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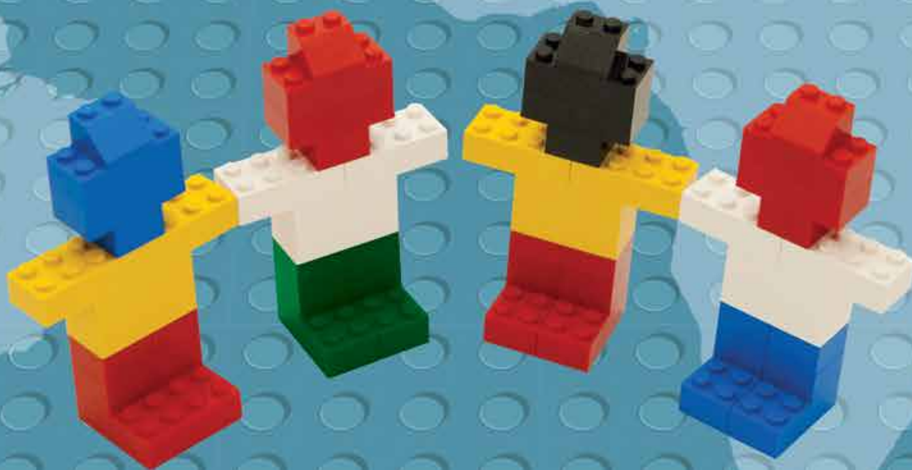

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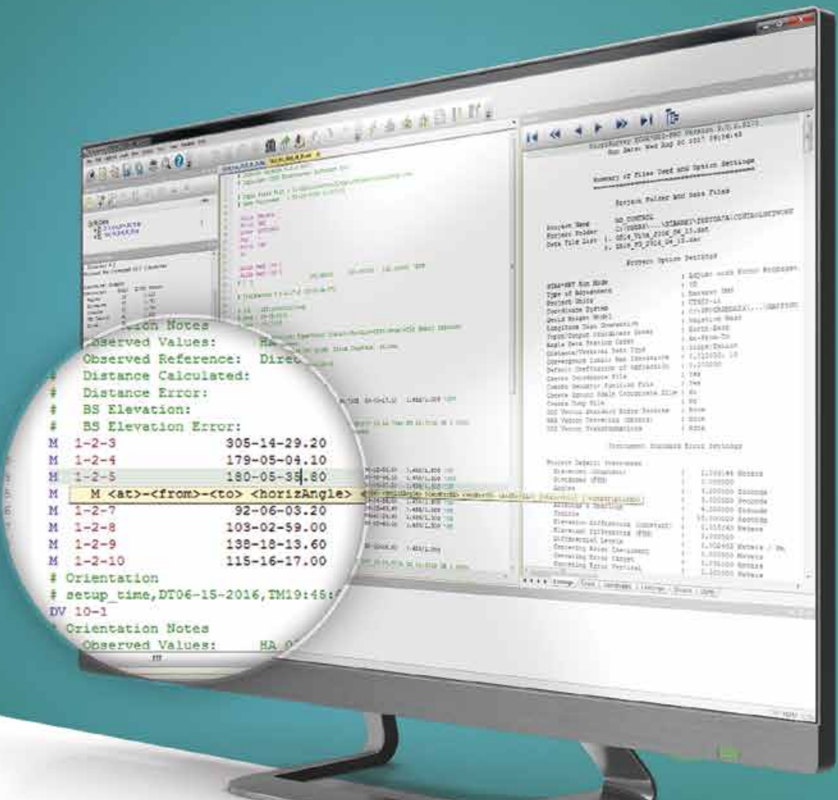

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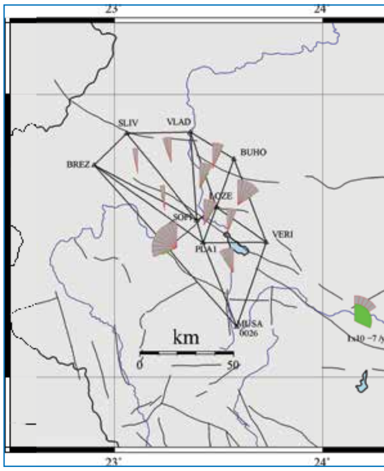

