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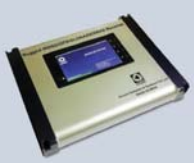

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Welcome to New Delhi.

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A sobriquet, the city is getting use to

With Air Quality Index

Reaching to around 999

At some parts of the city

During the first week of November

When the city got further strangulated

Leaving citizens gasping…

Is it not audacious of us

To dream about smart cities,

When the city in its present state

Is barely livable?

Bal Krishna, Editor
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An update from Bhutan, Nepal and Sri Lanka on activities and initiatives of Survey Departments

Adoption of necessary geospatial technologies translate into better services to the people

- Dasho Pema Chewang, Secretary,
National Land Commission, Bhutan

What are the main functions of National Land Commission and how is Survey of Bhutan associated with it?

The National Land Commission (NLC) of Bhutan is an autonomous body mandated to render land governance and NSDI services. The nomenclature Survey of Bhutan is not in use any more. There are two departments under the NLC. These are Department of Land Administration and Management and Department of Survey and Mapping. The later is responsible for NSDI and other technical aspects.

Your vision is to evolve as "A dynamic and professional organization that delivers excellent land governance services and provides reliable land information for the nation's well being". What are your plans to achieve this?

We have embarked on a very ambitious plan. In fact we have already achieved some. Having completed a historic nationwide cadastral resurvey exercise using state of the art technology we have the opportunity to render best land governance services. We have adopted three pronged strategy of (1) Institutional and human resource developments (2) harmonization and streamlining of policy, legal and procedural frameworks and (3) embracing state-of-the-art technology to enhance service delivery.

Share with us some of the key initiatives of your organisation especially GeoPortal, Rural e-Sakor and Urban e-Sakor?

Like I mentioned, enhancing service delivery is our main thrust area. We are also trying to adopt an open geospatial data policy with the objective of promoting a spatially enabled society. Towards this end we have initiated few flagship programs. These are development of national geospatial portal and online land transaction systems, the rural and urban e-Sakor.

We are aware that the geoportal is not complete in its true sense, but it is a good start for a small GIS society like ours. It is planned to be a geospatial information one-stop-shop. Although we have published metadata of more than 90 different layers there are very few users. Many still prefer traditional way of "copy-paste" method of data sharing. I am confident that this practice will change in few years. We have also realized some gray areas in geo-information management due to the lack of an appropriate policy. Therefore, we are in the process of drafting a national geo-information policy. The Center for GIS Coordination with 32 member agencies is spearheading this initiative.

The completion of comprehensive cadastral resurvey has significantly enhanced land governance services in Bhutan. In order to take a step further we have started an online land transaction system. Due to difference in the management systems we have two different systems; the rural and urban e-Sakor. Eventually, we plan to integrate them. Currently, we are in the process of enhancing the urban e-Sakor by incorporating mortgaging, taxation and real time data access and transaction status modules under the World Bank financing. The online land transaction system has significantly reduced turnaround time and transparency.

How do you see the technology like UAV/UAS contributing to the success of surveying and mapping?

We have experimented this technology and the result looks promising. In fact I am told that few agencies already possess UAVs. I think such technology will be useful during disasters and for land management in urban areas. I am not so sure about the use of UAV/UAS for base mapping. Therefore, we haven't thought of owning one. Bhutan has a mountainous terrain with most of the area covered with thick forest. Therefore, I see the topography and vegetation as limiting factors.

What are the effort in the direction of training and capacity building?

We are initiating capacity development in a big way. Geospatial information technology is changing rapidly. In order to reap maximum benefits it is important to keep abreast with the changing technology.

NLC is the parent agency of all surveying and mapping personnel in the country. It is also the Secretariat of the Centre for GIS Coordination. Therefore, we are responsible for the professional development of everyone involved in the geospatial field.

We are taking this at three levels: (i) Partner with schools, colleges and institutes in promoting GIS education, (ii) Educate policy makers on the benefits of geospatial information and (iii) Build a core team of highly trained and motivated GIS professionals. Towards this end we are mobilizing resources through annual national budgets and external technical supports.

How does your department extend support to other governmental and non-governmental organizations?

NLC is a national mapping agency, primarily mandated to produce fundamental geospatial data (FGD). We are not only producing FGD, but also helping users to make use of the technology and data. From our traditional role of the producer of base maps we have now embarked on data services. We are helping other agencies by sharing data, software and expertise free of cost. Besides, we are also spearheading the formulation of necessary legal framework. Developing surveyor's licensing system is in the pipeline.

What are the main challenges before your organisation?

NSDI development is still thought as optional. Therefore, it is very difficult to attract funding either through national budget or donor assistance. NSDI development is a very costly affair. I would say this is our biggest challenge.

How has geospatial technologies been able to contribute to the 'Gross National Happiness' of Bhutan?

Geospatial technologies help to plan accurately and take appropriate actions in a timely manner. The adoption of necessary geospatial technologies has translated into better services to the people. These directly contribute to the GNH.

NMOs have to change its strategy like it can work as an authority rather than its traditional way of doing business

- Krishna Raj BC, Director General, Survey Department, Nepal

What are the major activities of Survey Department, Nepal?

Survey Department, under the Ministry of Land Reform and Management, is the National Mapping Organization (NMO) of Nepal. The Department is responsible for regulating, monitoring and coordinating surveying, mapping and geospatial activities in the country. Major activities of the Department can be listed as follows:

- Establishment and maintenance of national control network (horizontal and vertical) through geodetic surveying
- Conducting cadastral surveying for the first registration and to prepare the national cadaster and support land administration and management activities in the country.
- Carrying out topographic surveying for national topographic map series and topographic database.
- Preparing various kinds of other geospatial information including thematic and administrative maps.
- Working as the nodal agency of national geospatial information infrastructure.
- Conducting international boundary surveys.
- Conducting research activities, especially in the sector of geospatial information.

What are the main services offered by the Department?

Based on the above mentioned activities, the Department provides following services:

- Providing horizontal and vertical control networks of different level
- Providing various kinds of geospatial information products including topographic maps (hardcopy as well as digital form), thematic maps, administrative maps, among others.
- Providing technical services regarding land administration and management, and dispute resolution in property boundary by delineating

property boundaries. Similarly, also provides cadastral maps and data as requested by the user.
- Providing expert services, in surveying and mapping, as requested by the government or non-government sector.

Share the role played by the Survey Department during and after the earthquake last year?

Survey Department played an important role to response the devastative earthquake last year. Immediately after the disaster, the Department issued all the geo-spatial data of the disaster affected area free of charge through online. The department produced damage assessment maps based on the satellite images provided by some companies, which was very useful for rescuing as well as assessing the loss. The Department also provided necessary spatial information to the task force of the Government formed for the Post Disaster Needs Assessment (PDNA).

At the same time, the Department mobilized its staff, as instructed by the Government, to the disaster affected areas to assess the damage caused by the disaster. As a scientific contribution, the Department carried out geodetic study surveys soon after the devastating earthquake, using GNSS technology, in the affected areas and released the outcome of the study. The study found the shift of Kathmandu valley approximately 1.8 meters southwest wards.

How do you plan to keep pace with the fast changing technology in the domain?

Keeping pace with the fast changing technology in the domain has become a challenge for the Department. However, the Department is making its best possible efforts to meet this challenge. The department introduces the newly developed technologies as pilot basis such that it helps developing new skill as well as learning what we need further. Depending upon the availability of the resources and capacity, we apply the new technology. At the same time, the department is also making best possible efforts in its capacity development.

What are the effort in the direction of capacity building?

As I mentioned earlier, professional capacity is one of the major hindrances to keep pace with the fast changing technology. Most of the professionals involved in this domain, within and outside the department, have gained professional skill through training and only quite a few professionals are university graduates in the field of geomatics. In recent years, the skill acquired through training seems insufficient to cope with the new technology. Therefore, the Government of Nepal is collaborating with the universities to produce university graduates in the field of geomatics. At the same time, the Department is exploring opportunities for its staff to go abroad for higher studies. At least two officers are funded by the department for the master's degree course abroad. The department is also making its effort to enhance the technical skill of its staff through trainings, motivating for technology transfer, exchange of knowledge, collaboration with professional community beyond the government sector.

What are the main challenges?

Following are the main challenges before the department:
- Rehabilitation novation of the geodetic control network that has been affected by the 2015 Nepal earthquake
- Providing updated geospatial information and maps for reconstruction and resettlement affected by the earthquake.
- Updating existing topographic map series that was prepared in late 1990s
- Improving the spatial quality of cadastral data
- Bringing all the players and produces of geospatial data within the network of national spatial data infrastructure.

Others
- Technology transfer with existing human resources
- Compete with the non-governmental enterprises in the sector
- Meet the need of the society with existing allocation of resources

What are the future plans?

After the devastative earthquake of last year, we have the responsibility of providing geospatial products of changed context. The shift in the geodetic datum has forced us to
- Rehabilitation of Geodetic Control Network and Establishing CORS throughout the country
- Initiating multipurpose mapping of the earthquake affected 31 districts in the basis of LiDAR survey , aerial photography and field verification as required
- Updating existing topographic map series and producing new topographic map series in larger scale.
- Renovating spatial quality of cadastral data by exploiting the opportunities offered by the modern technology.
- Developing fully functional national geospatial information infrastructure.

How do you see the technology like UAV/UAS for surveying and mapping?

This is an innovation, I would say, in the surveying and mapping domain. I have gone through literatures and so many case studies regarding its application. I see its potential, especially to meet the need of immediate geospatial information in disaster response. In the near future we wish to use it to see its suitability in the sector of our responsibility.

NMOs are increasingly becoming irrelevant with the advent of players like Google Earth. Comments.

l don't believe in this statement. There is no doubt such initiatives have brought challenges before National Mapping Organisations (NMOs), but I take this as an opportunity for NMOs to enhance its competitiveness. In the modern society, supply driven products only are not the only ones to work. There are various other activities of national interest and such global initiatives may not sufficiently meet such national needs. At the same time, assuring quality of the geospatial information for its authentic, reliable and authorative use is the most important thing, NMOs still need for it. Yes, I can say that in the current scenario, NMOs have to change its business strategy like it can work as an authority rather than its traditional way of doing business.

Increasing demand to surveys like completion of land alienation surveys and cadastre is a challenge

- P M P Udayakantha, Surveyor General of Sri Lanka

Please explain briefly the vision and mission of Survey Department of Sri Lanka (SLSD)? How is it being achieved the present days context?

Our vision is "To be the leader in providing land information right through"

Our mission is "Provide high quality land information products and services through a professionally qualified and dedicated staff"

We continuously work hard and make improvements to meet the challenges which are also dynamic.

What are key initiatives/project of SLSD in recent years?

Working on establishment of a National spatial Data Infrastructure Re engineer the process of field surveys in order to improve efficiency and compatibility with land information system requirements.

Upgrading Geodetic Control Network with Six CORS Stations as first stage. Expected to cover the whole country at next stage.

Lidar Survey of five districts (almost one tenth of the country) to provide high quality DEM for disaster mitigation activities related to floods and landslides.

Geographical Names Standardization Development of a National Land Information System Mapping using UAV.

Technology is changing fast in this domain. What are the SLSD endeavours to keep itself "technologically updated"?

We continuously keep vigilant on recent development in technology with the view of adopting them to improve efficiency of present systems. We frequently attend the international workshops and Training Programmes to update the knowledge in technology.

What is the status of Land Information Systems (LIS) in Sri Lanka?

We have captured about one million land parcels into the system and available. This is about one tenth of the country. Capturing other information in much speedy manner is in progress with the concept of parcel fabric.

> The challenge is to provide high quality surveying and mapping work within a short period of time

What is the update on Spatial Data Infrastructure of Sri Lanka?

Official activity is in progress. Baseline survey and Requirement study is being carried out and system development will commence soon. Data policy and standards are also being prepared and awareness activities are also in place.

It is realized that Disaster Management is an important area where all stakeholders agree on data sharing. This is prioritized in system development as it is required to share spatial data on regular basis for diasaster management activities.

How conducive is the policy for using UAV/UAS for the survey and mapping in Sri Lanka?

Survey Department recently acquired a UAV and now in operation. We are still at the initial stages for UAV surveys. There is a great potential and demand for UAV surveys.

Policy on UAV mapping is not being established yet. But i9t has been identified that in open areas where boundaries are clearly visible, it is possible to capture boundary points with an accuracy of 10-15 cm, which is as good as ground surveys. Application still have to be decided after further research. Still it is too early to develop a policy on UAV Mapping.

What are the main challenges before SLSD?

Increasing demand to surveys like completion of land alienation surveys and Cadastre in a shorter time is one of the main challenges.

Providing high quality elevation information is also another challenge we are facing. Development of a Geoid Model is in place in order to achieve this.

Provide high quality surveying and mapping work within a short period of time.

National Mapping Organisations are increasingly becoming irrelevant with the advent of players like Google Earth. Please comment.

These systems help many activities and it actually relieved us and allowed us to involve in more important activities related to development.

Stochastic behaviour quantification of GNSS receivers

In this paper, the repeatability standard deviation has been defined and measurements have been performed

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For intelligent transportation systems the information of any vehicle location in an absolute geodetic reference frame is essential. These locations can be estimated best on the basis of global navigation satellite systems combined with auxiliary sensors. A GNSS receiver serves as the major component. Since more and more GNSS are available or will be built up in the near future, availability and accuracy will increase. Therefore, the reliable determination of the receiver quality is currently under research at multiple institutions e.g. [1]. Especially for GNSS system manufacturers and system integrators, it is essential to determine which receiver is the most suitable for their specific applications. Thereby, the field performance evaluation is mostly performed by static tests or by kinematic tests driving randomly through an urban environment. But the gathered data is only a snapshot of the receiver performance and has a lack of statistic significance.

Measurements have shown that GNSS receivers of the same type with identical software versions and software settings provide different location data [2], even when operated with the same antenna input signals. That phenomenon has multiple reasons: maintaining a digital

Figure 1: Trajectories provided by the same type of receiver in different environments. Image by© 2013 AeroWest, Digital Globe, GeoBasis-DE/BKG, GeoContent, Google

phase lock loop is a very stochastic process especially in dynamic scenarios, receiver clocks are strongly temperature dependent and some parameters of internal filters have an internal memory effect [3]. Two examples are depicted in Figure 1.

The images present different trajectories of three GNSS receivers of the same type and same software versions, provided with the same input signals. It is visible that on the highway scenario (above) the distances between the trajectories are much smaller than in the urban scenario (below). This leads to the result that for a liable performance assessment it is not sufficient to execute simply one or few tests to estimate the performance parameters reliably. To deal with this situation, a new parameter has to be defined to quantify the repeatability characteristic.

Until today, there are mainly two options for testing the GNSS receiver and antenna combination on their stochastic behaviour. They can either be tested in parallel resulting in a large amount of receivers or one receiver can be provided with the same signals (recorded by a record and replay system) repeatedly. To provide a receiver with real signals, they have to be recorded during a test run and afterwards replayed in the laboratory. That operation can be performed with signal record and playback systems through the originally installed antenna. These systems work in the way that active GNSS signals are filtered, amplified, down converted and digitized. Later, in the laboratory the data can be replayed by reversing the process. In contrast to field tests, the financial cost of test repetitions is low. Hence, such a system is used in this paper to investigate the stochastic behaviour.

Methodology

Typical key performance accuracy characteristics such as trueness and precision (variance resp. standard deviation) are calculated according to the general understanding in metrology as the evaluation of the difference x_i between a reference location $x_{r,i}$ and the measured location $x_{m,i}$ (see eq. 2) [4]. To

> To achieve reliable results and to consider the stochastic behaviour, multiple measurements with the same input signals have to be performed

investigate the stochastic behaviour of the system under test, a new quantity, called the repeatability standard deviation, is introduced. That measure quantifies the standard deviation of possible location deviations from signal replays by means of the standard deviation for a scenario. This measure is derived from ISO 5725 where the repeatability is expressed by the repeatability variance. There it expresses the quality of a measurement system operated in different test laboratories [5]. In contrast to variance, standard deviation is a measure of dispersion which is much more illustrated. Therefore, the repeatability in this paper is presented by the repeatability standard deviation of the quantity introduced at the beginning. If the repeatability standard deviation is large, a strong stochastic behaviour with large standard deviations between different measurements is visible. If the repeatability standard deviation equals the standard deviation of the corresponding true measurement, the system reveals with a high probability a deterministic behaviour. The repeatability standard deviation s_r is formulated as:

$$s_r = \sqrt{\frac{\sum_{i=1}^{p}(n_{ij}-1)\cdot s_{ij}^2}{\sum_{i=1}^{p}\cdot(n_{ij}-1)}} \quad (1)$$

with s_{ij} being the variance of the performance parameter j of replay i, n_{ij} the amount of samples in replay i of performance parameter j, and p the total amount of replays. For reasons of simplicity, the index for the different scenarios is not included in eq. 1. Before calculating the repeatability, the measurement samples have to be investigated in terms of outliers. One possible test advised by ISO 5725 [5] is the Grubbs' test for outliers.

At the beginning of the test, the mean location deviation:

$$\bar{x} = \frac{1}{p}\cdot\sum_{i=1}^{P} x_i = \frac{1}{p}\cdot\sum_{i=1}^{P}(x_{ri} - x_{mi}) \quad (2)$$

and the related standard deviation:

$$s = \sqrt{\frac{1}{p-1}\cdot\sum_{i=1}^{P}(x_i - \bar{x})^2} \quad (3)$$

for the samples have to be calculated. Afterwards, the Grubbs' statistic value G_p can be calculated for the samples with the highest differences. G_p can be calculated by:

$$G_P = \left|\frac{x_p - \bar{x}}{s}\right| \quad (4)$$

with x_i being the measurement value of a test, P the amount of measurement samples, $\bar{x}$ the mean value of all measurements and s the standard deviation of all measurements. This is followed by the comparison of G_P and the critical value for Grubbs' test α, calculated from the student-t distribution or extracted from tables. If $G_p > \alpha$, an outlier is detected, the value has to be excluded from the sample and the test has to be redone with the newly calculated values. If $G_p < \alpha$, no outlier is detected and the repeatability standard deviation can be calculated.

Lastly, the confidence in the measurement results is of interest. It can be expressed by a confidence interval. This confidence interval defines a range around the mean value, where the real mean will most probably be. The confidence interval CI can be calculated by:

$$CI = 2 \cdot SE \cdot z \quad (5)$$

In this equation, SE stands for the standard error of the sample mean and z the quantile of the distribution. For this case a normal distribution is assumed and a 95% confidence is chosen. Hence, for the following calculation 1.96 is used for z. The standard mean error can be calculated for a given standard deviation s and the total number of samples for all replays n by:

$$SE = \frac{s}{\sqrt{n}} \quad (6)$$

Test data acquisition

To quantify the repeatability standard deviation, both real test data and replayed test data are required. During testing, the antenna was mounted on top of the test vehicle. From there signals were transmitted via a 0 dB antenna splitter to a reference measurement system, the GNSS receivers and the record and replay system. The reference measurement system was an INS system manufactured by OxTS provided with real time correction data from a certified local reference data provider. The reference locations of the reference system are known to be accurate to cm level. Hence, it can be regarded as the true value for this type of application. The systems under test were provided with the same signals at all times. During the test, measurements were performed with two Ublox Neo-6P GNSS receivers. All receivers were configured for the automotive application and to use SBAS data. To collect the necessary data for calculating the repeatability standard deviation, a record and replay system Spirent GSS6425 was carried along. It supports 3 frequencies, enabling the recording of GPS, GLONASS and SBAS data. Whereby, GLONASS data was not analysed.

To analyse the impact of the environment on the repeatability standard deviation, different scenarios have been classified in terms of the type of street, the height of surrounding buildings and their distances to the streets, the occurrence of highly reflecting materials and possible signal degradation elements such as trees. The urban scenario with trees comprises for example high buildings close to the street with trees growing between buildings and the street.

Results

The results contain the evaluation of both i) the real measurement (August 2015) and ii) the replayed measurement data. To calculate the accuracy for both types of data, the coordinates provided by the reference measurement system were used.

