018.cartography-gis.com

NT1065

4-channel GNSS RFFE IC

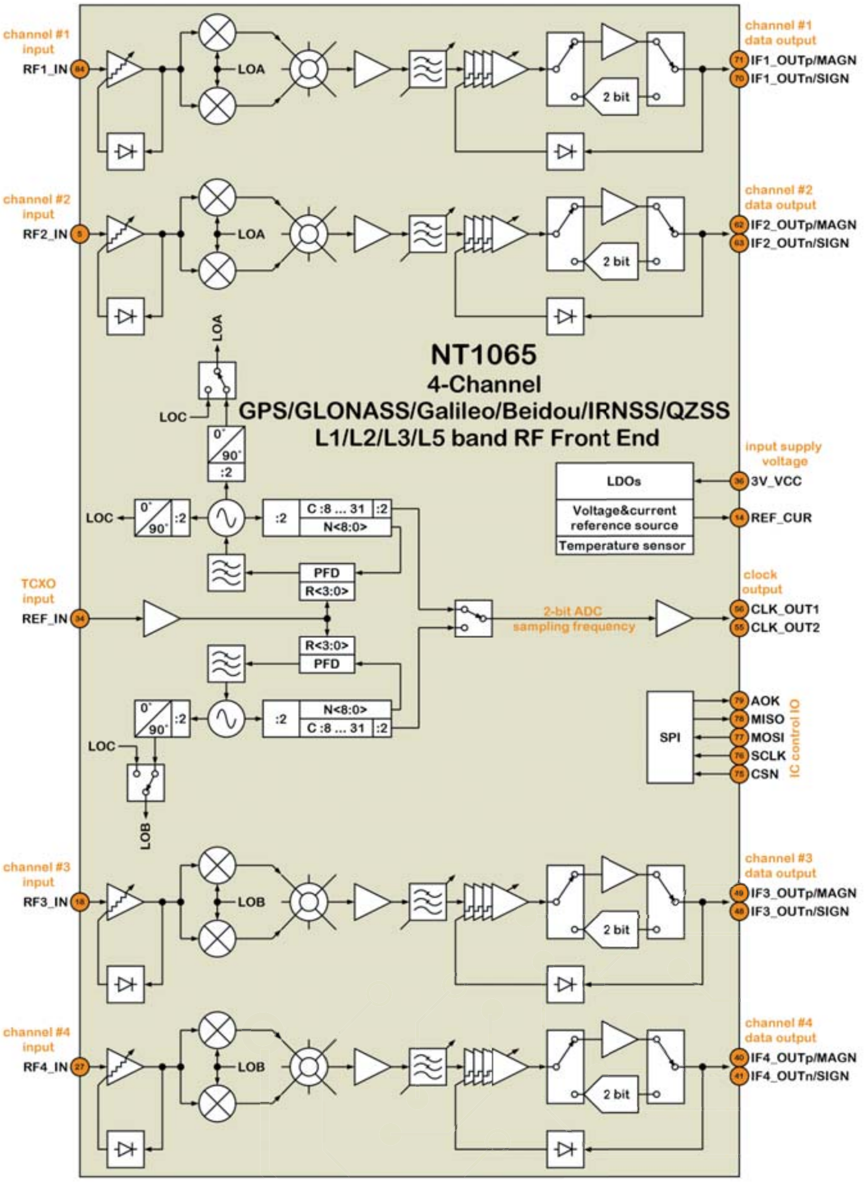
Precision is going to be
simpler, cheaper, faster ...

NT1065 is a 4-channel GNSS RF Front-End chip for professional navigation market: geodesy, driverless cars, drones and similar applications.

The feature list includes:

- **simultaneous reception of GPS/GLONASS/Galileo/BeiDou/IRNSS/QZSS signals**
- **frequency bands: L1/L2/L3/L5/E1/E5a/E5b/E6/B1-C/B1I(Q)/B1-2I(Q)/B2/B3**
- **full programmability of each of 4 channels (signal bandwidth, downconversion sideband, AGC options, analog/2-bit digitized output, etc.)**
- **simple and easy-to-use register map for chip configuration.**

NT1065 also could be used by GNSS researchers to create sophisticated front-ends for their receivers. For such purposes, we offer wide selection of evaluation kits: with 4 and more channels, analog and digitized outputs, connectable to PC or FPGA platforms.



www.ntlab.com info@ntlab.com

NT1065 is already in mass production. Fabricated by amsAG, Austria.