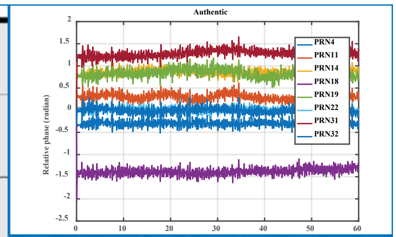

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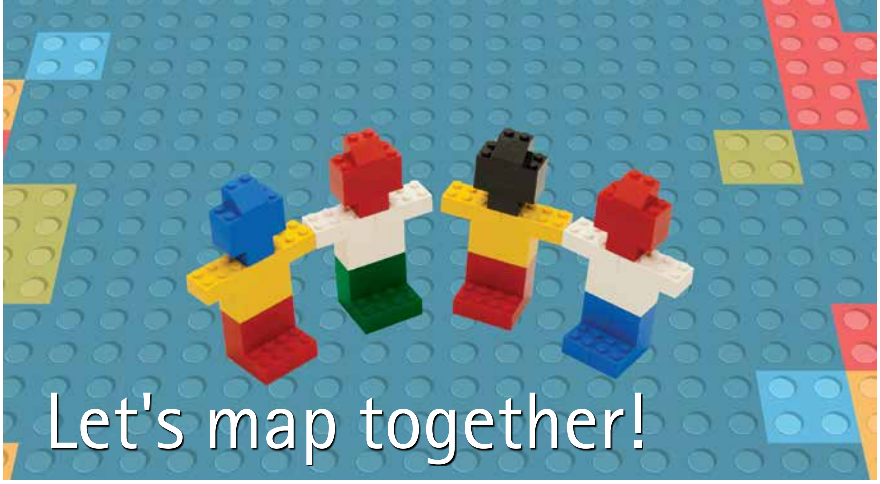

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Let's Map together!

Bal Krishna, Editor
bal@mycoordinates.org

GNSS authenticity verification in covered spoofing attack using antenna array

A covered spoofing scenario is considered in this research where the reception of the authentic signals are blocked and the receiver antenna only receives counterfeit signals

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Due to rapidly increasing applications of GNSS dependent systems, motivation has increased to spoof these signals for illegal or concealed transportation and to mislead receiver timing used by critical infrastructure. Detection and mitigation of spoofing attacks on GNSS receivers has become an important research topic [1-5]. Spoofing countermeasure methods analyse specific features of the counterfeit signals which may enable a receiver to distinguish them from authentic signals.

The spoofing detection techniques implemented at the pre-despreading and post-despreading signal processing layers of a GNSS receiver are effective and can detect spoofing attacks in presence of authentic signals [6-11]. Pre-despreading metrics have been employed to detect the presence of excessive amount of power in GNSS bands [12-13] and [16]. The received signal strength (RSS) spoofing detection approaches generally rely on the assumption that spoofing signals are more powerful than the authentic ones and a successful spoofing attack transmits several counterfeit GNSS-like signals. These methods evaluate the overall power of the received signal set without separately analyzing different signals. This category of spoofing detection analyse any abnormal variation in the received signal power prior to the despreading process in the receiver. The power-based spoofing detection methods requires calibration to be performed under the non-spoofed condition. Post-despreading methods are employed to detect an abnormal behaviour of cross-correlation function which may be caused by the presence of both genuine and counterfeit signals [14-15]. The interaction between authentic and counterfeit signals causes distortion on the shape of the correlation function. Signal Quality Monitoring (SQM) tests focus on this feature in order to detect any asymmetry and/or abnormally sharp or elevated correlation peaks due to the presence of undesired signals [15].

It is important to note that these methods make the ctitical assumption that both authentic and spoofing signals are present and the receiver is initially tracking authentic signals. Hence, in absence of authentic signals, when only counterfeit signals are received, these two assumptions are invalidated, and so these methods may no longer work. This may occur, for example, when the GNSS antenna is covered and only exposed to counterfeit signals, or overpower non-overlapped spoofing attack and the receiver is exposed to counterfeit signals during cold start.

An antenna array processing is another approach to detect and mitigate spoofing attacks [14],[17-20]. Under the assumption that all counterfeit signals are broadcast from a single spoofing source, this approach takes advantage of the similarity between the angle-of-arrival (AoA) of counterfeit signals. Algorithms applied to the signals received using an antenna array can classify signals according to their respective AoA and to steer a null in the directions from which the counterfeit signals arrive. At the pre-despreading level antenna arrays can be also used to extract the spatial signature of counterfeit signals without acquiring and tracking the counterfeit and authentic signals [21-22]. The receiver structure in the antenna array case consists of several antennas each connected to a separate radio frequency down-conversion channels and digitizers in a phase coherent mode usually utilizing a single reference oscillator and synchronized voltage controlled oscillators. The antenna elements separation in such cases is about half of the carrier wavelength and the antenna array is generally considered a single receiver unit for a specific application [23-24].