Table 1: Measurement results

Scenario description	Mean 2D deviation (real) in m	Real standard deviation 2D in m	Mean 2D deviation (Replay) in m	Repeatability standard deviation in m	CI for mean 2D deviation (Replay) (95%) in m	Total amount of samples	Percentage of excluded outliers
Urban with trees	6.17	4.21	6.98	5.84	6.74	19250	0.65
Urban little trees	4.87	3.45	3.30	3.04	3.5	21098	0.71
Urban no trees	5.02	9.41	3.25	2.29	2.64	22410	1.10
City 1	1.51	1.28	1.96	0.85	0.88	39664	0.12
City 2	1.86	0.68	1.46	0.41	0.48	15984	0.06
Rural 1	1.05	4.28	1.96	0.85	0.88	39664	0.12
Rural 2	1.43	0.89	1.29	0.61	0.7	35464	0
Highway	1.27	0.79	1.34	0.37	0.44	29393	1.68
Forest streets	8.41	8.51	4.51	4.62	5.34	38962	1.33
Steel bridges	125.08	16.95	38.78	26.02	30.06	739	11.64
Open highway tunnel 1	14.06	8.17	8.23	5.25	6.06	1012	0
Open highway tunnel 2	31.29	20.68	37.83	21.04	12.15	1855	3.77
Open bridges	6.64	8.80	4.62	4.03	2.33	6534	3.2

Evaluation and results of real measurement data

First the location deviation in terms of trueness and standard deviation is calculated. Therefore, the difference of the reference location and the measured trajectory is calculated, followed by the calculation of the mean location deviation and standard deviation for each scenario. The location deviations for the different scenarios are depicted in Table 1.

It is obvious that the scenarios show major differences for the mean location deviation for the different environments. One very interesting result is that the 'Rural 1' scenario has the lowest mean location deviation, but the most precise scenario is the 'City 1' scenario. The special scenarios (bridges and tunnels) surprise with high location deviations. This is due to the very challenging environmental conditions. The steel bridge scenario e.g. is the most limiting scenario, where the line of sight signal reception is completely denied.

Evaluation and results of replayed measurement data

After the test drive, a total of 11 replays was performed and recorded. In a first step,

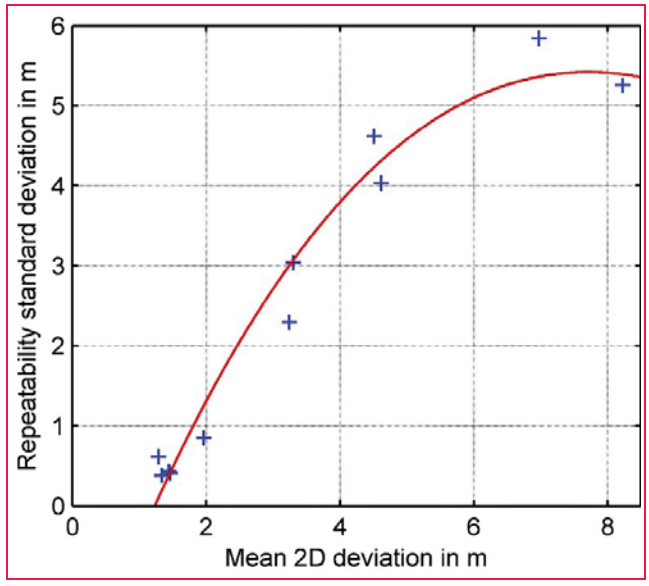

Figure 2: Dependency between repeatability standard deviation and 2D mean deviation

the replayed measurement data as well as the real measured data were analysed. In a second step, the measurement sets were analysed for outliers. Once all outliers were excluded from the measurement, the repeatability standard deviation was calculated according to eq. 1. The results for the real and the replay measurement data are concluded in Table 1.

At first glance the mean deviation between the true measurement and the total mean of the replayed signals exhibits strong variations. This is strongly depending on the environment. It can be seen that open environments such as 'Highway', 'City 1' or 'Rural 2' differ in the range of decimetres. In contrast, for more sophisticated environments the mean location deviations differ in the range of meters (urban scenarios) to multiple meters (forest, steel bridge)

The repeatability standard deviation demonstrates the stochastic behaviour of the GNSS receivers under test. But there are strong differences between the different scenarios. For scenarios with low mean location deviations, the repeatability standard deviation is low. In contrast, it can be seen that for scenarios with large mean location deviations the mean standard deviation is also large. This behaviour is depicted in Figure 2, where the two extreme scenarios 'Steel bridge' and 'Open highway tunnel' are left out. It can be identified that there is nearly a linear behaviour with a degression towards higher values of the repeatability standard deviation. This observation leads to the fact that it can be assumed that in challenging environments the stochastic behaviour is more distinct than in open sky scenarios.

The confidence in the measurement is expressed by the confidence interval. It can be seen that for 11 replays the confidence interval differs for the scenarios. For some scenarios, the true mean lies most probably within 1 meter, for others the confidence is much smaller. To get reliable results, more replays are required, at least for the more complex scenarios.

For some scenarios, the total number of outliers is quite high, but only limited

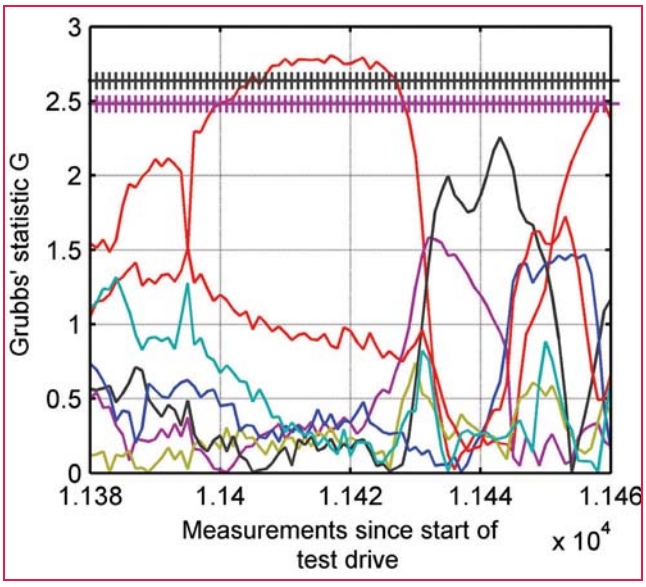

Figure 3: Grubbs' statistic values for different repetitions. The crossed lines represent the αs for n=12 (upper) and n=10 (lower). The other lines represent the different test repetitions

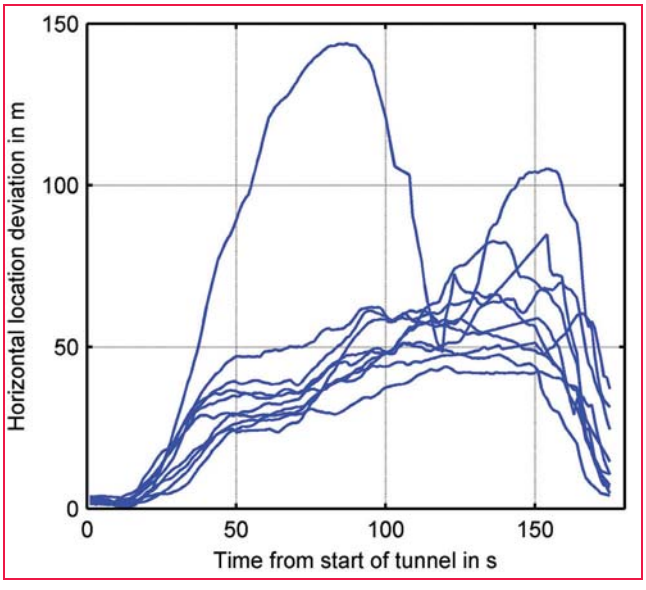

Figure 4: Location deviation for the scenario open tunnel for the different Repetitions

strugglers were identified. Most of the outliers have their origin in a replay performed within the moving vehicle. It is assumed that due to vibrations of the vehicle the internal clock of the replay system was disturbed. The exemplary Grubbs statistic G is depicted in Figure 3. In this figure, G values of repetition 3 exceeds the α values clearly for a certain time.

The behaviour of larger location deviations for that replay is visible when the trajectories of each trip are plotted in Figure 4. It can be seen that repetition 3 (large position deviation at the beginning) does not follow the other repetitions. Even though one imperfect replay was identified, the maximum amount criterion of outliers according to JRC 51300 [6] (exclusion of maximum 2/9 of the samples) is still fulfilled.

Conclusion

In this paper, the repeatability standard deviation has been defined and measurements have been performed.

With the conducted measurements it could be proved that it is not sufficient to simply go out into the field, drive around and acquire measurement data. Within the measurement results, strong variations were even visible for the mean location deviation. Furthermore, it could be identified that the measurement environment has a major impact on repeatability.

Depending on the system under test and the environment, the repeatability standard deviation varies strongly.

Hence, to achieve reliable results and to consider the stochastic behaviour, multiple measurements with the same input signals have to be performed. That can either be done by testing different systems in parallel or by using a record and playback system. For the measurement results presented, the confidence intervals were calculated. By increasing the number of replays, the confidence range could even be reduced. One open question is the impact of the record and playback system quality on the measurement results. This is currently under investigation.

Acknowledgment

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The effects of climate change on land tenure in Zanzibar Islands

This paper addresses implications of climate change and land tenure in Zanzibar (focusing on) alarming issues on population growth, coastal development and sea level rise, land uses and land policy

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Zanzibar has a very high population density of 500 per sq. km, in a land area 2,650 sq. km. This ratio is alarming when it comes to actual development planning. After the 1964 Political Revolution, a number of land reforms were instituted aimed at changing the ownership of land rights and the system of land administration, the main concern being land scarcity and an inadequate land management system. Poor land registration implies that land tenure in the two islands is a challenge. The informal land distribution has involved mainly the urban poor, which is one of the biggest administrative challenges facing the responsible institutions. Therefore, there is a need to undertake a study in order to improve land management systems and human settlements development and this will help in achieving the targets indicated in the Vision2020.

Zanzibar Government has established the Department of Disaster Management, to monitor climate changes and improve information based on disasters in the islands. The Department is still new and is facing many challenges including professional staff in disaster management, up to date equipment and centres of monitoring disaster information.

The impacts of climate change can be expected to have a range of direct impacts on land use systems, with both direct and indirect repercussions for land access and land tenure. Shifts in climatic regions, rising sea levels and increases in extreme climatic events are likely to reduce the availability of land suitable for human settlement and agricultural production, as a result of temperature increases, sea level rise and associated flooding, and restrictions in water supply, leading to population migration and displacement and the need to adjust livelihood patterns to new circumstances. These changes will involve increased competition for land and are likely to trigger changes in access to land and land tenure arrangements.

Institutional arrangement

Zanzibar commission for lands

The role and functions of this institution is to prepare and implement major land issues including development of digital mapping, prepare National land use plans, Local land use plans, tourism- zoning plans, urban-master plans for the towns, land adjudication and registration and develop digital database (land information system) land parcels. The first National Land Use Plan was prepared in 1995, and the second was in 2014, the only land use plans covering both Unguja and Pemba. Implementation of plans are facing several problems including limited financial and skilled human resources, rapid urbanisation and socio-economic development, an inappropriate legal set-up and the lack of resources for monitoring land use developments.

The Zanzibar land Information Systems which started since1995 has yet not shown any progress. Many consultants have tried to develop sustainable system for Land Information. However the traditional techniques used for capturing land information (surveying and mapping methods) are not sufficient to cope with the demand for managing and coordinating land matters. Therefore actual qualitative and quantitative use of

land information is also limited due to low awareness of its importance among planners and decision makers, and a lack of institutional and policy arrangements. Information on land accessibility and application is not coordinated for spatial development projects.

The Commission for Lands has started the exercise of land adjudication and registration in both islands, but the process is very slow. The target set up to 2015 by the Commission is 8,000 parcels to be registered. The donor support ended in December 2015, less than half of the target were demarcated but not registered. Land registration is a very important factor in land administration and in securing land rights. It guarantees the right of occupancy for individuals legalises transfers of land and can be used to acquire loans. However, most Zanzibaris are not aware of the land registration process and its benefits. The major challenges facing the land sector are:

- Donor support projects have time limit. There is no sustainability after the donor support ends.
- The government funds to continue the programs are limited.
- Lack of enough professional staff at office and in the field. Land information and GIS experts are not enough to handle all LIS work.
- Implementing and monitoring of on-going projects is another issue. Due to limited staff goals set always fail to meet the targets set.
- Increase of informal developments in urban and the coastal areas.
- Land pressure especially in the peripheral urban and emerging new settlement of coastal areas affect forest land and other natural resources.

Zanzibar environmental management agency and department of environment

These two government institutions are set up to monitor and develop environmental guidelines for sustainable uses of natural resources. There have been major success stories of these two offices. They have developed Environmental legislation, environmental guidelines and EIA guidelines and standard for both investments and individual developers.

The Department of Environment has already developed Zanzibar Climate Research document (Technical Report, May, 2012). It spells all challenging issues climate changes in Zanzibar Islands and its mitigations measures. These institutions are key offices for developing environmental awareness by using different Medias and non-governmental organizations (NGOs). The departments commissioned the Institute of Marine Sciences (University of Dar es Salaam, 2007) to make study of beach erosion status in both Islands. The implementation of the findings and monitoring is another challenging issue of many Zanzibar Government offices.

Zanzibar department of disaster management:

Zanzibar Department of Disaster Management is in the Second Vice President's Office which oversees and coordinates all issues related to disasters in Zanzibar. In order to strengthen the institutional and coordination capacity as well to insure that disaster risk management is a multi- sectorial issue, the department with the support by UNPD formulated the Disaster Management Project. The main components of the project include formulation of National Operational Guidelines and Monitoring and Evaluation Framework.

The department now is more conducting training at the local levels. The Education Unit section is taking a big role to strengthen information and communications.

Disaster incidents are increasing in frequency and intensity due to changing weather patterns. Recently, Zanzibar experienced flooding in 2005, 2011 and 2014 which affected more than 1000 homes, displaced 10,000 people and damaged infrastructure in both islands.

Other institutions which support the department of Disaster Management include Police Force, Meteorology Department, Fire fight and Rescue, Military Force, NGOs and National Disaster Steering Committee chaired by the Zanzibar President. The department has established District Disaster management committees to monitor and report them to Regional offices.

However, the department lacks enough human resources and technical staff of monitoring and predictions such GIS teams to assess the risks zones and other high tech equipment. It also needs modern office to facilitate their operations. In addition to that, the following are also affecting the smooth operations of the department:

- Lack of a system to detect disaster and put inform the government accordingly.
- Risk assessment results are not fully utilized for intervention and planning purposes due to inadequate financial resources.
- Ability to assess the full range of consequences and vulnerabilities, especially secondary impacts, comparative economic analysis and assessing non-monetary costs

Urbanization

Zanzibar is experiencing major transition process that has been and will be affecting the country in many years to come. The urban population and urbanization is rapidly increasing. In 1988 little more than 30% of the population was living in the towns. In 2002, it was almost 40 %, (2012 census report)

Zanzibar islands have three major towns, Zanzibar Municipality, Chake Chake, Wete, and Mkoani. Zanzibar Municipality is the administrative and commercial centre.

The urban economy is also developing fast attracting more people to migrate to urban areas. Tourism and other service sectors have increased in the Zanzibar economy.

Population growth generates a demand for land use changes for housing, infrastructure, and other use. Protected areas for forest and agriculture have been shrinking. Large amount of urban land is unplanned, many living in areas of high risk, prone to floods.

Climate change land related issues

Land use planning

Zanzibar has prepared many land use plans at different hierarchies since 1990s when Finnish government signed agreement to support the Zanzibar government in land and forest sectors. In the year 2002 and 2015, the government prepared strategic plans at different levels with the help of consultants. It prepared the National Strategic Development, Regional Plans and Local Village with the same concept used in the country of Mauritius. In 2014, the Master Plan for Zanzibar Municipality was prepared under the sponsorship of World Bank (Urban Services and Sustainable Program) package.

These Land use plans aimed at improving the living standards with the style of minimizing the land under development. The idea of compact development was introduced to reserve more land for other uses such as forests, agriculture and reserve land.

Zanzibar has experienced a high speed of uncontrolled development at the periphery of the urban areas. There are conflicts of developments. The compressive land use plan should consider the protection of nature, valuable agricultural land and sensitive areas. The informal settlements outside the municipality have increased. Agricultural land and sensitive areas are being changed to residential at an alarming rate. Low income communities take the advantage of building their houses close to flood prone areas because the land is cheaper in those areas. The combination of spatial planning with enforcement of protected areas should include:

- Participatory planning
- Raising awareness of protected areas such water sources, agricultural land,
- Minimizing the impacts of development on valuable lands by providing guidelines and standards for the proper protection of these lands.

The adverse effects and environmental impact of land degradation caused by unsustainable excavation of non-renewable natural resources in Zanzibar have evidently become irreversible. The aim is to reduce land degradation through sustainable use of non-renewable natural resources. The use of alternative construction materials and the development of proper skills to improve the degraded environment are very important. Figure 1.

Environmental degradation

This phenomenon results from poor land use patterns and other practices that lead to waste and destruction of ecological patterns. Environmental degradation is caused by overgrazing, destructive tilling practices on sloping landscapes, monoculture, unguided and uncontrolled use of fertilizers, bush burning, overfishing, poor methods of quarrying and deforestation.

Wetland degradation occurs as a result of drainage, over-harvesting and burning of wood for brick making, as well as settlement and development projects like industries and irrigations. Encroachments in protected areas destruct habitats and loss of flora and fauna.

Tourism and coastal areas

A Tourism Zoning Plan was prepared in 1995 to guide the coastal development in a sustainable manner. A number of tourism zones along the coasts were prepared and with services and infrastructure allocated to govern the socio-economic developments. The tourism plan has been unsuccessful in regulating development in some coastal areas Coastal resources of Zanzibar constitute a complex interconnection of a variety of ecosystems (both terrestrial and marine). There has been over utilization of coastal resources, due to multiple uses, such as hotel and settlement construction, salt farming, and others that have led to severe damage to of these resources.

The risks of climate change to coastal areas associated pressure on land

Figure 1: Sand mining in agricultural area

Figure 2: Tourism development in beach areas

Figure 3: Retaining wall mitigation in beach erosion

Figure 4: Seawater raises impact in tourism hotel development

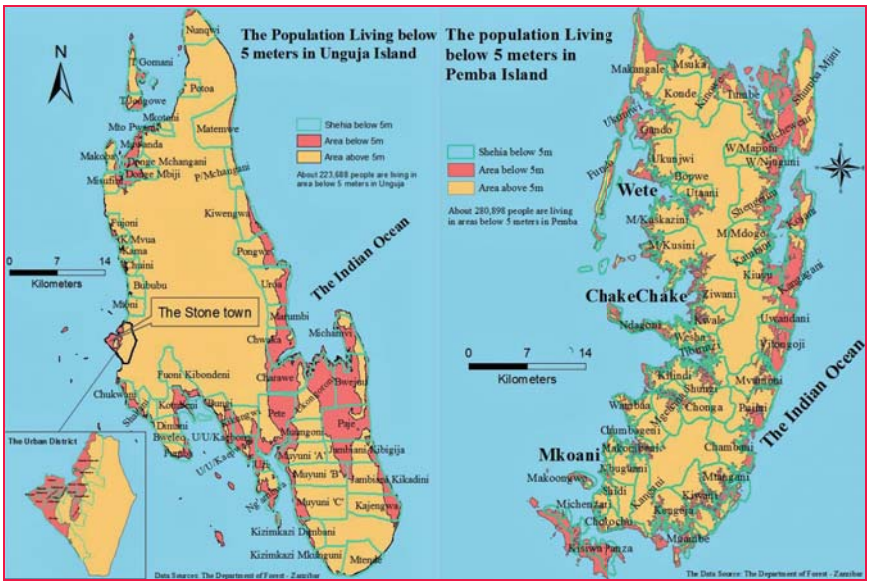

Figure 5: Villages along the beach fronts

demand for tourism are a key issue for Zanzibar, particularly from sea level rise, but also from other factors such as from sea surface temperature, salinity, wind speeds and direction, etc.

The direct impacts of sea level rise will be felt primarily in the so-called Low Elevation Coastal Zone (LECZ) which can be defined as "the contiguous area along the coast that is less than 10 metres above sea level." This area comprises only 2% of global land area but contains 10% of the world' population, and 13% of the world's urban population. (McGranahan etal).

Human settlements along the coastal lines have increased effect of coastal erosion. Unguja which is the main island has around 224,000 people live below the 5 metre contour line (with 281,000 below the 10 metre line). For Pemba islands around 281,000 people live below the 5 metre contour line (with 309,000 below the 10 metre line).

In many island areas, the population is fairly concentrated around the coastline, and these leads to relative high exposure. When compared to current population, 29% of Unguja and 54% of Pemba population are within the 5 metre contour zone.

There are also other reports of increasing erosion, particularly on the eastern coast of Zanzibar possibly from the strengthened north-eastern monsoon and increase of wave activity due to increasing wind regime. Most of the settlements in the island are along the coastal lines some are less than twenty meters from highest water marks.

Zanzibar's coastal resources offer great potential for diversifying the islands' economy. The economically valuable attributes include its diverse nature, various ecological systems such as coral reefs, mangroves forests, sandy beaches, swamps. This zone now is highly vulnerable and prone to physical damage. Effects related to the use and exploitation of those resources mainly are due to development activities which combine fisheries, tourism, agriculture, human settlements, quarrying, waste disposal and transport. In view of the increasing pressures on the coastal zone, the following issues have been identified:

- Degradation, the unregulated resources exploitation, coral reef damage, tourism development pressure on fishing resources.
- Land use conflicts, pressure on marine islets by competing uses of tourism, unabated allocation of lands for hotel development along the coastal zones conflicting with traditional villages and local economy.
- Mangrove cutting, sand and rock mining, reef destruction, sea level rise by natural and human effects.
- Carrying capacity, the population increase of human activities in the coastal area has triggered the overuse of coastal resources such land, forest, building materials, marine species, protection of indigenous plants,etc.
- Minimum or lack of community participation in coastal resources management

Land Policy Registration

Zanzibar has established the first comprehensive land policy and legislations in 1990s, aiming of regulating land administration and improve security of tenure. The Tourism policy and agricultural policy were also put into place to stimulate proper land use planning. But due to the speed of economic changes and increase of tourism sector, these policies and legislations did not work well as expected.

There has been very slow process of provision of secure land rights under a diversity of forms, including the recognition and devolution of responsibilities for land registration, promoting land access for low income peoples, upgrading of tenure and infrastructure in urban informal settlements; improving equality in the distribution of land. The management of natural and non- renewable resources and inclusive frameworks for stakeholder involvement and management of land conflicts better governance in land administration are not yet in place.

Socio economic on Land Use

The poor are most vulnerable to the impacts of climate change and variability, and women are over- represented amongst the poor. Approximately 70 percent of the world's poor are women and their vulnerability to natural disasters and environmental hazards is further accentuated by questions of race, ethnicity, and age (IUCN 2007).

The people most at risk from climate change are those living in affected areas, who are least able to avoid the direct or indirect impacts (as a result of having poor quality or poorly located housing), being physically more vulnerable, and

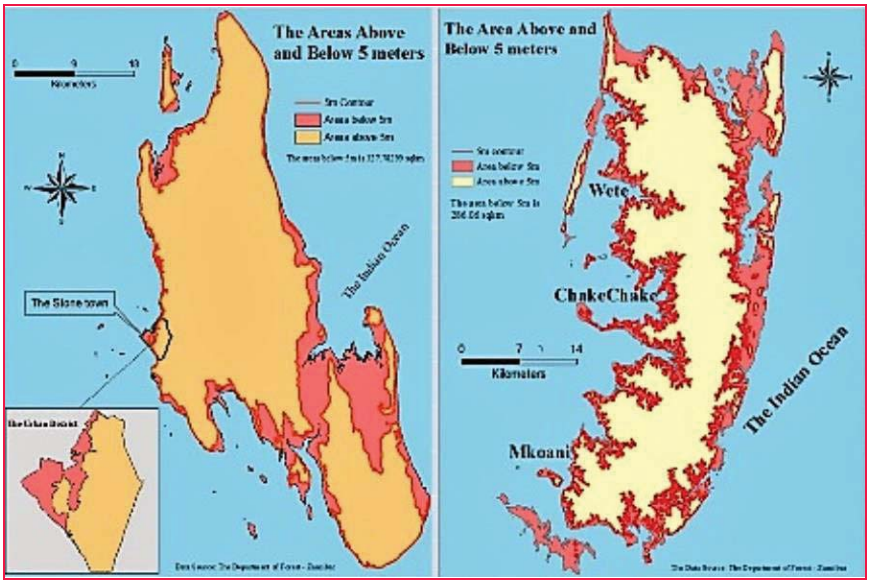

Figure 6: Maps Source: Zanzibar Department of Forest

least able to cope with the loss of income, livelihood assets, ill health and injury. In low income populations, women's vulnerabilities in all of these respects tend to be more pronounced, in part because their limited access to and control over assets such as land exposes them to all of these risks (Satterthwaite et al).

In both rural and urban environments, pre-disaster patterns of gender inequality can be exacerbated and are likely to be reflected in greater difficulties faced by women in the aftermath. In developing countries low income communities are built their home without having land tittles and when the government evicts them mostly do not get compensation.

Energy

The Zanzibar Energy Policy 2009 set out the need for norms, codes of practice, guidelines and standards to facilitate the creation of an enabling environment for safe use of energy efficient appliances and in particular appliances based on environmentally friendly technologies. It included a policy statement that Zanzibar shall introduce limits on standards for import of electrical appliances. Energy efficient equipment shall be promoted by lowering import duties for such goods. It also highlighted that a major obstacle for the development and market up-take of energy efficient technology was the higher (relative) capital costs) and the need to addressing financing. At the small scale it highlighted the potential role of micro-finance institutions in facilitating investments in energy efficient equipment and for large scale investments, energy efficiency funds.

The escalating demands for wood fuel, settlement expansion are the most important drivers of deforestation. The

distribution of the main energy sources used in Zanzibar is: biomass fuels 74%, petroleum products 21% and electricity 5% (The Economic Climate Change Study – 2012). It is estimated that peri-urban and rural population cooking energy needs on biomass reached 40% and 96% respectively. This situation pushes the forest degradation and deforestation.

Mitigations and adaptation

Urbanisation

- Set development strategies to reduce the effects and guide urban growth in order to minimize the effects of investments while on environment.
- Set population development strategies on coastal settlements and tourism developments.

Land use planning

- Improve land and natural resources information including improve inventories on land in urban and rural areas,
- Improve analysis and mapping of natural hazard risks for informal settlements,etc.
- Dykes construction for seasonal water / flood management, some short term displacement and resettlement; better land use and water management in irrigation systems.
- Greater security of tenure to facilitate adaptive management; resettlement and facilitated migration; compensation for land loss; improved land inventory;
- To ensure that the development of rural and urban settlements are proportional to the rapid growth of population and the need for basic services.
- Conservation management and sustainable utilization of forest and marine resources to be strengthened
- Develop a set of ordinances or regulations and associated standards intended to control aspects of designs, constructions, materials, alteration and occupancy of structures that are necessary to ensure human safety and welfare including resistance to collapse and damage during disasters.

Tourism and coastal areas

- Effective supporting broad based sustainable developments in the coastal areas.
- awareness raising on the importance of creating a positive balance between conservation and the use of local resources
- introduction of coastal protection and coastal zone management to protect tourist infrastructure
- diversity of tourist product to reduce over dependency on marine environment
- risk management skills organised by education, NGO's and other institutions in coastal areas
- Forming a professional team of land sector to review and monitor the tourism zoning plan changes and its effects on the communities' interests and nation at large.

Land policy registration

- Develop land policy based on inclusive and consultative process that makes provision for those high at risk natural disaster and those with poor tenure security.
- Establish guidelines of land registration system
- Develop institutional infrastructure, good governance, spatial data infrastructure, ITC infrastructure and recruitment of land professional skills.

Socio economic on Land Use

- Measures to protect the poor and vulnerable from loss of livelihood resources and develop the opportunities available for them to gain direct benefit as a result of climate change mitigations measures.
- Prepare hazard map that highlights areas that are affected or vulnerable. Hazard maps are useful in disaster management in order to address prone areas to hazards.

Energy

- Develop planning guidelines and building codes for efficient energy use such as building design standards to facilitate safe and sustainable energy use.
- Promote alternative energy use such as of solar and wind power through tax relief and lowering of tariffs.

Conclusion

Policies regarding land sectors such as agriculture, land and tenure, forest and water management, environmental management including urbanization need to be improved and demand for introducing an integrated approach to deal with climate change adaptation. To meet this challenging demand, land policies can play a leading role in improving adaptation policies in the face of climate change. A thorough review of literature is made in this chapter is to explore the ways of developing integrated approaches to integrate climate change issues related to land into land policies.

The land related instruments such as land use planning, land management and administration can play a role in adapting and mitigating climate change. However, Zanzibar needs to put all these together in reality with enough funds and technical/scientific human resources to with climate changes

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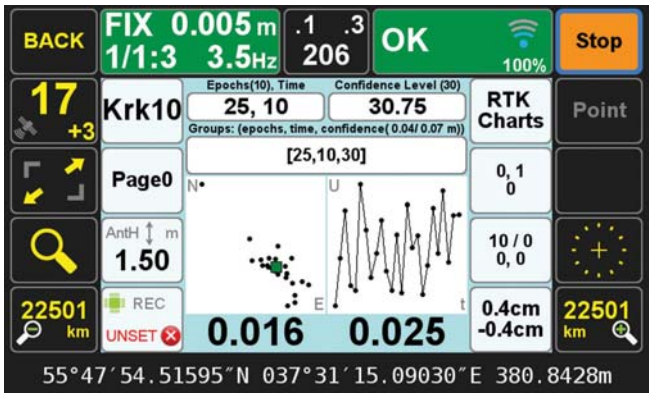
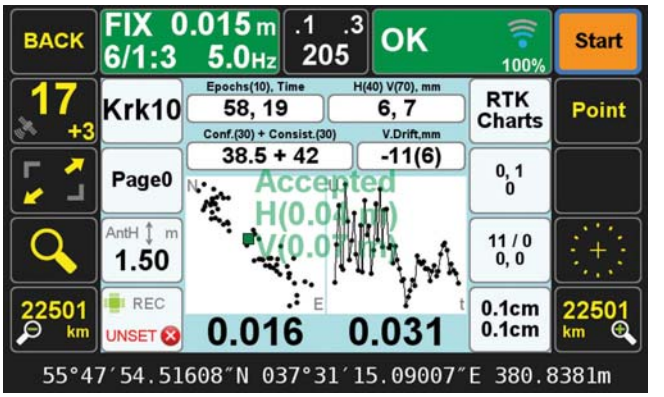
RTK Verification, Phase-1

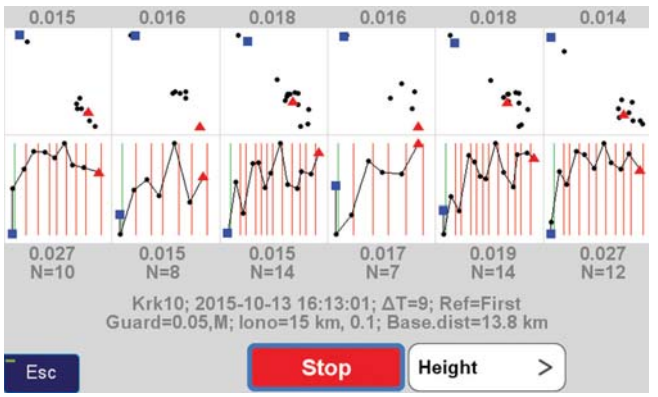


This graph shows the horizontal and vertical RTK epochs of Phase-1 along with their statistics. Each epoch is the average of six RTK engines.

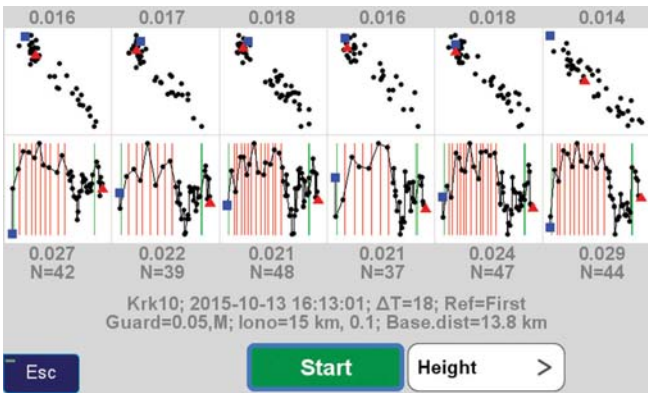
RTK Verification, Phase-2



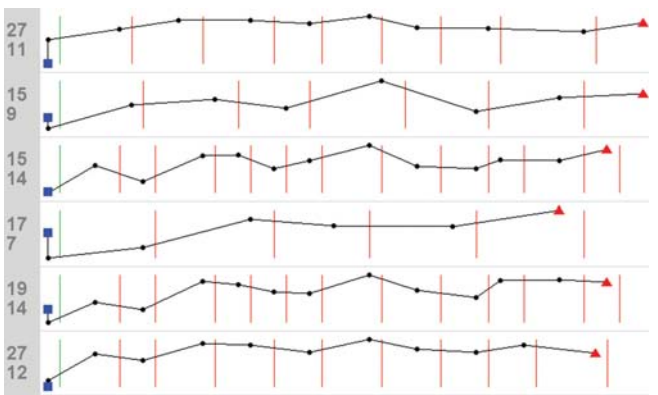
In Phase-2 the best ambiguity solution is selected and RTK is continued with the best ambiguity selection.



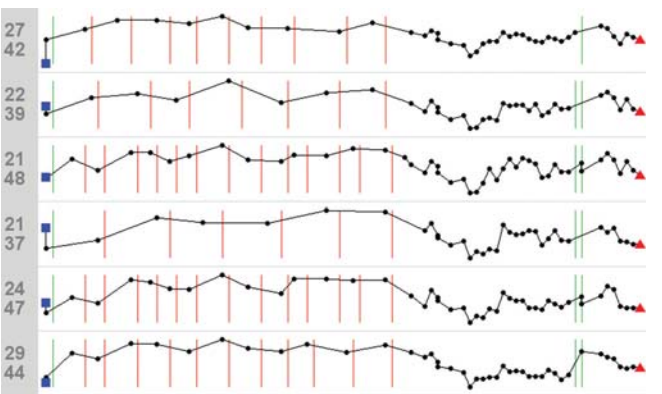
Phase-1 horizontal and vertical solution of each engine for each epoch.



Horizontal and vertical view of each engine in Phase-2. At the end of the process, all engines are reset once more to ensure correct ambiguity resolution.



Expanded view of the vertical solution of each engine. Vertical red lines show the instants in which each engine has been reset and ambiguity solutions recalculated.

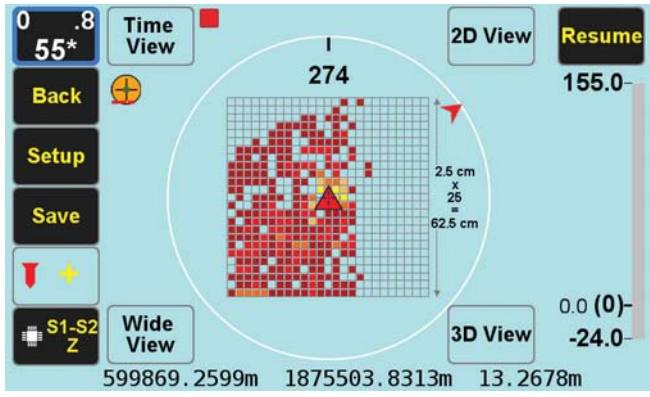


Similar expanded view of the vertical solutions in Phase-1 and Phase-2.

FL

We have planted 19 mag nails, close together, from 16d common nails to 2-3/4 inch Mag Spikes from ChrisNik, in an 18 x 12 feet land in front of our San Jose headquarters.

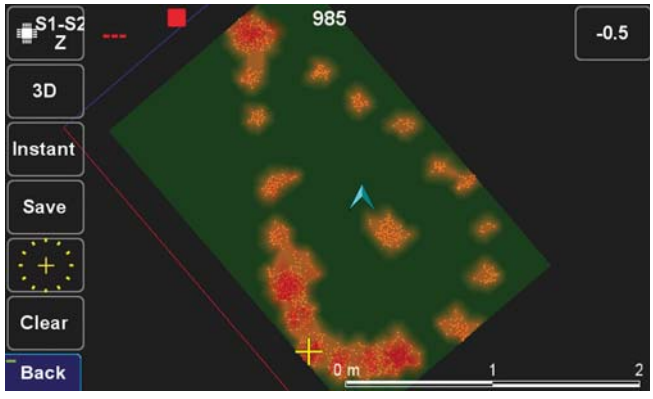
The site has a great deal of ambient noise from a nearby freeway and construction work.



The initial Mag View focuses only on the mag object with the highest mag value.

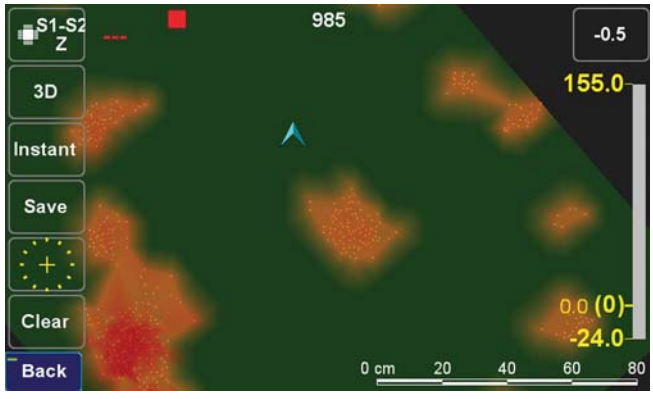
The audio and graphical bar on the right side show the magnitude of the magnetic object.

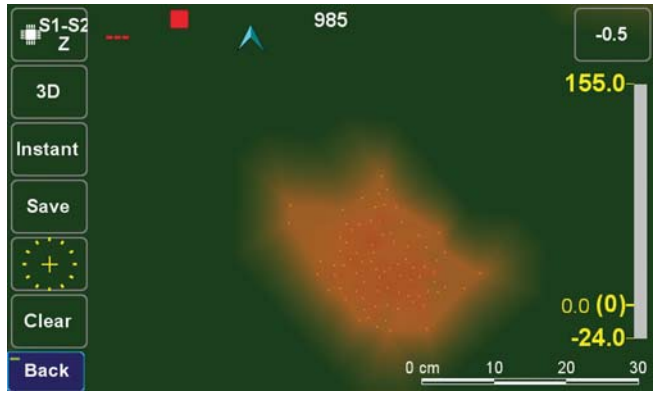
In “Setup” you can select the cell size and the size of the field you want to scan.

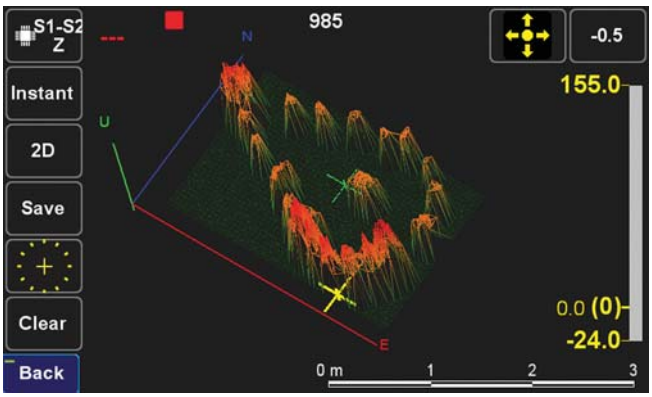


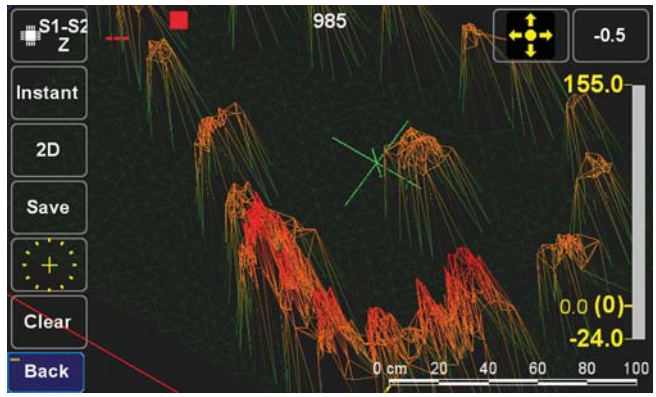
2D view of the field shows the magnetic objects that have been scanned.