The counterfeit signals sourced from a single antenna have the same spatial signature, which means that all the signals experience the same channel parameter variation in the spatial domain. This can be used as a metric to detect a spoofing attack. The spoofing detection unit places all signals with the same spatial signature in the spoofing group. The advantage of the antenna array processing over the single antenna spoofing detection methods is that it can detect spoofing attack in absence of authentic signals (in the covered antenna case) as long as spoofing signals are transmitted from a single antenna.

Herein a covered spoofing scenario is defined to establish a foundation to analyze sensitivity of different spoofing detection methods. The receiver equipped with an antenna array is covered to block reception of authentic signals where a small antenna connected to a spoofing generator transmits an ensemble of counterfeit signals which are received by the antenna array. Then detection performance of the antenna array processing based on the near-filed signal propagation is analyzed. The performance of single antenna spoofing detection metrics including IF sample variance and SQM methods will be also investigated.

Spoofing detection metrics

Several spoofing detection metrics in different operation layers of a GNSS receiver have been proposed. These metrics can generally be divided into two categories, namely pre-despreading and post-despreading techniques [3]. In the following some of them are introduced.

Pre-despreading spoofing detection

Different spoofing detection methods based on monitoring the received signal strength are discussed here. These techniques rely on the assumption that counterfeit signals are more powerful than the authentic ones. Pre-despreading methods analyse the overall power content of the received signal set without separately analyzing different signals. This type of counterfeit signal detection examines any abnormal variation in the baseband signal power prior to further processing signals. At this stage, the GNSS signals are buried under the noise floor and a spoofing detection test is performed based on the analysis of the power content of the received baseband signals.

Baseband variance analysis

This method continuously monitors the variance of baseband signals in order to detect additional power injected by interference signals. Most commercial GNSS receivers are equipped with an automatic-gain-control (AGC) module that adaptively changes the receiver input gain based on the variance of the received signal in order to efficiently use the quantization levels of the input analog-to-digital-convertor (ADC) module, and to protect the baseband amplification stages from excessive power. A feedback circuit controls the AGC gain and monitoring of this gain value is used to detect variations in signal variance due to the presence of interference. In the case of fixed AGC gain and adequate ADC digitizer bits, the IF sample variance can be used to monitor the excessive power in the band. This method does not take advantage of any signal structure and simply assumes that the counterfeit signals' power content elevates the ambient noise floor. A spoofing (or generally interference) attack will be detected if the estimated variance is higher than a predefined detection threshold. Defining a proper detection threshold requires an initial power level calibration in the presence of clean signals in a typical operational environment.

Structural Power Content Analysis (SPCA)

SPCA takes advantage of the cyclo-stationarity of GNSS signals in order to detect excessive amount of structured signal power in the received sample set [3]. In this approach, the received IF samples are first filtered within the GNSS signal bandwidth and then multiplied by their one-chip delayed version in order to remove the effect of Doppler frequency. The resulting signal has a line spectrum since it is generated by multiplication of cyclo-stationary signals. In the next stage, the signal and noise components are filtered by suitably designed comb filters [3]. A detection test statistic is calculated based on the filter outputs and is then compared to a threshold in order to differentiate between the presence and absence of counterfeit signals. Since each PRN signal is received from a different satellite with different relative dynamics with respect to a user, their corresponding Doppler frequencies are different from each other. Therefore, in order to concentrate all signal components on the same spectral lines and facilitate spectral filtering, the Doppler shifts of the signals should be removed. To this end, the sampled baseband signal components are first multiplied by the complex conjugate of their one chip delayed version. This operation removes the phase rotation due to the Doppler frequency of received signals. It also removes the navigation data bits and secondary codes and GNSS subcarriers that are modulated on each spreading code.

Post-despreading spoofing detection

Herein some of the widely applied spoofing detection methods are described.

Effective C/N_0 analysis

Effective C/N_0 analysis is a common signal strength monitoring metric that is available in most commercial receivers. The effectiveness of this metric towards the classification of an interference signal is investigated herein. Generally, three terms can affect the effective C/N_0. The first one corresponds to the noise component due to thermal noise or other interference sources, the second refers to the cross correlation between counterfeit signals and authentic replica and the third refers to the cross correlation caused by other authentic signals. The cross correlation term caused by high power spoofing signals can become the dominant term which is directly proportional to the power level of spoofing signals. This term considerably reduces the effective C/N_0 of authentic PRNs and leads to saturation of spoofing C/N_0 values.