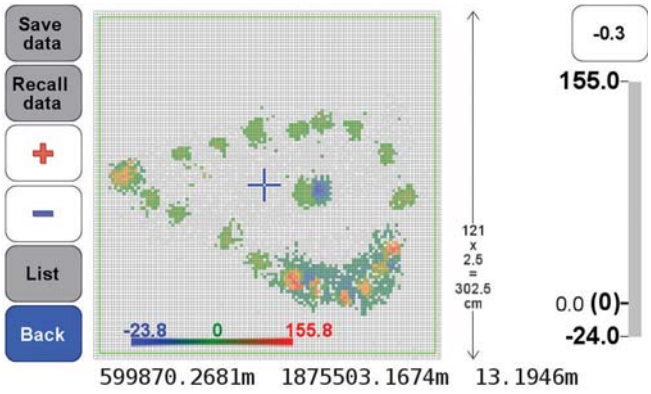
Zooming the 2D screen can show the shape of the magnetic objects under the ground.

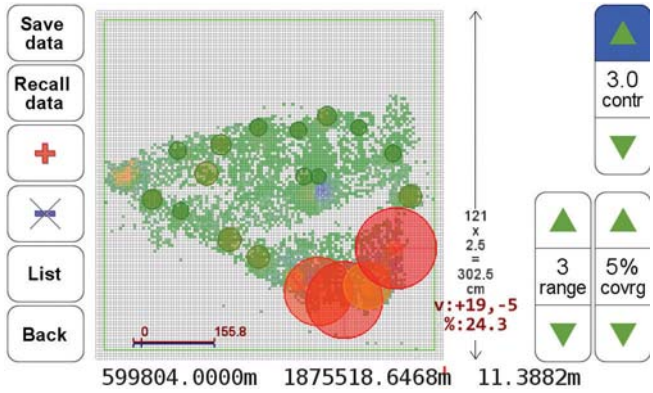


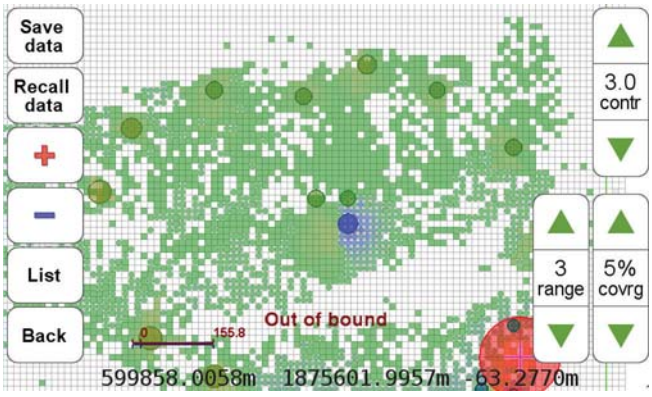


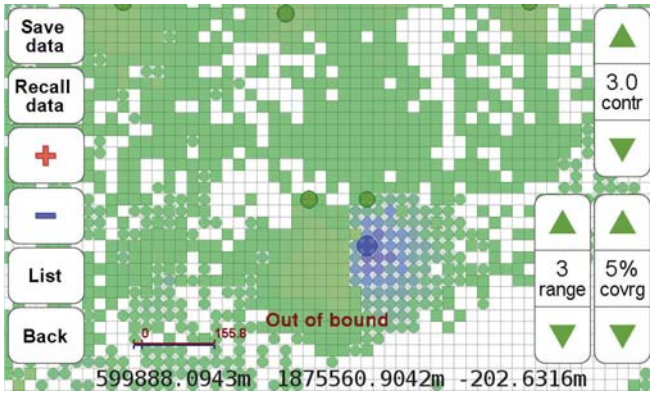


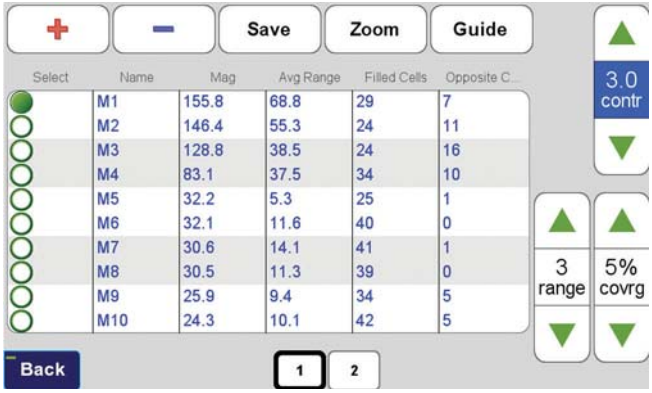




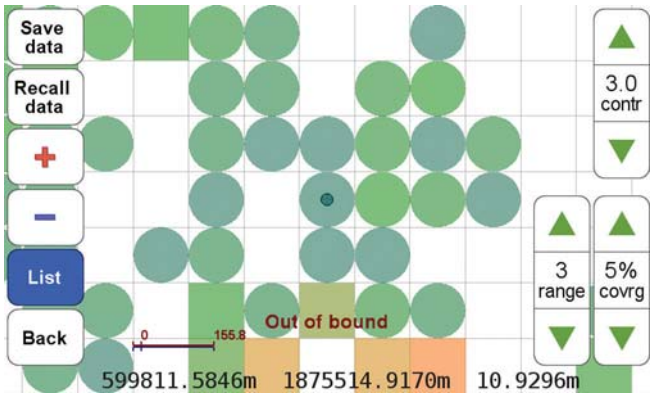






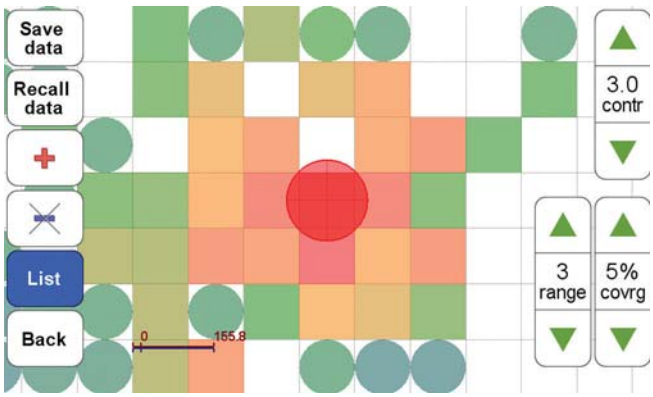


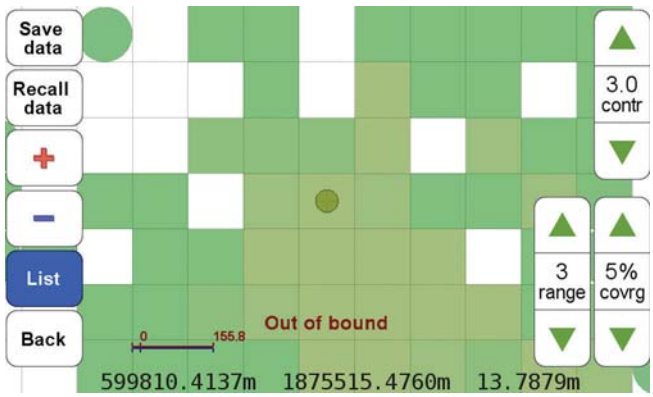
The top two graphs show the 3D view of the magnetic objects in the field. The following four screens show the digitized version of the 2D view. The mag data collected can be saved and recalled for further viewing and documentation. The “List” button lists the magnetic objects detected and their characteristics. Zoom button shows details of the selected object. Guide button will guide to the selected item.

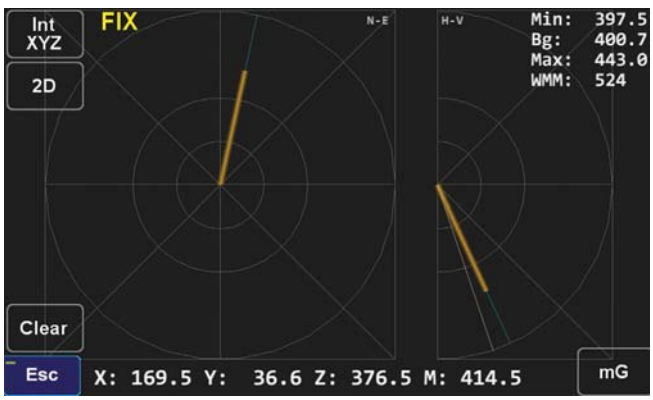


MRI Magnetic Raster Imaging

When zoomed to any selected point, the characteristics of the cells around the peak are shown. Squares show the positive and circles the negative cells. Cell sizes are programmable. Similar to the MRI used by doctors!

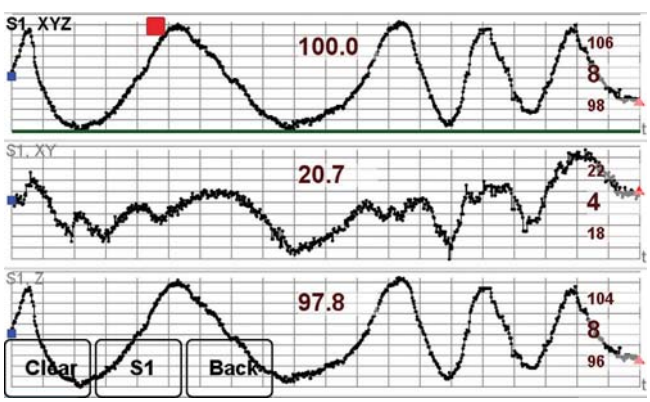


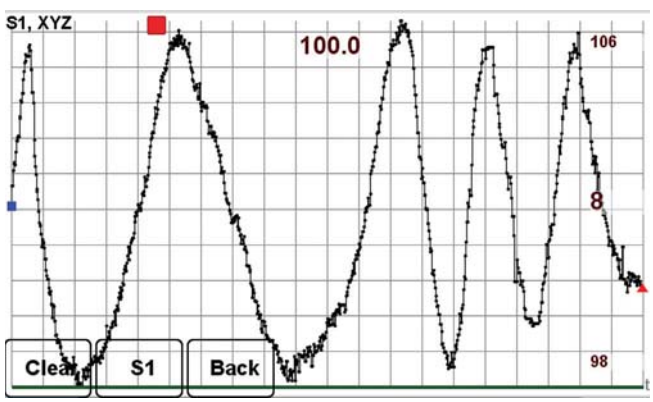


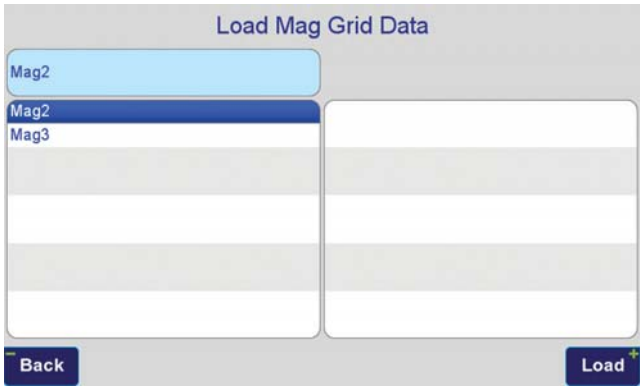


Horizontal and vertical magnetic vectors show the instantaneous vectors from the current position to the mag point.

Below graphs show the Time View of the mag values of the two sensors and their difference as scanning is in progress. Clicking on any graph shows its expanded view.



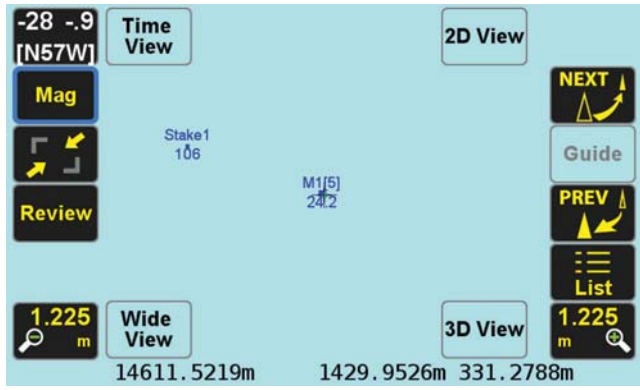




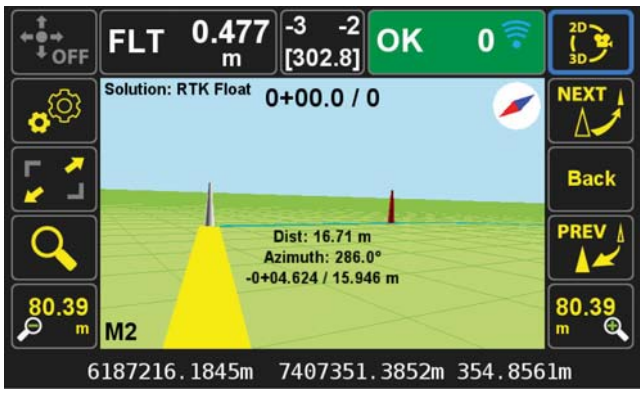
Field View

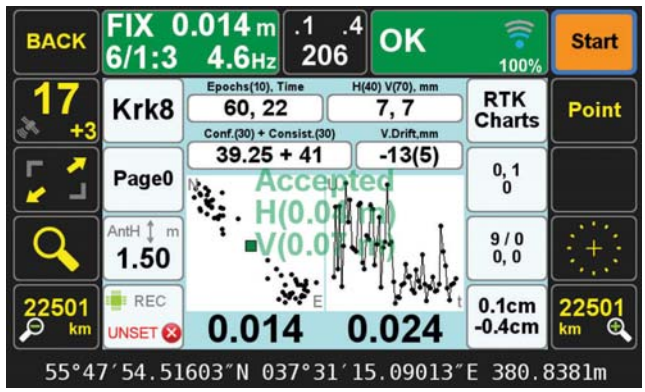
When you scan a large area, you can save all possible peak points, view them on the map and select the point with the highest peak to dig.

When you save a point, you can also save all the raw Mag sensor data for future view and documentation.



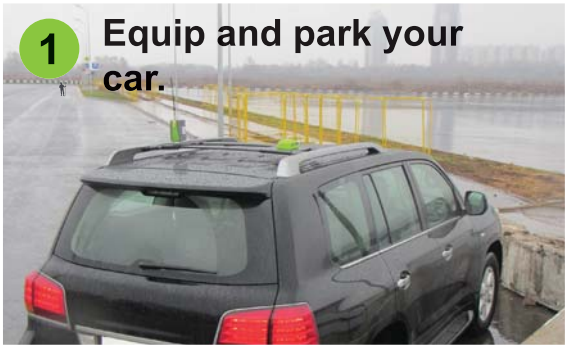
Work Flow



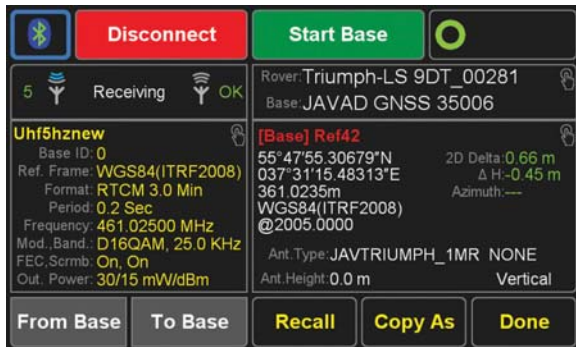


We have not only integrated a sophisticated magnetic locator in the TRIUMPH-LS, but we have also streamlined the whole process. First, the “Stakeout” screen will guide you towards the target.
Then the “Mag” screen locates your underground target and determines its coordinates. You can also save this point.
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.

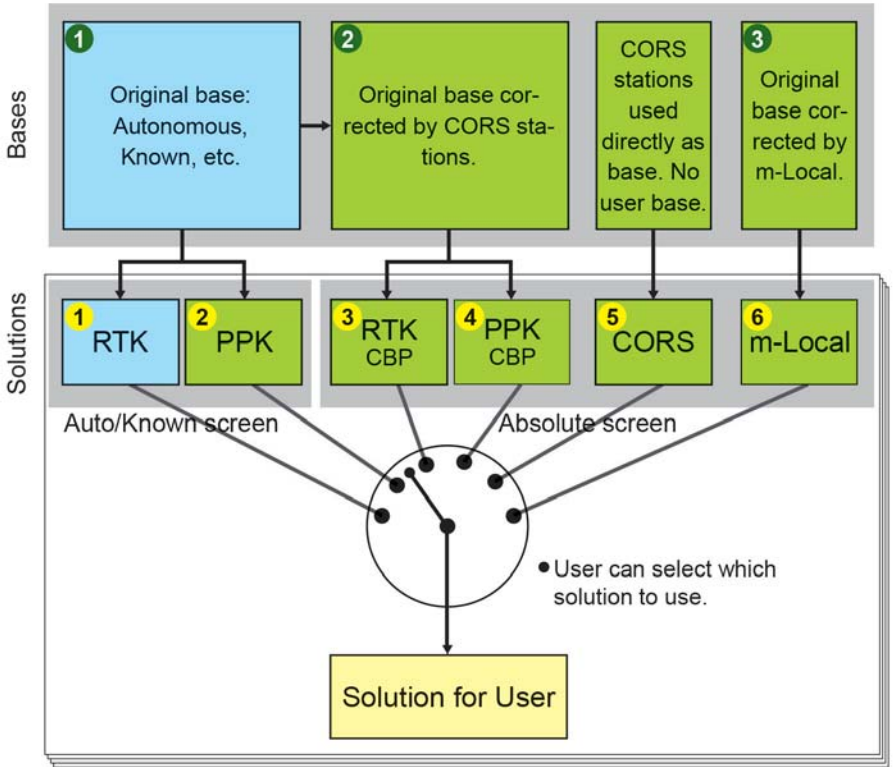
We have shown many J-Tip internal details to show the sophistication embedded in it. Its operation is much easier than conventional magnetic locators.



2
Start Base

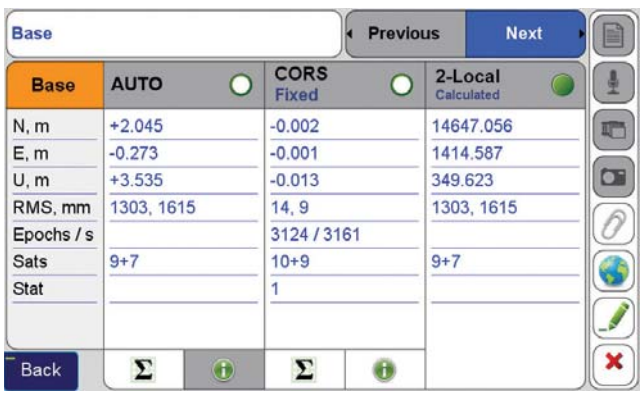


After your field work, sip your favorite drink... ...while we fill the other 5 buckets.

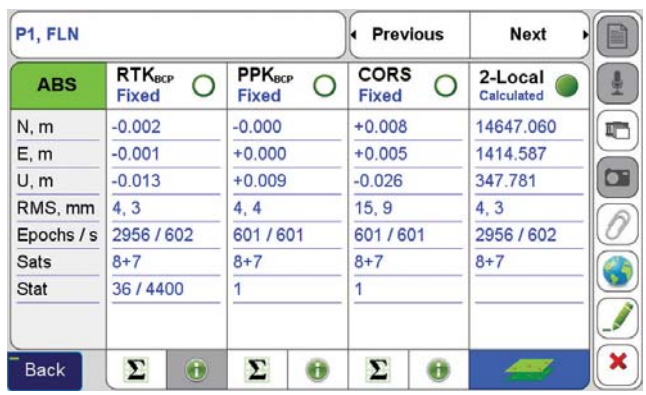


Mount your base on your car, park it in any unknown location and start the base. Perform your RTK work. Then download the base data in your TRIUMPH-LS rover. We will do the rest as follow:

TRIUMPH-LS will send the base data to DPOS, which will process it with CORS stations, and will determine the accurate position of the base and then corrects all of your rover points. DPOS also post processes the rover data and ensures that RTK solutions were correct and applies the base corrections to these solutions as well.

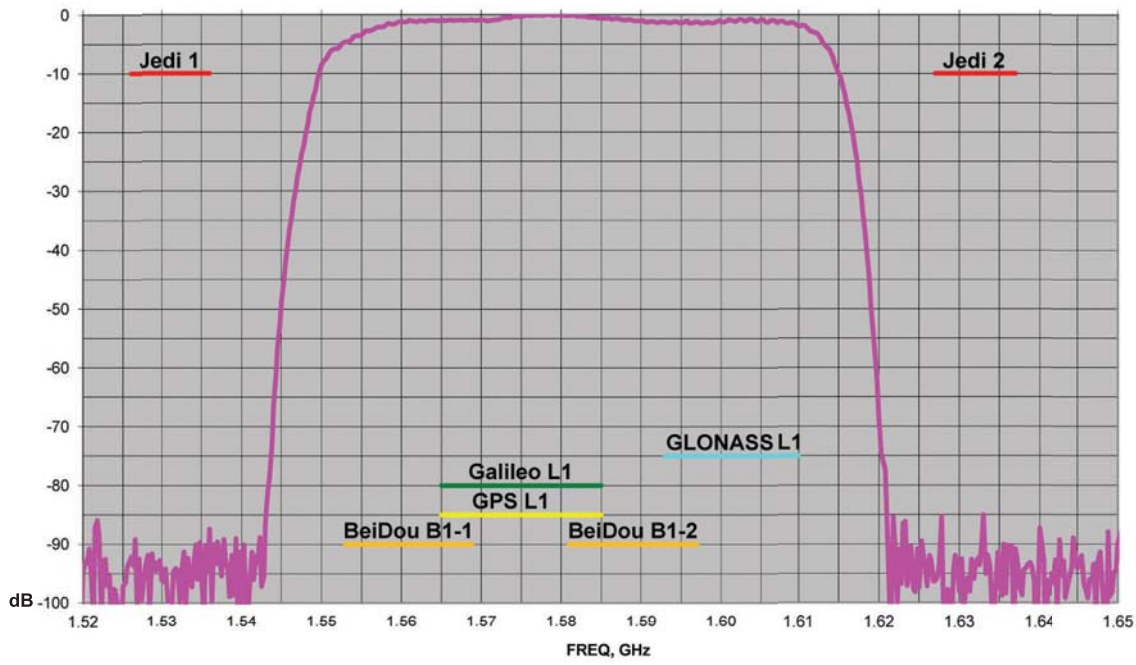


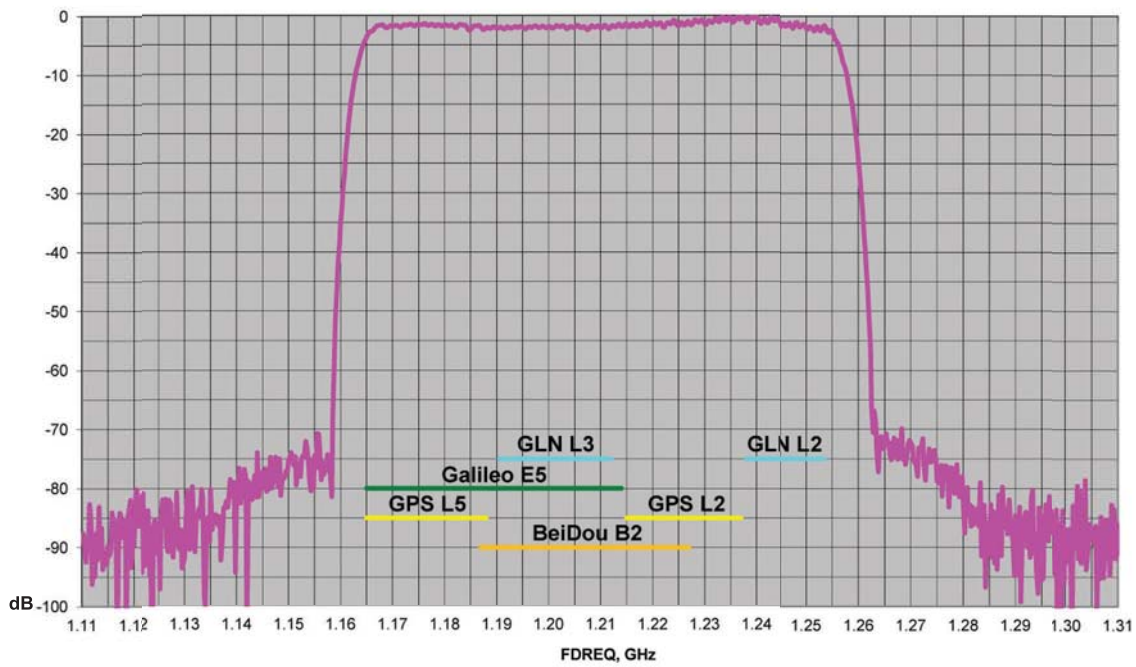
Initial base position can also be corrected by the rover occupying one or more known positions. This screen shows the initial and corrected positions of the base both by CORS and by m-Local known rover occupations.



All rover positions (initial RTK, Post Processed, corrected with CORS and corrected with m-Local) are shown in this screen. User can select the desired solution. Statistics and differences are shown as well.

If the **Jedi** returns
J-Shield is ready for it!





J-Shield in TRIUMPH-LS protects all GNSS Bands

Terrestrial laser scanning helps to reconstruct a damaged train

This article describes the implementation of terrestrial laser scanning (TLS) in the accurate documentation of a damaged train wagon after a derailment accident

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Railway safety

Trains remain one of the safest ways to travel in Europe, where millions of euros have been sunk into rail safety and infrastructure. According to the European Railway Agency (ERA), trains are far safer than most other forms of transportation within Europe and about as safe as air travel (Table 1, ERA, 2013).

Recent studies regarding the train accident rate within the European Union show that the rate of fatal incidents has been declining steadily (*ec.europa.eu / eurostat/ Transport_ accident_ statistics*). The majority of the accidents involve cars crossing train tracks and not mass derailments such as the rail accident in Spain on July 2013 with 80 people killed, the high-speed TGV train derailment near Strasbourg in France killing 11 people on November 2015, and most recently in Spain on September 2016 killing 5 people (*https:// en.wikipedia. org/ wiki/ Lists_of_rail_accidents*).

Train incidents are classified into three groups: collisions with objects (i.e. crossing incidents), single train events (i.e. derailments), and train-to-train collisions. Regardless the type, the collision energy in a train crash is generally very large and causes significant damage on the train structures. An interesting point is that, unlike in the car industry, there are no European safety regulations covering vehicle design in the railway industry. All countries conform to the recommendations of the International Union of Railways on crashworthiness but adopt different structural specifications. Trains have, in most cases, been designed to crumple in a crash, to dissipate the enormous amount of energy released by the impact.

Table 1: Fatality risk of passenger using different mode of transport (2008-2010) (ERA, 2013)

Transport mode used by user	Fatality risk (2008-2010) Fatalities per billion passenger km
Airline passenger	0.101
Railway passenger	0.156
Car occupant	4.450
Bus/coach occupant	0.433
Powered two-wheelers	52.593

Train accident documentation

Recording a vehicle scene accident can be of two types; in situ documentation of the actual accident scene immediately after the accident and a post-accident mapping of the vehicle involved. The former is usually most relevant to automobile traffic accidents where it is very advantageous to know the condition or state of a car and to analyze data of, for example, acceleration, angular velocity, etc. of the vehicle at the accident occurrence time. Transitory events, e.g., accident scenes in particular, must be accurately and quickly recorded in situ prior to the removal of the affected vehicles. The second type refers to the detailed mapping of vehicles after their transfer from the scene of the accident to special repair sites. In the field of accident reconstruction, it is often important to measure the deformation of large sized vehicles (e.g. train, truck) after a crash has occurred. The measurements must be of high detail and accuracy to lead to conclusions including whether the vehicle is repairable, what kind of repair is needed and other useful information e.g. energy calculations, speed, etc.

Current methods of reconstructing accidents include total stations and laser rangefinders. With the advances in computer vision, 3D measurements are used offering a fast and detailed capture of complex environments that can help

reconstruction experts in various types of analysis including crush deformation, impact configurations, and analysis of vehicle components. Close-range digital photogrammetric systems and terrestrial laser scanning provide such 3D data sets where timing and accuracy is critical (e.g. Behring et al., 2011; Randles et al., 2010; Du et al., 2009; Pagounis et al., 2006).

Accident description

The specific train accident described herein occurred on 22nd February 2008 at 12.30 pm, in the depot (parking and maneuvering) Station of Piraeus in Greece. The passenger train of the Urban Rail Transport Company of Athens comprised six carriages and was stationery prior to the accident. Cleaning personnel was only in the carriages for the routine cleaning. Due to human error, the lever - brake of the train was released and the train started moving and changed track lines covering a distance of about 300m. Then it was cruising uncontrolled at a speed of 40km/h and collided with a wall fence. The train dragged part of the wall and continued its unregulated course towards a busy street with cars and pedestrians (Figure 1). The end result was the loss of one pedestrian, injury of six cleaners working inside the train and serious damages on the protective wall and the train carriages.

From the six train carriages, the first three suffered major damage which was not repairable, the fourth suffered extensive damage but was repairable, and the last two had no damage. For this reason, it was important to have a full geometric documentation of the exterior and interior of the fourth carriage and provide a deformation model in order to assess the extent of the damage. The unique, complex shapes of the damage on the wagons made capturing and analyzing the deformations using traditional methods, such as tape measures and mechanical profilometers, very difficult.

Data processing

The data collection of the damaged carriage was performed with a Leica Scanstation 2 terrestrial laser scanner. The scans were acquired using a number of reflective targets placed on the external surface of the carriage to enable the georeferencing and registration process of the collected data (Figure 2). In order to avoid gaps and noisy data in the final model due to the large number of window openings, these were covered by paper. The scan acquisition was accomplished within 5 hours, obtaining about 9 million points.

The scan registration was performed using the proprietary software Cyclone (*hds.leica-geosystems.com)* with a precision of 3mm. The processing includes the transformation of all point clouds from the local scanner coordinate system into the common coordinate system using the targets as tie points. The registered point cloud of the object is shown in Figure 3.

The modelling process was performed in the proprietary software Geomagic *(www.geomagic.com)*. The first step involved filtering for the removal of outliers and noise from the dataset. Redundant information is also removed at this stage. For noise removal, the free form shape algorithm was chosen after several trials. The associated statistics for the filtering is average distance of 0.0011m and standard deviation of 0.0009m. The full point cloud was also resampled by about 10%. This essentially reduces file sizes and ultimately lowers processing times for the modelling algorithms.

The creation of the TIN (triangulated irregular network) was performed in Geomagic, but the resultant surface had many gaps and other irregularities. The small gaps due to data missing were filled in using suitable filtering algorithms. There are cases however where the algorithms produce results that do not always correspond to the real surface. An interesting example is given in Figure 4 which shows the point cloud of a selected part of the external surface with graffiti drawings and the corresponding TIN model indicating these as deformations. This can happen because intensity values, which are registered by a TLS for each point of a 3D point cloud in addition to its coordinates, are affected by the characteristic of the measured object and the parameters of the environment (e.g. Pfeifer et al., 2007). The backscattered electromagnetic signal is influenced in its strength by the reflectivity of the scanned object surface, the incidence angle, the distance between laser scanner and object and the atmospheric specific setting of the TLS-measurement.

Figure 1: The train accident in Piraeus, February 2008 (source: Urban Rail Transport Company of Athens, Greece)

Figure 2: Coverage of large openings prior to scanning and use of reflective targets

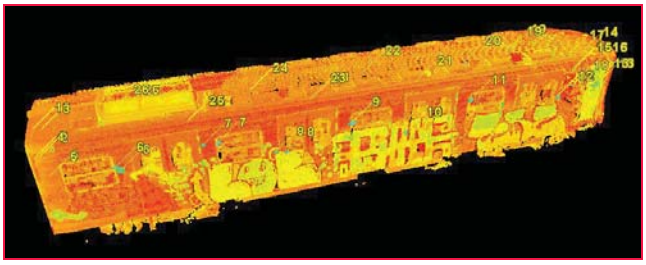

Figure 3: Registered point cloud of the damaged train carriage

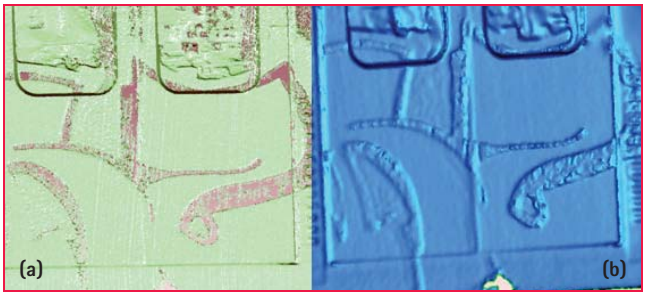

Figure 4: Graffiti shown in the (a) point cloud and (b) TIN model

For this reason, a process is followed which fills the holes taking into consideration the complex geometry for specific parts of the object. The final model was also reduced further in size totalling to about 3.3 million triangles. Views of the final wagon model are shown in Figure 5. Clearly the front part of the wagon suffered most of the damage.

Deformation measurements

The 3D model created for the wagon was used to quantify the damage by measuring a number of profiles and sections. Crush along one horizontal axis and front-end shift or longitudinal bowing in a side impact are also measured. Additionally, the measurements from the model were compared with respective conventional measurements. The conventional measurements were carried out by the Urban Rail Transport Company of Athens (ISAP) in 2D by using tape measures and mechanical profilometers at specific sections along the wagon and height differences in selected parts of the frame. For each section, measurements of the lowest frame point (noted as 'a') and the top part of the roof (noted as 'b') were used. In Table 2, a comparison is given for the values of 'a' and 'b' for a number of sections between the measurements provided by the 3D model and the conventional methods.

Figure 5: Views of the 3D wagon model

The maximum difference is 1.3cm and the rms is 0.008m. It is seen that there is a fairly good aggreement of the results considering that there is a practical difficulty in identifying the exact sections between the two methods of measurements. The main disadvantage of the 2D deformation retrieval is that selected points on the damaged surface are examined. Instead, the use of a 3D high density model is more advantageous as it provides information about the deforming areas from the entire object's surface. For this reason, the deformed wagon model was compared with the undeformed model of the same wagon. As there was no available point cloud data of the wagon before the accident, a CAD model was constructed based on the design plans for the specific type of wagon. The two models (undeformed and deformed) were aligned using a number of correspodence points.

A comparison between the two models in the form of deviations is shown in Figure 6. The example shown here was performed in Geomagic but there are open source software suites that provide similar tasks (e.g. Cloudcompare). The statistics of the 3D comparison gave a maximum difference of 0.4m with a standard deviation of 0.0507m. The colour variation provides the deforming regions in the front part of the wagon.

For a detailed examination, a number of longitudinal and sectional profiles were constructed along a predefined axis (Figure 7). The result is a 2D representation measurement in the vehicle X-Y plane at prescribed heights. This method of vehicle measurement conforms to those used in vehicle damage analysis (SAE, 1980). Example of profiles for lines 1 and 2 (cf. Figure 7) are given in Figure 8 and 9.

Both the 2D diagrams and the 3D comparison provide comparative results with respect the undeformed model of the train. It is important to emphasise that the undeformed model is lacking in reliability because it was created based only on design plans. The alignment of the two models is based on the identification of corresponding points in both models. Therefore, the high value of rms at 5.7 cm does not indicate the accuracy of the 3D model but rather the alignmnent of the two models. Nevertheless, the

Table 2: Comparison between conventional and 3D model measurements

	3D model		Conventional		Differences	
	a(m)	b(m)	a(m)	b(m)	a(m)	b(m)
1	2.745	---------	2.758	----------	-0.013	----------
2	2.742	2.573	2.748	2.576	-0.006	-0.003
3	2.747	2.58	2.751	2.579	-0.004	0.001
4	2.751	2.563	2.749	2.578	0.002	-0.015
5	2.749	2.579	2.749	2.574	0.000	0.005
6	2.739	2.567	2.749	2.574	-0.010	-0.007
7	2.756	2.581	2.75	2.574	0.006	0.007
8	2.749	2.562	2.75	2.573	-0.001	-0.011
9	2.752	2.565	2.748	2.575	0.004	-0.010
10	2.747	2.566	2.75	2.575	-0.003	-0.009

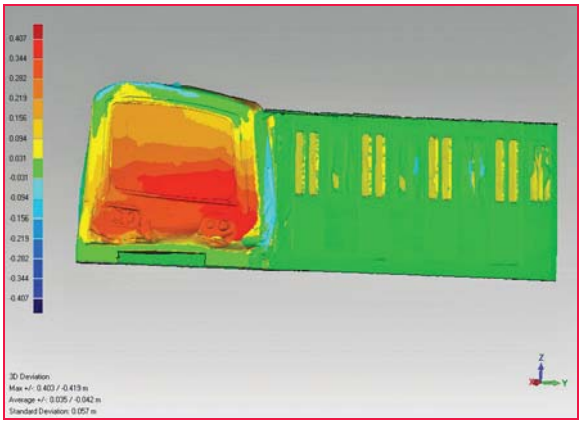

Figure 6: The 3D deformation regions on the front part of the wagon

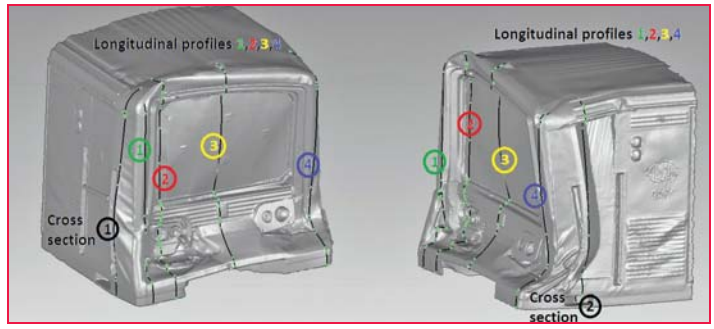

Figure 7: Positions of sections and profiles

results show that this method has the advantages of high automation and 3D deformation quantification. Clearly, such type of qualitative information is difficult to retrieve using conventional methods of measurement.

Concluding remarks

The current technology for 3D recording using terrestrial laser scanning has reached a high level of development. The availability of this technique for accident reconstruction applications yields to several notable advantages. The created virtual model enables the investigator to look at the accident scene from different points of view and can be exploited to reproduce the event's dynamics. Also, the digital set of data can be used anytime and shared among different operators. On the other hand, the acceptance of this type of data as valid and legal evidence is still to be recognised in many countries.

The field survey is not a trivial task, especially in the case of large or complex scenes. This requires the presence of experts to plan and carry out effective data acquisition. In the same direction goes the development of best practices, data interoperability and management and better understanding of the data quality needs for implementing terrestrial laser scanning for accident investigations.

The use of terrestrial laser scanning can add value to the achievable results. The good knowledge of the impact phenomena could not be achieved only by means of the traditional theoretical and analytical models used in crush analysis, because of the complexity of dynamic effects. Instead, the 3D models created by terrestrial laser scanning are able to virtually reproduce the bodies (vehicle, barriers, etc.), and be used to evaluate the deformations and dynamic actions exchanged during the crash.