The upper limit of a GNSS signal power level is known a priori. Hence, for a given receiver, an upper limit for the C/N_0 value can be defined. The spoofing detection metric based on C/N_0 monitoring works based on this fact. An abnormally high C/N_0 value can be an indication of a spoofing attack. In addition, jamming signals also affect the effective C/N_0 values by increasing the noise floor. A constructive multipath signal can cause a C/N_0 value to exceed the spoofing detection threshold and result in a false alarm. Hence, this metric should be used in conjunction with other spoofing detection metrics to reduce false alarm probability.

SQM

The interaction between authentic and spoofing signals causes distortion on the shape of the correlation function. Signal Quality Monitoring (SQM) tests focus on this feature in order to detect any asymmetry and/or abnormally sharp or elevated correlation peaks due to the presence of undesired signals [25]. This metric is originally designed to monitor the correlation peak quality affected by multipath signals and has been widely used in the monitoring of signal quality in applications that require high integrity, such as aviation and rail.

One of the advantages of SQM tests is that they are not highly dependent on training or a calibration process based on a clean data. As mentioned previously, SQM metrics are designed to monitor correlation peak distortions due to multipath or overlapped spoofing attack. As such, they may exhibit high false-alarm rates under multipath conditions. Moreover, in the case of covered or non-overlapped spoofing attacks these metrics are not effective.

GNSS signals authentication using antenna array processing

A receiver equipped with an antenna array can employ spatial filtering techniques in order to shape its reception beam pattern. This type of receivers can steer a null toward the spoofing source and suppress its destructive effect [23]. Antenna array processing to detect spoofing attacks can be implemented at the pre-despreading (IF sample level) or post-despreading stage of a GNSS receiver. In the following each implementation approach are discussed.

Pre-despreading spoofing mitigation

Assume a spoofing attack scenario where a single source spoofer propagates several counterfeit PRNs. A low computational complexity multi-antenna spoofing detection and mitigation method that is able to spatially filter out the spoofing signals has been proposed in [22]. This method cross-correlates the baseband samples from different antennas in order to form a spatial correlation matrix and extract the spatial signature of the spoofing source. The steering vector corresponding to the spoofing signals can be extracted since all of the spoofing signal energy is coming from the same spatial sector. This type of spoofing detection approach considers the spoofing source as a wideband interference signal and successfully detects and mitigates the spoofing source. Considering the fact that several spoofing PRNs impinge on the antenna array from the same direction, it can be observed that their power outputs are added constructively from a specific spatial sector. In other words, the spatial power density of the spoofing signals is considerably higher than that of the authentic signals. The spatial correlation matrix of the received signal can be constructed to estimate spoofing steering vector. To estimate the spoofing sub-space or equivalently the spoofing steering vector one can employ Eigen value decomposition of the spatial covariance matrix where the spoofing steering vector is related to the Eigen vector corresponding to the largest eigenvalue. One of the advantages of this method is that it does not require array calibration and its computational complexity is low. Figure 1 shows the block diagram of the pre-despreading spoofing detection and mitigation approach. Digitized baseband samples from a multiple-channel synchronized front-end are passed to the null-steering unit where the weights to suppress a spoofing signals are calculated. The output of the null-steering unit is baseband spoofing free complex samples that are passed to a conventional receiver acquisition and tracking module.

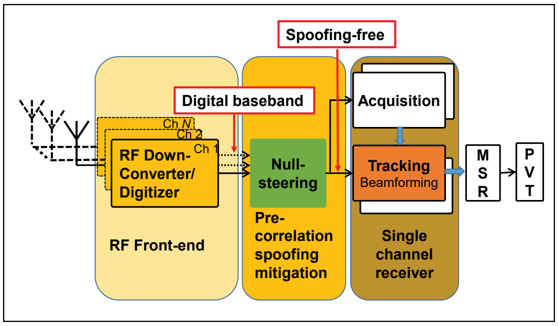

Figure 1: Pre-despreading spoofing mitigation (MSR: Measurements, PVT: Position, Velocity and Time)

Post-despreading spoofing mitigation

In post-despreading antenna-array based spoofing detection and mitigation methods the despreading and accumulation process are applied to each digitized baseband antenna samples. Figure 2 shows the post-despreading spoofing detection and mitigation block diagram. The output baseband samples from different front-end channels are first fed to the acquisition engine to detect available signals. The acquisition routine in this case is modified to detect all of the peaks above the detection threshold and passes all of the initial code phases and Doppler frequencies to the tracking unit. The despread samples of different detected signals are then fed to the steering vector estimation unit. The spoofing detection unit correlates the estimated steering vectors of all detected signals. High correlation among estimated steering vectors indicates that the signals are transmitted from a single source. The estimated steering vector then is passed to the classification and weight calculation unit. The output of the weight calculation unit is then forwarded to the beamforming and null-steering module. The output of the beamforming/null-steering module is a single channel spoof free signal used to calculate GNSS measurements for different PRNs.