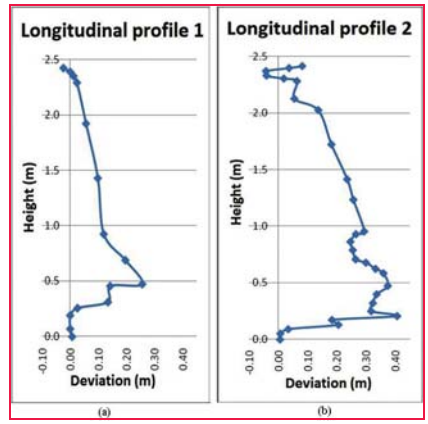

Figure 8: Example of longitudinal profiles

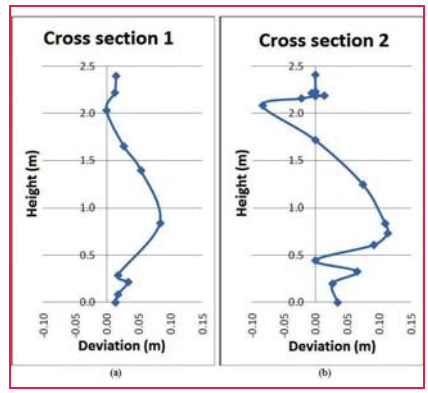

Figure 9: Example of cross sectional profiles

References

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Spoofing monitoring sensor for airports

This paper describes the innovative SMART (Spoofing Monitoring And ReporTing) sensor. The SMART sensor has been developed as part of the H2020 GMCA with main objective the enhancement of DW International's GPMS monitoring system with the integration of interference and spoofing detection sensors

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In aviation, the extension of the utilization of GNSS that today is only a complementary system for air navigation and air traffic management systems has become the priority of many national plans. By 2030 it is expected that GNSS will be the main navigation system for most of the flight phases. GNSS is nowadays also as an essential component for other aviation systems, such as the Enhanced Ground Proximity Warning System (EGPWS) and Ground Based Augmentation System (GBAS). Navigation systems provide several advantages in aviation such as the increased safety and efficiency of flights. It is expected that GNSS based air routes will be able to accommodate up to three times the current traffic volume, [1]. Moreover, at remote locations, where traditional ground-based services are unavailable, airports approaches based on GNSS could be implemented providing increased operational and safety benefits.

Complementary to GNSS, Satellite Based Augmentation Systems (SBAS), that are scaled on aviation requirements, have been introduced to allow planes landing even during poor visibility conditions. Navigation signals performance and integrity monitoring is a consolidated functionality in the aviation domain, however, only few systems dedicated to spoofing monitoring have been designed and deployed. In the domain of critical infrastructure, several concepts and system architectures for interference and jamming monitoring have been designed and deployed, see for example [2]. However, only few solutions are known for the monitoring of spoofing threats. For example the GAIMS testbed has been prototyped with main objective to show importance to monitor the radio-frequency spectrum and to detect interferers increasing reliability and availability of GNSS and SBAS/SMGCS at airfields. Another solution, described in [3], presents a multi- layered and multi-receiver architecture that hardens GNSS-based timing against hazards with multiple spoofing monitoring technologies with effectiveness depending on the attack model. The main objective of the GMCA project is to extend the GNSS Performance Monitoring System (GPMS), developed by DW International, to include Galileo Monitoring. Moreover, the system has been updated to include the capability of interference and spoofing monitoring. Spoofing detection has been implemented using Qascom SMART sensor.

Overview of interference scenarios and contermeasures

GNSS monitoring is essential for increasing the availability and integrity of aviation applications. As well-known navigation systems have several vulnerabilities. Vulnerabilities are commonly classified as unintentional and intentional interferences such as jamming and spoofing. .According to [4], dated 2003, successful spoofing and meaconing attacks are considered remote because of the complexity of the technology required. However,

it has to be noted that, nowadays, the likelihood of occurrence of spoofing threats is increasing as the implementation of spoofers has become more feasible and less costly due to rapid advances in software-defined radio technology. In addition, the likelihood of success might increment with the level of sophistication of attacks.

As written in [RD5], the GIISST (GNSS Intentional Interference and Spoofing Study Team) has identified eight scenarios (collected in November 2012 DHS GPS National Risk Estimate). These are four Interference Scenarios and four Spoofing Scenarios (three intentional and one unintentional spoofing)

Details of the definition of the FAA scenarios are not publically available; however a high level classification is available in [RD7]:

- **Pinpoint Spoofing Attack:** already partially demonstrated (research, test for hovering UAV with non-aviation grade equipment and pre- determined knowledge of vehicle position/time)
- **Coordinated Spoofing Attack:** no known event for civil, approved, aviation applications
- **Coordinated Interference and Spoofing Attack:** no known event for civil, approved, aviation applications
- **Unintentional Re-radiator:** this is caused by malfunctioning or improper use of GPS re- radiators or pseudolites typically installed in the airports. This impact mainly the taxiing and take- off flight phases.

Spoofing and meaconing threats could be critical in terms of aircraft system impacts, as they might lead to the avionic receivers issuing hazardously misleading information (HMI). Indeed, potential erroneous position might be output to primary flight displays/indicators and other aircraft and ATC systems. Moreover, conventional RAIM is only partially effective against GPS spoofing. FAA scenarios have been considered as reference also in the project. However, for the prototyping activities two main spoofing scenarios have been analyzed:

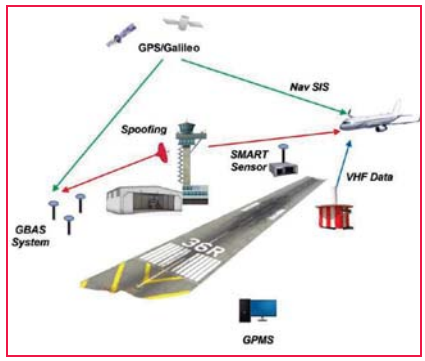

Figure 1: Intentional Spoofing Scenario

- Intentional Spoofing during Approach
- Non Intentional Spoofing during Taxi-In or Take-Off

Intentional Spoofing during Approach

Depending on speed of the aircraft, availability of weather information, and the complexity of the approach procedure or special terrain avoidance procedures for the airport of intended landing, the in-flight planning phase of an instrument approach can begin as far as 100-200 nautical miles (NM) - from the destination, [6]. An instrument approach may be divided into four approach segments: initial, intermediate, final, and missed approach.

The ILS system is, nowadays, the primary system for instrumental approach for category I-III-A conditions of operation and it provides the horizontal as well as vertical guidance necessary for an accurate landing approach in IFR (Instrument Flight Rules) conditions, thus in conditions of limited or reduced visibility. The major risk for aircraft navigation (most likely during bad visibility conditions) is at the beginning of the approach phase. Assuming the SMART is located and operated in the airport area, this will be capable to detect spoofing events whenever the spoofing signals, which are targeting the airplane, reaches also the sensor antenna.

This scenario, drives the spoofing detection algorithms configurations as:

- Spoofing Doppler could have an offset of several KHz from the authentic.
- Spoofing delay might have an offset up hundreds of chips from the authentic
- Spoofing power offset depends on the relative distance between the aircraft under attack and the sensor

Non Intentional Spoofing during Taxi-in or Take Off

Certain non-aeronautical systems transmit radio signals intended to supplement GNSS coverage in areas where GNSS signals cannot be readily received (e.g. inside buildings). These systems include GNSS repeaters and pseudolites. GNSS repeaters (also known as "re-radiators") are systems that amplify existing GNSS signals and re-radiate them in real-time. A case of interference has occurred in Germany, in 2012, due to a malfunctioning of a GPS repeater operated in a hangar of Hannover. airport The interference caused alerts of the Enhanced Ground Proximity Warning System providing the messages "pull-up" and "FMS/GPS Position disagree" during Taxi-in and departure of the airplanes. With an EIRP of the GPS repeater in the order of -60 dBm (to be confirmed) the interference range was several hundred meters. The operation of the GPS-repeater has been suspended until the end of the investigation. It has to be verified whether the EIRP limit of -77 dBm as stipulated in the draft ECC recommendation ECC/REC/(10)02 would have ensured sufficient protection. Several other events have been recorded in the US.

At the sensor position the reception of the unintentional spoofing signals depends on the malfunctioning of the repeater and generating GNSS signal with higher power (e.g. 20 dB to 30 dB). From the signal point of view, non- intentional spoofing is equivalent to meaconing.

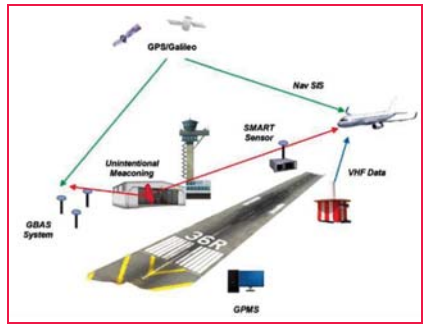

Figure 2: Non Intentional Spoofing Scenario

Spoofing Contermeasures

As written in [7], FAA will require that future aircraft equipment to cease GNSS use when intolerable interference or spoofing is detected. Several countermeasures against intentional interference can be addressed, [4]; these could be operational mitigations that require the integration with other airborne systems (e.g. GPWS, TCAS, etc...) and methods at receiver. Even low- complexity techniques could reduce the vulnerability to spoofing. Examples are: AGC/SNR valid range, PVT checks, additional channels to detect presence of duplicate PRNs, navigation data simple checks or antenna technologies can reduce vulnerability to spoofing and interference. At system level also the introduction in GNSS and SBAS on navigation message authentication will provide benefits for aviation.

Spoofing monitoring sensor description

Figure 3 shows the high level architecture of the sensor.

The sensor is composed by:

- an Antenna for the collection of GNSS signal in space, spoofing signals and interference in the E1 band. The antenna signal is input to the RF Digitizer and the GNSS Receiver.
- a High End RF Digitizer: the board is capable of sampling RF signals with a high resolution ADC. This module receives commands coming from embedded PC and it sends IQ samples to the same device using an USB3 link.
- a GNSS Receiver: the receiver that processes the GNSS signals, generating raw data and PVT that are sent to the embedded PC via USB.
- an Embedded PC that runs the main SW modules including:
  - SDR based spoofing detection techniques
  - PVT and observables spoofing detection
  - IQ data batches collection
  - communication with the external central processor

The sensor is designed to acquire batches of samples configurable length (i.e. 50ms), in E1/L1 band, at a configurable rate (i.e. 1 Hz). Monitoring of GNSS signals is achieved in real-time. Any detection of spoofing signals raises an alert that is forwarded to the central server. At the same time, the sensor collects the observables and PVT data from the GNSS receiver and uses also these data to monitor the presence of spoofing signals. The sensor software has a high level of configurability. Moreover the application is hardware independent except for the interface with external devices (GNSS Receiver, Front End). The communication with the GPMS system is managed by the Server Interface that exchanges with the GPMS main controller the following XML messages via HTTP:

- Output Configuration containing Sensor Position, General settings, Front End settings and Spoofing Detection techniques settings
- Sensor Status containing the status of the sensor that is regularly sent
- Spoofing Data that collects the spoofing detection flags and metrics for all the Satellites in view, generated at the rate of 1 Hz.
- Input Configuration that is the configuration message of the sensor that can be written by the GPMS controller to configure sensor settings and enable/disable the spoofing detection techniques.

Figure 4 shows a prototype of SMART sensor. The software runs in the laptop that is connected with the Front End and the GNSS Receiver.

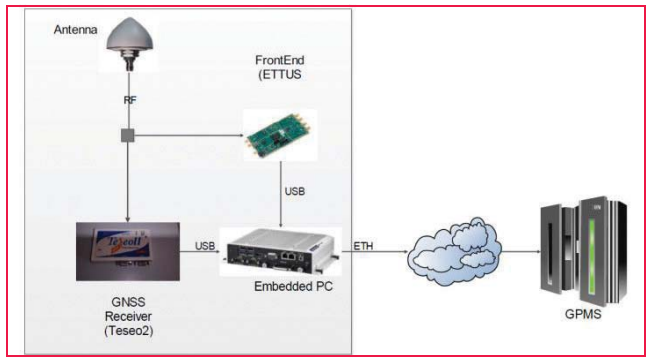

Figure 3: SMART Sensor Architecture

Figure 4: SMART Sensor (Qascom Permises)

Spoofing detection techniques

The spoofing detection engine has been designed according to the following requirements:

- Capability to Monitor Spoofing with:
  - Power Offset: between -3 dB and +15 dB. Lower bound is related to receiver acquisition sensitivity, upper bound is a limit over which the spoofing signal can be considered as an interferer.
  - Frequency Offset: related to the maximum relative velocity between the sensor and a plane during the approach phase.
  - Delay Offset linked to common distance from the airport of the approach phase beginning.
- Spoofing Detection probability 95% and False Alarm lower than 10^{-4}
- Time to Alarm lower than 5 seconds.

The spoofing detection engine is the core element of the SW. This includes five different methods operating at IQ level, observables levels and PVT level.

IQ Level Spoofing Detection

At IQ level, two spoofing detection techniques have been integrated. These use as input the batches of samples collected

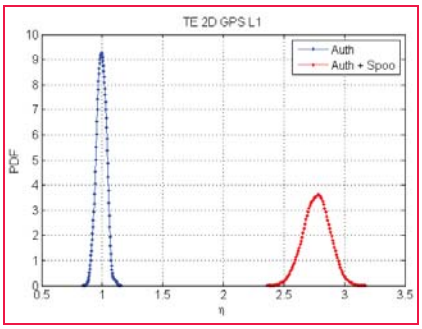

Figure 5: Probability Density Function of the Normalized Total Energy detector with and without Spoofing (GPS L1CA)

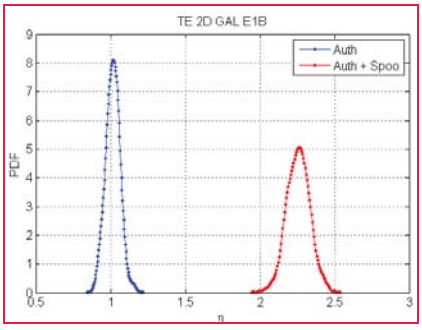

Figure 6: Probability Density Function of the Normalized Total Energy detector with and without Spoofing (GAL E1B)

with the RF digitizer. The first approach is the *Multi-Peak detector*: in presence of spoofing, the Acquisition Cross Ambiguity Function (CAF) has two peaks. The first step of the detection algorithm is the estimation of Doppler and code phase of the CAF bin that has the maximum magnitude, above the acquisition threshold. Then the peak (that could be the authentic or the spoofing one) is cancelled out from CAF and the algorithm proceeds with the estimation of the second highest peak. In case a secondary peak is detected, spoofing is declared. The second method is the *Total Energy* detector. The algorithm is based on the computation of the sum of the correlation values power. To detect the presence of spoofing this value is compared with the total estimated power in nominal conditions. Figure 4 and Figure 5 show the probability density function (PDF) of the normalized total energy indicator under hypothesis H0 (no spoofing) and H1 (presence of spoofing) for GPS L1 and Galileo E1B. An optimized procedure to monitor all satellites in view or non in view (the spoofer can generate satellites

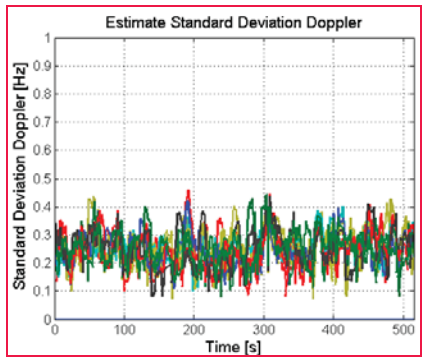

Figure 7: Doppler Standar Deviation without spoofing

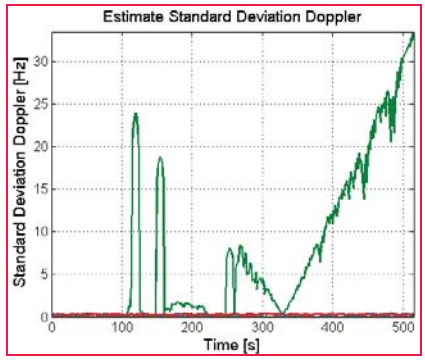

Figure 8: Doppler Standard Deviation with spoofing in one PRN

that are not visible to the sensor) has been integrated. The satellites are divided in two groups (in line of sight and non-line of sight) and the monitoring is done with different periods on the two groups.

Observable Level and PVT Level Spoofing Detection

Two observable level and one PVT level spoofing detection methods have been introduced in the SMART sensor SW. These solutions use as input C/N0, Doppler and the PVT generated by the GNSS receiver.

The *Power Threshold Detector* is based on monitoring the change of a satellite's signal power. The method estimates the moving variance of the observed signal C/N0 that is a metric that is sensitive to the transition between the legitimate and a spoofing signals.

The second method is a *Doppler Threshold Detector* that as for the Power threshold detector, is based on the computation of the moving variance of the Doppler. Doppler offsets can indicate the beginning of a spoofing attack, when an adversary is trying to make the GNSS receiver lock onto the false signal.

The third method is the *PVT detector*. This method is based on the check between the estimated Position and the reference Position of the sensor that is known a priori.

A weighted majority voting approach has been proposed to generate a unique detection flag using all the spoofing detection methods' outcomes. Moreover, to maximize the spoofing detection the application of Weighted Majority Voting is of benefit also in improving spoofing detection probability between different tracking channels. The baseline assumption is that if one satellite is spoofed it is highly probable that also others are spoofed.

Table 2 reports a mapping between the expected effectiveness of spoofing detection techniques and the spoofing scenarios identified.

The main findings, during preliminary simulation assessment, are that Multi-peak approach is particularly effective in case of Intentional attack in the approach phase because the Doppler and Code Phase separation between

Table 1: Mapping between spoofing detection techniques and scenarios

Detection Method	Spoofing Scenario	
	Intentional Spoofing during Approach	Unintentional Spoofing during Taxi-in or Take Off
Multipeak	Effective	Complementary
Total Energy	Complementary	Effective
Doppler Variance	Complementary	Complementary
CN0 Variance	Complementary	Complementary
PVT Check	Ineffective	Effective

authentic and spoofing signals is high. The Total Energy approach is considered complementary as this detector computes the energy near the acquisition matrix peak which is particularly effective for non-intentional spoofing. The PVT Check is considered ineffective for intentional spoofing as it is unlikely that the GNSS receiver channels lock on spoofing signals. Power and Doppler methods are considered only complementary as they are capable of revealing spoofing only during the transition between authentic to false signals in the tracking channels.

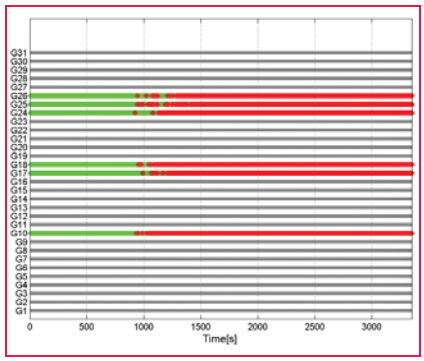

Figure 9: Spoofing Detection for Galileo Constellation during Intentional Spoofing Scenario (green: no detected spoofer, red: detected spoofer)

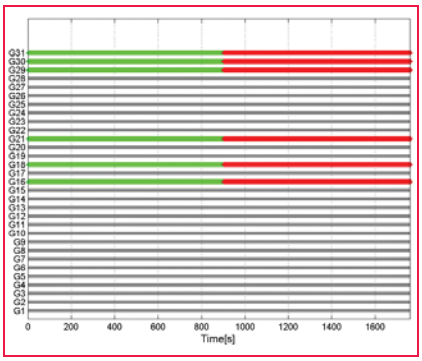

Figure 11: Spoofing Detection for the GPS Constellation during Intentional Spoofing Scenario (green: no detected spoofer, red: detected spoofer)

Simulation and test results

The SMART sensor is being validated using radio navigation laboratory equipment. In particular a Spirent Constellation simulator GSS6700 in connection with the SimSAFE software tool (developed by Qascom and distributed by Spirent) has been used to test spoofing scenarios. SimSAFE represents an innovative approach to the simulation of attacks, the test of detection techniques and signal authentication schemes, permitting maximum flexibility and the opportunity to leverage existing Spirent RFCS equipment. SimSAFE controls Radio Frequency Constellation Simulator (RFCS) hardware in order to emulate signal simulation attacks and test receiver mitigation techniques. SimSAFE allows flexibility in the attack scenario definition and test of interference detection techniques. The following two scenarios have been simulated to emulate the Intentional and Unintentional spoofing scenarios. Spoofing is generated on six channels for each constellation (GPS and Galileo) with the objective of demonstrating the detection capability of the implemented spoofing detection methods. Table 3 reports the main parameters of the Intentional Spoofing Scenario.

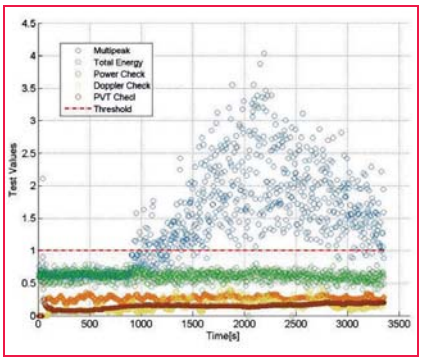

Figure 10: Galileo PRN 10 Algorithms Test Values during Intentional Spoofing Scenario (detection is declared when the test value is above 1)

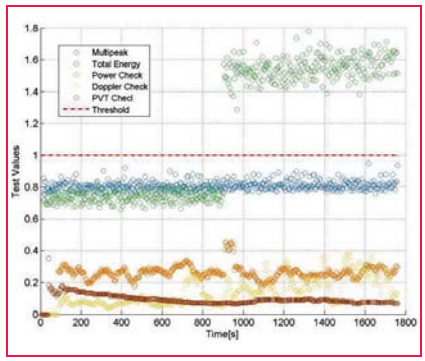

Figure 12: GPS PRN 36 Algorithms Test Values during Unintentional Spoofing Scenario (detection is declared when the test value is above 1)

Table 2: Intentional spoofing scenario configuration

Spoofing Scenarios	Intentional during Approach
Constellations	GPS/Galileo
Code Offset	1800 meters
Doppler Offset	0 Hz
Initial Power Offest	-6 dB
Power Rate Offest	0.4 dB/minute

Table 3: Unintentional spoofing scenario configuration

Spoofing Scenarios	Unintentional during Takeoff
Constellations	GPS/Galileo
Code Offset	150 meters
Doppler Offset	0 Hz
Constant Power Offest	2 dB
Attack Time	15 mintues
Constellations	GPS/Galileo

Figure 8 shows the global detection flags using the weighed majority voting between all spoofing detection algorithms for Galileo visible satellites. The plot lines are green when spoofing is not detected whereas the line is red when spoofing is detected. Figure 9 shows the output test values for the five spoofing detection methods implemented in the SMART sensor. It is resulted that only the Multi peak algorithm detects the spoofer, as expected, with a spoofing detection probability higher than 95%.

Table 4 reports the main parameters of the Unintentional Spoofing Scenario.

Figure 10 shows the global detection flags using the weighed majority voting between all spoofing detection algorithms for GPS visible satellites. The plot lines are green when spoofing is not detected whereas the line is red when spoofing is detected. Figure 11 shows the output test values for the five spoofing detection methods implemented in the SMART sensor. It this scenario, the Total Energy algorithm detects the spoofer as expected, with a probability of spoofing detection higher than 95%.

The experimental results confirm that the Multi peak solution is adequate for intentional scenarios whereas the Total Energy solution is more effective in unintentional cases.

Conclusions

This paper describes the innovative SMART (Spoofing Monitoring And ReporTing) sensor, designed and engineered by Qascom for critical applications, with primary focus on airport infrastructures. The sensor embeds effective spoofing detection mechanisms at IQ, observable and PVT level. The signal processing is optimized to ensure adequate missed detection probabilities and very low Time to Alarm as per the ICAO standards. Qualification test results in representative test scenarios have been shown. Several evolutions have been envisaged for the proposed technology such as multi- frequency capability in particular for GPS/SBAS L5 and Galileo E5a and the introduction of the spoofing direction of arrival capability based on a dual antenna configuration.

Acknowledgment

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Smart geoinformation shaping the future

INTERGEO 2016, 11-13 October, Hamberg, Germany

The world is getting smart. At the heart of these tumultuous changes to our lives, economy and work lies digitalisation. And at the core of this transformation, it's intelligently networked and applied coordinates that often create the added value. The geo IT sector gains from this.

Its players create and supply smart geoinformation and services and position themselves firmly at the interface with industry and administration. Their growing influence is clearly apparent at INTERGEO, the leading international trade fair for geodesy, geoinformation and land management. After notching up 531 exhibitors from 37 countries, more than 17,000 visitors from over 100 countries and an international INTERGEO conference attended by 1,300 delegates, INTERGEO has now drawn to a close on this Thursday. The sector's dynamic momentum was keenly evident in packed exhibitions halls and conference rooms, the young, international audience and three days full of information and discussion. "INTERGEO is where the geo IT sector meets its users. INTERGEO is cross-industry dialogue at its very best. It focuses on the resource of the future – smart geoinformation," says Prof. Hansjörg Kutterer, the newly elected President of INTERGEO's host organisation, the DVW.

Trade fair exhibitors from all over the world have been showcasing their product innovations and intelligent solutions and services at INTERGEO – covering the entire process chain from data collection and analysis through to presenting and displaying results. INTERGEO was the highlight event of the year for manufacturers and service providers of GNSS surveying, mobile mapping, laser scanning and surveying, and inspection and monitoring with drones/UAS. Dr.-Ing. Christoph Fröhlich from Zoller+Fröhlich speaks for the majority of exhibitors with his verdict that: "INTERGEO is the world's absolute top event for our customers. They fly in from all over the world in order to meet us and check out the latest developments in the sector."

Smart cities a key topic

At the heart of the exhibition themes and conference program stood cities as our habitat and working and economic environment. Keynote speaker Nigel Clifford, Chief Executive of British Ordnance Survey, used the case study of Manchester to show how geoinformation in the Internet of Things (IoT) will shape our urban surroundings. Ron Bisio, Vice President Geospatial at Trimble, crafted smart cities scenarios in his own keynote speech. Environmental pollution, energy consumption, effective transportation and traffic processes, civic dialogue and transparency, digital transformation in the health sector and culture – there is no sphere of life that will remain cordoned off from digitalisation. The seeds for our digital future are being sown right here and now.

The setting for the Smart City headline could not have been better. Hamburg's strategy for digital development as a smart city paves the way forward. Its digital strategy is firmly anchored in the highest political ranks. This was confirmed by the attendance of Hamburg's Senator Dr. Dorothee Stapelfeldt at INTERGEO, where she scrutinised the wealth of smart city providers. This year also heralded the first dedicated Smart City SOLUTIONS platform.

Building Informantion Modelling

The topic of Building Information Modelling (BIM) is also gaining considerable ground. BIM transfers the processes involved in planning, constructing and operating structures and infrastructure into the digital world. The same clear message rings out – BIM enjoys solid political support and is only a matter of time. The German Federal Ministry of Transport and Digital Infrastructure (BMVI) has set the schedule for introducing BIM as the standard method for infrastructure projects with its multi-tiered Digital Planning and Building plan. Industry and sector associations are pressing for rapid changes. Speakers from the planen-bauen 4.0 platform, the BMVI and the international Smart Building association along with industry representatives intensively debated developments towards transparent and internationally competitive construction processes in panel discussions and conference sessions during INTERGEO.

Galileo update

Galileo satellites begin their launcher hardware integration

The launch campaign for Arianespace's upcoming Ariane 5 flight from French Guiana has entered its latest phase of preparations, with the mission's four Galileo satellite passengers being installed on their multi-payload dispenser system.

Two of the four Galileo satellites are shown after their installation on the multi-passenger dispenser system, with a third being positioned for its integration.

This activity – performed in the Spaceport's S3B clean room – clears the way for the satellites' integration as a single unit atop the heavy-lift Ariane 5, which was transferred earlier this week from the Launcher Integration Building to the Final Assembly Building, where payload integration is set to occur.

Designated Flight VA233, the upcoming mission will mark Arianespace's first use of Ariane 5 to loft spacecraft for Galileo, following seven previous missions with the medium-lift Soyuz – which carried a pair of satellites on each liftoff. Flight VA233 is scheduled as the company's ninth launch overall performed so far in 2016, as well as the sixth this year using the heavy-lift workhorse. Arianespace's full launcher family is rounded out by the light-lift Vega. *http://www.arianespace.com*

Galileo could suffer from payment dispute

The Russian space agency, Roscosmos have given written warning to the French government that it would take France to court in six months unless France's Arianespace launch-service company frees up about 300 million euros ($330 million) in long-overdue payments.

In what appears to be an attempt to force France's European neighbors to apply pressure to Paris, Roscosmos hinted that multiple cooperative space efforts between Russian and the European Union, and with the European Space Agency (ESA), could suffer if the payments are not freed.

The payments, which are not disputed by Arianespace, have been one of the collateral effects of the battle by former shareholders of Russia's Yukos oil company. In 2014, these shareholders won an initial award of $50 billion from an international arbitration panel in The Hague, Netherlands, against the Russian government for dismantling the company. Since then, the shareholders have been trying to collect Russian government assets wherever they find a sympathetic legal environment outside Russia, including France and Belgium. In France, different shareholder representatives sought seizure of the Eutelsat and Arianespace payments.

The same dispute has blocked payments to other Russian companies.

In a letter sent to the office of French Prime Minister Manuel Valls, Roscosmos Deputy Director-General Sergey Savelyev said Russia's work with all European governments could suffer. *http://spacenews.com/*

Geospatial 4.0

The concept of Geospatial 4.0, which has emerged in tandem with Industry 4.0, has really pushed to the fore. This year's INTERGEO showed not only that smart geoinformation and services have proved to be motors of innovation in the economy and administration, but also that more and more industries are basing their business models on the intelligent use of geoinformation. Correct and sustainable decisions depend on impeccably prepared information. The DVW's President Kutterer emphasises that standardisation, licensing and pricing issues now need resolving in order to promote geoinformation as a lynchpin in business and administration. Dr. Jürgen Dold, CEO of Leica Geosystems, is clear that the online environment is steadily becoming reality. With regard to the big data debate, he says: "Whatever the volume of data, the key lies in using it smartly."

UAV sector

The UAV sector is looking exceptionally dynamic. INTERAERIAL SOLUTIONS, which was introduced as a free-standing platform at this year's INTERGEO, brought together over 130 exhibitors – from start-ups to global corporations – with their customers. Kay Wackwitz from market researchers Droneii.com deems INTERGEO the ideal platform for the fledgling UAV sector: "The market is absolutely exploding. More and more start-ups are jostling to find their own niche. INTERAERIAL SOLUTIONS covers the sector's entire spectrum. And INTERGEO is the perfect medium for these companies to show off their skills – with the key applications still lying in surveying, inspection and monitoring of infrastructures and structures." Fields of application and upcoming trends were examined in forum presentations and panel discussions.

Brings together employees and job seekers

The new GEOCAREER.COM careers service has joined forces with "jobware.de", the specialist national career platform for experts and managers in IT and technology, to bring together employers in search of specialist staff with experienced experts in the sector.

Russia makes BIM compulsory

The use of BIM is likely to become compulsory on all construction projects commissioned by the Russian government from 2019.

An announcement made by Mikhail Menn, head of the construction, housing and utilities ministry, during the ProEstate Forum for international property companies in Moscow, was reported in a Russian construction magazine.

Menn was reported as saying that the Russian government had been influenced by the "interesting" British experience in the field of BIM technologies implementation. He claimed that the UK government's use of BIM was directly responsible for a 30% reduction in construction cost: "Their experience showed that we, in Russia, are heading in a 100% right direction."

Governments around the world have urged the use of BIM to get more value for money from their capital investment projects. *www.bimplus.co.uk*

Imagem and Dutch Kadaster to implement Hexagon solutions

Imagem and Dutch Kadaster have signed a strategic framework agreement to deploy and develop Hexagon Geospatial solutions within Kadaster. The high grade knowledge available within Kadaster in the fields of cadastral and topographic processes allows Imagem and Hexagon Geospatial to focus further development of geospatial technology in GIS, Remote Sensing, Photogrammetry, and Geospatial Data Management domains.

The contract includes M.App Portfolio that is used to create Hexagon Smart M.Apps. Next to making end-user products available, Kadaster will also have access to all knowledge on Hexagon Geospatial technology, both through the team at Imagem as well as Hexagon worldwide. The cooperation offers the partners the possibility to work closely together to create solutions in a broad range of working processes inside Kadaster. *www.imagem.nl*

Ian Masser to receive GSDI Global Citizen Award

Emeritus Professor Ian Masser is to receive the Global Spatial Data Infrastructure (GSDI) Global Citizen Award during the 15th GSDI World Conference in Taipei, Taiwan on December 2nd 2016. "This is the greatest moment in my life," Masser said, "I couldn't believe my ears when I heard the news."

Masser's acceptance speech, which will be entitled 'Looking back on SDI developments with an eye to the future. The GSDI Association occasionally recognizes globally an individual who has provided exemplary thought leadership and substantive worldwide contributions in promoting informed and responsible use of geographic information and geospatial technologies for the benefit of society and fostering spatial data infrastructure developments that support sustainable social, economic, and environmental systems integrated from local to global scales. *http://gsdi15.org.tw*

Caliper support for the EPA Smart City Air Challenge

Caliper is excited to be supporting the United States Environmental Protection Agency (EPA) Smart City Air Challenge.

Caliper is supporting the challenge through an in-kind match that will provide Caliper geospatial technology to local governments who will incorporate Caliper software into their EPA grant proposal. The Caliper grant, valued at $33,000, will be awarded to the two winning local government agencies. It is Caliper's goal to provide the geospatial technology that supports the objectives of the EPA's challenge.

Bentleys CivilStorm and StormCAD

Bentley Systems announces the availability of the new CivilStorm and StormCAD CONNECT Edition applications for the analysis and design of stormwater networks. The CONNECT Edition provides a unified, common environment that advances productivity, team collaboration, and project performance.

From land development to highway drainage to city-wide analysis and optimized best management practices and designs, CivilStorm and StormCAD provide an easy-to-use environment for engineers to analyze, design, and operate stormwater conveyance systems, using built-in hydraulic and hydrology tools, and a variety of wet-weather analysis methods.

Bentley Systems has also announced the availability of the new SewerGEMS and SewerCAD CONNECT Edition applications for the analysis and design of sewer networks.

Get information on Tata Power portal through GIS

Tata Power has made important information available such as scheduled power outage information, location of customer relation centres and bill collection centres on the Tata Power customer web portal- cp.tatapower.com through a GIS enabled map.

The proactive real time monitoring and analysis of power failure complaints by Tata Power call centre will ensure speedy restoration of power and enhances customer satisfaction. *http://timesofindia.indiatimes.com*

GSI launches online system to manage, share geo-data

The Geological Survey of India has launched the Online Core Business Integrated System (OCBIS) to efficiently manage and share quality geo-scientific data through digital channels for socio-economic and scientific gain.

GSI maps, reports, data will be put in public domain so that the information is utilised by all stakeholders. It will help industry users by providing latest data through the web portal and ensure transparency and efficiency. Responsive across mobile platforms, the portal will also let users tour virtual repositories of resources like 2D and 3D photos of rocks, fossils and meteorites and features natural geological sites for the interest of tourists. *http://odishatv.in*

The GSA unveils the 1st GNSS User Technology report

The European GNSS Agency (GSA) unveils its first GNSS User Technology Report - designed to help users understand today's receiver technology and the trends transforming the GNSS landscape. Written with contributions from leading GNSS receiver and chipset manufacturers, the GSA GNSS User Technology Report is as a valuable tool to support planning and decision-making in developing, purchasing and using GNSS user technology.

GNSS technology has advanced quickly – both on the side of global constellations and user receivers. With this development, EGNOS and Galileo are becoming standard features of GNSS receivers, providing enhanced performance to users across the globe. Even with the increased deployment of other positioning technologies, thanks to its widespread and cost-effective source of location information, GNSS will remain at the core of all positioning technology.

GPS is failing users in Moscow

What is happening to mobile apps that rely on GPS in Central Moscow? Apps ranging from Pokemon Go to Uber are not working near the Kremlin. Instead, apps that rely on GPS coordinates to work correctly are either shutting down, or showing users to be 18 miles away at Moscow's Vnukovo airport. Those near the Kremlin trying to grab a ride via Uber cannot give the ride-sharing service their correct location. Pokemon Go players are having trouble in that area finding and catching Pokemon. The GPS issues started taking place in June, and seem to come and go in a pattern. Grigory Bakunov, a programmer with Russian internet firm Yandex, believes that the Russian government is playing around with the GPS near the Kremlin to prevent drones from flying over the area. He comes to this conclusion based on the GPS diversion to Vnukovo airport.

Dmitry Peskov, a spokesman for Russian President Vladimir Putin, said that he recently experienced the GPS issue himself while driving past the Kremlin. He says that he does not know the reason for the GPS malfunction. *http://www.phonearena.com*

NASA and ESA to Test GPS/Galileo receivers on board the ISS

The National Aeronautics and Space Administration (NASA), the European Space Agency (ESA) and Qascom, an Italian company specializing in Galileo, are collaborating to build the first GPS and Galileo receiver to be tested on board the International Space Station (ISS) Space Communications and Navigation (SCaN) Testbed. SCaN is a payload developed by NASA that has been hosted on board the ISS on an external truss since late 2012. It has the objective of testing navigation and communication experimentations with a Software Defined Radio (SDR) approach, which permits software, only updates for testing new experimental configurations.

In May 2016, Qascom was awarded with the "GPS and Galileo Receiver for the ISS" (GARISS) activity in support of collaborative experimentation with ESA and NASA, which has the objective of developing and validating the acquisition and processing of combined GPS and Galileo signals on board the ISS SCaN Testbed. This is also the first attempt to develop software for the ISS SCaN as part of an international collaboration between the United States and Europe, according to Qascom. To date, the team has successfully acquired and processed GPS and Galileo signals on dual-frequency bands. Initial operations will use a single-frequency processing methodology, although the final mission will target dual-frequency GPS and Galileo operations.

Cars in Russia could be required to have black boxes

A proposal has been put forward in the Russian government on installing black boxes in vehicles that would be connected to the Glonass navigation system. The ERA-GLONASS system would provide basic infrastructure for the proposed project. ERA-GLONASS must be mandatory installed in all cars starting from 2020. Glonass JSC is the operator of the ERA-GLONASS system, providing data to emergency responders via Russia's GNSS. It is designed to reduce emergency service arrival times by quickly pin-pointing incident sites. The system calls an emergency service number automatically if the on-board transponder signals an accident. *https://sputniknews.com*

New navigation system for cars launched in Abu Dhabi

A new car navigation system was launched in the capital to provide real-time updates about traffic, parking spots, routes and road conditions to motorists in the emirate of Abu Dhabi. Fact Box description starts here Fact Box description ends here. The system, which has been developed by Abu Dhabi's transport sector regulator, the Department of Municipal Affairs and Transport (DMAT), will be made available to car dealers to be installed in vehicles sold in Abu Dhabi. Fact Box description starts here Fact Box description ends here

In the first year itself, the DMAT hopes to have 50,000 vehicles that install and use its navigation system, the official added. Fact Box description starts here Fact Box description ends here. *http://gulfnews.com*

ASTE readying military planes for using Isro's SatNav

The Aircraft and Systems Testing Establishment (ASTE) is in the process of integrating 'systems' into military aircraft that will use the Indian Space Research Organisation's (Isro) Indian Regional Navigation Satellite System (IRNSS). Speaking at a press conference to announce the 84th anniversary celebrations of the Indian Air Force on Tuesday, Air Vice Marshal and Commandant, ASTE, Sandeep Singh, said: "A navigation system like the IRNSS is a necessity for both the civilian and military use. All the three services and particularly the Air Force are in the process of integrating this in the aircraft."

Further, he said that the high accuracy IRNSS will be a navigation system, which the country will use. With the use of the IRNSS, India will no longer have to rely on global positioning satellite system of the US. *www.deccanherald.com/*

HYPACK chose the Ellipse-D inertial navigation system

HYPACK chose the Ellipse-D inertial navigation system to equip their new UAV-based surveying solution: the NEXUS 800, which is an out of the box turnkey system that tightly integrates hardware and software to provide an advanced and seamless solution for LiDAR survey planning, data acquisition, post processing and analysis, and product creation. Powered by HYPACK, it is a full end-to-end solution that represents a new paradigm in Unmanned Aerial Vehicle (UAV) data collection by seamlessly harmonizing LiDAR data with photogrammetry. *www.hypack.com*

senseFly unveils new RTK/PPK-ready

senseFly has introduced its next-generation fixed-wing system for survey-grade photogrammetric mapping recently. It features three component parts, each developed with photogrammetric mapping in mind. A breakthrough innovation of the eBee Plus is High Precision on Demand (HPoD). This describes the drone's built-in upgrade path to real-time and post-processing correction (RTK/PPK) functionality.

Rwanda launches world's first national drone delivery service

Rwandan President Paul Kagame launched the world's first national drone delivery service during a ceremony in the country's centrally located Muhanga District. The Rwandan government will begin using drones to make up to 150 on-demand, emergency deliveries per day of life-saving blood to 21 transfusing facilities located in the western half of the country.

The drones and delivery service are built and operated by Zipline, a California-based robotics company. While Rwanda's drone delivery service will initially focus on blood, an international partnership between UPS, Gavi, the Vaccine Alliance, and Zipline will help the country quickly expand the types of medicines and lifesaving vaccines that can be delivered. *www.pressroom.ups.com*

Chinese researchers develop solar-powered UAVs

Chinese aviation researchers are developing solar-powered drones that would be capable of staying airborne for at least a month, a senior designer informed.

Shi Wen, head of unmanned aircraft development at the China Academy of Aerospace Aerodynamics, said in an exclusive interview that his team has developed prototypes to demonstrate new technologies and equipment.

Recently, his team conducted the maiden flight of a giant solar-powered drone at an airport in northwestern China. Shi said the 14-meter-long drone has a 45-meter wing span, longer than a Boeing 737, and can carry a payload of 20 kilograms. He said mass-produced models will eventually be able to fly for one to six months, and added: "We plan to make one that can stay in the air for five years. Our next-generation drones will have a 60- to 70-meter wing span and will be able to carry a payload of at least 50 kg."

Sweden bans flying camera drones in public places

In a huge blow to the aerial photography and camera drone industry in Sweden, the country's highest court has ruled that it is illegal to fly camera drones in public places because they qualify as surveillance cameras. The Supreme Administrative Court of Sweden ruled yesterday that cameras mounted on drones require a permit under camera surveillance laws. At the same time, the justices decided that dash cams or cameras mounted on bicycle handlebars are not surveillance cameras (because they're operated in the owner's immediate vicinity) so they won't require a permit.

If you wish to use a camera drone in a public place now, you'll need to pay a hefty fee to apply for a permit. County administrators will then decide whether your use of the "surveillance camera" provides a legitimate benefit that outweighs public privacy. If not, your request to fly will be shot down. *http://petapixel.com*

Trimble sells its UAS business to Delair

Trimble has announced that Delair-Tech has acquired its Belgium-based Gatewing Unmanned Aircraft System (UAS) engineering and manufacturing business. Delair-Tech is a leading provider of long-range, fixed-wing UAS solutions for industrial inspection and asset management applications headquartered in Toulouse, France. Delair-Tech intends to grow the acquired business as part of its portfolio.

Gatewing has been reported as part of Trimble's Engineering and Construction segment. *www.delair-tech.com*

ESNC Winner 2016: One Step Ahead of the Civilian Drone Market

This year's European Satellite Navigation Competition, the world's leading innovation platform for forward-thinking applications in its field, centred on the topic of civilian drone use. On 25 October in Madrid, its 2016 edition culminated in an awards ceremony featuring prominent industry representatives and the winners of 32 categories, which included 11 drone applications. Rafael van Frieken, Madrid's regional minister of education, youth, and sport, presented the grand prize to the innovative security system GUAPO, which promises to take the use of drones to the next level. *www.satellite-masters-conference.eu*

OriginGPS elevates Drone Navigation

OriginGPS, one of the leading manufacturers of miniature GNSS modules, has launched three new products built on the flash-based SiRFstar V from Qualcomm Technologies, Inc. This latest trio of modules is now boasting key drone features like low-latency velocity and position outputs and 5 Hz position updates to their already industry leading Multi Hornet, Multi Micro Hornet and Multi Micro Spider. *www.origingps.com*

First Copernicus Accelerator Bootcamp

40 pioneering entrepreneurs, 31 mentors and representatives of the European Commission and the European Space Agency gathered in Madrid on 24 and 25 October 2016 for the initial bootcamp of the first Copernicus Accelerator. The new business coaching programme, funded by the European Commission, will accelerate the market entry of innovative space applications and products submitted to ESA's Earth observation competition Copernicus Masters with tailored expert support.

The Accelerator Bootcamp sets forth the official start of the 8 month-long coaching programme provided to the 40 best entrants of this year's Copernicus Masters competition. It was the first time mentees and mentors joined up in person, and had the opportunity to begin developing a coaching plan, including objectives and KPIs of their affiliation. *http://ec.europa.eu/growth/about-us/index_en.htm*

FARO releases the Vantage

FARO® has launched Vantage - a new addition to its Vantage Laser Tracker product line. It has well-proven features and capabilities such as high-speed dynamic measurement, and is affordably priced for customers who demand high performance while working with short-to-medium range applications. The Tracker is ideally suited for customers who do not require the extended measurement range that is provided by the premium Vantage solution but still demand the trusted and robust features the Vantage platform provides. *www.faro.com/*

Proteus Geo wins ESA backing to advance bathymetry data service

Proteus Geo has won the backing of the European Space Agency (ESA) to create a new bathymetry data service that leverages DigitalGlobe satellite imagery to allow everyone to explore the shallows around the world's coastlines. Over the last four years, Proteus Geo has worked in partnership with DHI to provide a vast range of customers with bathymetry data, derived from satellites. *www.proteusgeo.com*

NASA's next civilian land remote sensing satellite

Orbital ATK, Inc. has been awarded a contract by the National Aeronautics and Space Administration (NASA) to design and build Landsat 9, an advanced land surface mapping satellite to be operated by the United States Geological Survey (USGS). The Landsat 9 satellite will extend the Landsat program's record of global terrestrial imagery to half a century. Under the contract, Orbital ATK will design and manufacture the satellite, integrate the two government furnished instruments with the spacecraft and support launch, early orbit operations and on-orbit check-out of the observatory. Landsat 9 is scheduled for launch in December of 2020. *www.orbitalatk.com*

In a first, PSLV puts 8 satellites in two different orbits

In a first, Indian Space Research Organisation (ISRO)'s PSLV C-35 rocket launched a total of eight satellites, into two different orbits. The 371 kg SCATSAT-1, a satellite for weather-related studies, was placed in the polar sun synchronous orbit at an altitude of 730 km some 17 minutes after the rocket took off from Satish Dhawan Space Centre at Sriharikota.

About two hours later, the rocket placed two satellites from two educational institutions (PISAT and PRATHAM), three commercial payloads from Algeria (ALSAT-1B, 2B and 1N) and one each for Canada (NLS-19) and the United States (Pathfinder-1). Announcing the successful launch of all the satellites from the Mission Control Centre, ISRO chairman A.S. Kiran Kumar said the Monday launch marked a "landmark day" in the history of ISRO.

The 10 kg PRATHAM by IIT Bombay intends to estimate the total electron count with a resolution of 1km x 1km location grid and PISAT (5.25 kg) from PES University in Bengaluru intends to explore remote sensing applications. Algeria's ALSAT-1B is an earth observation satellite (103 kg), ALSAT-2B a remote sensing satellite (117 kg) and ALSAT-1N (7 kg) a technology demonstrator. Canada's NLS-19 is a technology demonstration micro satellite (8 kg) and Pathfinder-1 is a commercial high resolution imaging micro satellite (44 kg). *www.thehindu.com*

Russia, India agree on mutual placement of satellite stations

Russia and India agreed on mutual placement of Russia's Glonass satellite navigation system and Indian NavIC navigation system on the sidelines of the BRICS Goa summit, Russia's Roscosmos space corporation said in a statement. "Today, October 15, 2016, in Goa (India) a Memorandum of Understanding was signed between the state corporation Roscosmos and the Indian Space Research Organisation. Russia and India are planning a mutual placement of ground stations for gathering data GLONASS global navigation system and Indian satellite system NavIC," the company specified in a statement. Roscosmos stressed that the document had a strategic importance for the development of Russian-Indian cooperation and its implementation would increase accuracy in reporting data of Russian and Indian navigation systems. *https://sputniknews.com*

Satellite-based surveillance system to monitor illegal mining

In a path-breaking move, the mines ministry, India came out with mining surveillance system (MSS), a pan-India surveillance network using latest satellite technology, to check illegal mining. Launching the system, Mines Minister Piyush Goyal hoped the technology will ensure sustainable utilisation of the country's mineral resources. "MSS will trigger an alarm whenever there is an instance of illegal mining outside permitted areas. Karnataka, which saw large instances of illegal mining in the past, stands to gain tremendously from this technology," he added.

This technology will help design planned development of mining as also provide complete data of labourers working in the sector online, which will lead to better safety standards, the minister noted. MSS is a satellite-based monitoring system, which aims to check illegal mining activity through automatic remote-sensing detection technology. *http://indianexpress.com/*

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Rockwell Collins receives the first FACE™ Conformance Certificate

Rockwell Collins has announced that it has received the very first Future Airborne Capability Environment (FACE™) Conformance Certificate for its Required Navigation Performance (RNP) Area Navigation (RNAV) capable Mission Flight Management Software (MFMS). This certificate identifies the MFMS-1000 software product as conformant to the FACE Technical Standard Edition 2.1, the latest open architecture software standard for creating portable and reusable software.

According to The Open Group FACE Consortium, FACE Certification proves that a software component has successfully been through an independent verification and certification process defined by the FACE Conformance Program. This includes technical verification by a designated Verification Authority (VA) and subsequent certification by the FACE Certification Authority (CA). *www.rockwellcollins.com*

Seafloor Systems signs agreement with Teledyne Marine

Seafloor Systems has signed International Distributorship Agreement with Teledyne RESON and Teledyne BlueVew, business units of Teledyne Instruments, Inc. RESON manufactures the most advanced, industry leading SeaBat Multibeam Sonar systems. BlueView manufactures a variety of underwater surveying systems, including M900-2250 2D and 3D imaging sonars, and BV5000 3D Multibeam inspection sonars.

Arithmetica launches Pointfuse V2

Arithmetica has launched Pointfuse V2 - point cloud processing software. It represents a major change in the way that point cloud data is automatically converted to three dimensional vector models. Offering a "one button" approach, the new techniques in Pointfuse V2 not only convert point clouds into 3D vector models with accurate geometry, but also enable discrete surfaces in these models to be isolated and manipulated in third party software to a greater extent than before. *www.arithmetica.com*

Hemisphere GNSS announces New Eclipse™ P328 OEM Positioning Board

Hemisphere GNSS has announced the Eclipse P328, the next offering in a line of new and refreshed, low-power, high-precision, positioning OEM boards. The multi-frequency, multi-GNSS P328 is an all signals receiver board that includes Hemisphere's new and innovative hardware platform and integrates Atlas® GNSS Global Corrections. Designed with this new hardware platform, the overall cost, size, weight, and power consumption of the P328 are reduced. It offers true scalability with centimeter-level accuracy in either single-frequency mode or full performance multi-frequency, multi-GNSS, Atlas-capable mode that supports fast RTK initialization times over long distances. The 60mm x 100mm module with 24-pin and 16-pin headers is a drop-in upgrade for existing designs using this industry standard form factor.

The latest technology platform enables simultaneous tracking of all satellite signals including GPS, GLONASS P-code, BeiDou, Galileo, and QZSS making it robust and reliable. *www.HGNSS.com*

Hemisphere GNSS and Carlson Software continue collaboration

Hemisphere GNSS and Carlson Software recently collaborated to produce the Hemisphere S321 and Carlson BRx6, all-new, compact, state-of-the-art GNSS receivers. The two companies previously worked together on the design and production of Carlson's BRx5 GNSS receiver (Hemisphere S320), developed using Carlson's widely respected software and interface expertise with Hemisphere's design and manufacturing experience and RTK correction technology leadership. *www.HGNSS.com*

Applanix announces POSPac MMS 8

Applanix, has introduced POSPac MMS™ 8, the next generation of GNSS-Aided Inertial post-processing software for georeferencing data collected from cameras, LIDARs, multi-beam sonars and other sensors on mobile platforms. Using the Trimble® CenterPoint® RTX subscription service with RTX™ technology, POSPac MMS 8 delivers significant new benefits for mobile mapping from land, air, marine and UAV platforms.

Arrow Gold High-Accuracy iOS/Android GNSS receiver by Eos Positioning

Eos Positioning Systems has announced the world's most advanced high-accuracy Bluetooth GNSS receiver, the Arrow Gold. It is the first high-accuracy iOS, Android, and Windows Bluetooth GNSS receiver to implement all four constellations (GPS, Glonass, Galileo, BeiDou), three frequencies (L1, L2, L5), and satellite-assisted RTK. It provides 1cm real-time accuracy in more places, and on all iOS, Android, and Windows devices. The palm-sized Arrow Gold works with any data collection app designed for iOS, Android or Windows. It means that apps like Esri's Collector/ArcPad/Survey123 and others work with the Arrow Gold right out of the box. *www.eos-gnss.com*

Telit launches new ultra-low-power GNSS module

Telit has launched its SE873Q5, an ultra-low-power, high-sensitivity GNSS module with very small physical dimensions, completely compatible with its popular SE873 module. Its new module leverages innovation in miniaturization technology to improve power saving and sensitivity, delivering longer battery life and expanding design possibilities for tracking and navigation application areas particularly in wearable devices. The SE873Q5 is the smallest flash-memory based GNSS module capable of tracking three constellations simultaneously at its power level.

NavCom launches Onyx Software-upgradeable GNSS OEM Board

NavCom Technology has released the Onyx multi-frequency GNSS OEM board. Offering integrated StarFire/RTK GNSS capabilities, Onyx features 255-channel tracking, including multi-constellation support for GPS, GLONASS, Beidou and Galileo. It also provides first-rate

performance in GNSS receiver sensitivity and signal tracking as well as patented multi-path mitigation, interference rejection and anti-jamming capabilities.

The new Onyx GNSS OEM board is a fully upgradeable GNSS receiver, allowing the receiver to upgrade from free DGPS signal sources such as WAAS to increased accuracy services with integrated features StarFire with Rapid Recovery or RTK with RTK Extend through software optioning alone. The software enabled features are sold in convenient software bundles, but can also be purchased individually, to suit changing application needs.

Teledyne Optech launches Lynx HS-600

Teledyne Optech has released the Optech Lynx HS-600 mobile LiDAR scanner. Available in single- and dual-sensor configurations, the HS-600 is a major step forward for collecting uniform LiDAR data from high-speed platforms, Teledyne Optech says. The HS-600 model is an addition to the Lynx product line and complements the Optech Lynx SG and SG-S models by providing 1,200 lines/second scanner speeds on the dual-sensor version.

Swift Navigation announces a new GPS Module for robots

Swift Navigation™, building centimeter-accurate GPS technology, has announced its newest product, Piksi™ Multi, and the robotics industry is going to take notice of this multi-band, multi-constellation high-precision GNSS receiver. Swift Navigation solutions utilize real-time kinematics (RTK) technology, providing location solutions that are 100 times more accurate than traditional GPS. *www.swiftnav.com*

LNA front-end module for GPS/GNSS wearables

Skyworks' SKY65903-11 is a new low-noise amplifier, front-end module with integrated pre- and post- filters for GPS receiver applications: a 1559-1606 MHz high performance module for GNSS end products such as fitness/activity trackers, watches, pet trackers, smartphones and tablets. The device features high linearity, excellent gain, and a low noise figure for improved signal-to-noise ratio. *www.skyworksinc.com*

Trimble's new SX10 scanning total station redefines surveying

Trimble has released its next-generation survey instrument—the Trimble SX10 Scanning Total Station. Merging high-speed 3D scanning, enhanced Trimble VISION imaging technology and high-accuracy total station measurements. The SX10 comes with Trimble's patented technology that enables the capture of both high-accuracy measurements critical for traditional survey projects and rich point cloud data at 26,600 points per second with a range of up to 600 meters. As a result, surveyors can now include 3D scanning into existing workflows to increase productivity and versatility.

Topcon announces new MAGNET software solutions

Topcon has announced two new software platforms designed to provide multi-disciplinary model management and increased collaboration and integration. MAGNET Explorer offers model management, simulation and design analysis for construction projects where multiple design disciplines need to function as one.

Trimble launches New Portfolio of Wireless IoT Sensors

Trimble has introduced its Telog® 41 Series of wireless, battery-powered sensors for water monitoring applications. These new Internet of Things (IoT) sensors use innovative, low-power, Long-Range (LoRa® technology) wireless communications to remotely measure and monitor water, wastewater and groundwater systems including water pressures, flows, levels and rainfall volumes. As part of a smart water infrastructure, the Telog 41 Series wireless sensors work in combination with Telog cloud-hosted and on–premise software to allow utilities to more easily and economically deploy wireless monitoring. *www.trimble.com*

Sokkia SRX Robotic Total Stations

Sokkia Corporation announces the release of four new SRX total stations -- SRX1X, SRX2X, SRX3X and SRX5X. "Incorporating an array of new technologies and enhancements, the new SRX will certainly bring a new level of work efficiency to all robotic surveying and setting-out tasks"

"The new SRX series is developed to maximize all performances, primarily focusing on auto-tracking and distance measurement capabilities," said Brice Walker, vice-president of survey sales. *www.sokkiacorp.com*

GEOCIRRUS launches new Mining Tool

GEOCIRRUS MINE-which takes the next logical step in smart mining technology. MINE is the only web-based mining solution that completely eliminates the need for specialist GIS software while also enabling all mine personnel to share crucial information and mapping data instantaneously. Improved project planning and site efficiency was the foremost goal in MINE's development; with its cloud-based, feature-rich interface, MINE delivers. *http://www.aamgroup.com*

Spirent GSS200D

Spirent Communications plc's has announced the GSS200D Interference Detection and Analysis solution. The GSS200D has been developed as part of Spirent's partnership with Nottingham Scientific Limited. The GSS200D solution comprises field-based hardware and a secure data server for automatic capture and analysis of global navigation satellite system (GNSS) radio frequency interference. Deployments of GSS200D probes readily provide users with a thorough understanding of the RF interference environment at sites of interest. The GSS200D detection system operates simultaneously on GPS, GLONASS and GALILEO in the L1 band.

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November 2016

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

December 2016

ISGNSS 2016
5 - 7 Dec
Tainan, Taiwan
http://isgnss2016.ncku.edu.tw/

IGNSS 2016
6 - 8 December
UNSW Australia
ignss2016.unsw.edu.au

United Nations/Nepal Workshop on the Applications of GNSS
12 - 16 December
Kathmandu, Nepal
http://www.unoosa.org/pdf/icg/2016/nepal-workshop/InfoNote.pdf

Navitec 2016
14 - 16 December
Noordwijk, Netherlands
http://navitec.esa.int

January 2017

Esri India User Conference
19 – 20 January
Delhi, India
http://www.esri.in/events

February 2017

17th annual International LiDAR Mapping Forum (ILMF)
13-15 February
Denver, Colorado, USA
www.lidarmap.org

March 2017

2017 GIS /CAMA Technologies Conference,
6 - 9, March
Chattanooga, Tennessee
www.urisa.org

Munich Satellite Navigation Summit 2017
14 – 16 March
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2017

International Navigation Forum / Navitech'2017
25 - 28 April
Moscow, Russia
www.navitech-expo.ru/en/

GISTAM 2017
27 - 28 April
Porto, Portugal
http://gistam.org

May 2017

MMT 2017: The 10th International Symposium on Mobile Mapping Technology
6 - 8 May
Cairo, Egypt
http://mmt2017.aast.edu/index.php

XPONENTIAL
8 - 11 May
Dallas, USA
http://xponential.org

11th Annual Baska GNSS Conference
7 - 9 May
Baska, Croatia
www.rin.org.uk

The European Navigation Conference 2017
9 – 12 May
Lausanne, Switzerland
http://enc2017.eu

GeoBusiness 2017
23 - 24 May
London, UK
http://geobusinessshow.com

FIG Working Week 2017
29 May - 2 June
Helsinki, Finland
www.fig.net

June 2017

TransNav 2017
21 - 23 June
Gdynia, Poland
www.transnav.eu

July 2017

Esri User Conference
10 – 14 July
San Diego, USA
http://www.esri.com/events/user-conference/papers

September 2017

Interdrone 2017
6 - 8 September
Las Vegas, USA
www.interdrone.com

ION GNSS+ 2017
25 - 29 September
Portland, USA
www.ion.org

Intergeo 2017
26 - 28 September
Berlin, Germany
www.intergeo.de

October 2017

ACRS 2017
9 - 13 October
New Delhi, India
www.acrs2017.org


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