Here, it is assumed that the antenna array is not calibrated. More specifically the relative phase and gain of the antenna elements are unknown and the orientation of the array is not known. After tracking all spoofing and authentic signals, the spoofing detection module correlates the array responses (steering vector) of different signals. The spoofing signals sourced from a single antenna have the same spatial signature, which means that all the PRNs experience the same channel parameter variation in the spatial domain. This can be used as a metric to detect a spoofing attack and classify spoofing and authentic signals. Covered Spoofing Attack

This section describes the data collection procedure used to analyse different spoofing detection metrics under covered spoofing attack.

Data collection and processing

In the covered spoofing attack investigated in this paper the receiver antennas were enclosed to avoid reception of authentic signals while the spoofer propagates counterfeit signals. An antenna array with two Maxtena helical antenna elements with 8 cm spacing was used for spatial processing. Data was collected with a phase-coherent multi-channel Fraunhofer/TeleOrbit RF front-end with 10 M samples/s, 8 bit quantization and disabled automatic gain control (AGC). A metallic case was developed to cover the receiver antenna array. The antenna array was placed inside the case where authentic signals reception were blocked and the array was exposed to only counterfeit signals. The covered spoofing scenario is shown in Figure 3. There are two input ports for spoofing propagation and two receiver antennas for antenna array processing. Data was collected in two cases namely open sky and under covered spoofing attack. In the open sky scenario, the two-element antenna array was exposed to a clear open sky during the data collection. In the spoofing scenario, the receiver antenna array was placed inside the metallic case shown in Figure 3. Spoofing data was collected inside a lab where the spoofing antenna propagated counterfeit signals inside the case and captured by the receiver's antenna array. A hardware simulator was used to generate counterfeit signals. The counterfeit signals power level were tuned beforehand in a calibration process to be received at the receiver antennas with the same power level as that of the authentic signals.

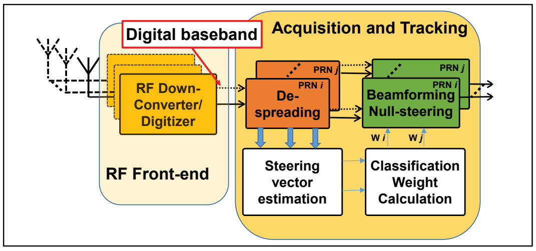

Figure 2: Post-despreading spoofing detection and mitigation (MSR: Measurements, PVT: Position, Velocity and Time)

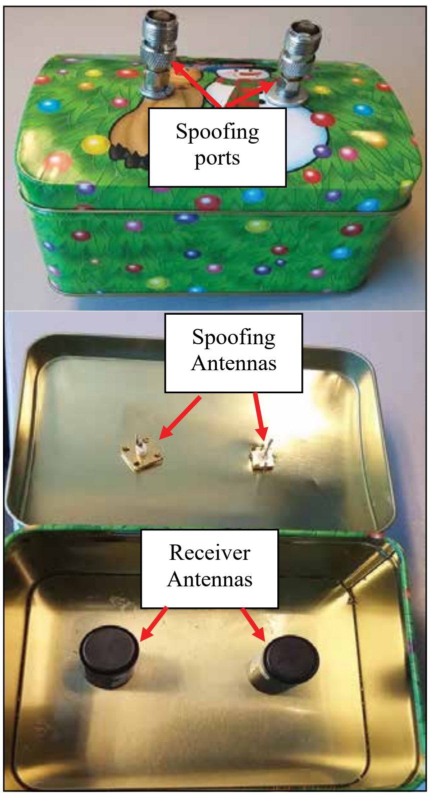

Figure 3: Covered spoofing scenario

Signal quality in the covered spoofing scenario

The first step to develop proper counterfeit signal detection metrics in the covered spoofing attack is to characterize the signal parameters. Since the counterfeit signals are propagated inside the case the received signals by the receiver antennas may be subject to attenuation and multipath propagation which may affect the received signal quality and hence receiver performance. This investigation may lead to some counterfeit signal detection metrics. To this end a data set was collected to analyse the performance of signals propagation inside the case. The data collection procedure is shown in Figure 4. The hardware simulator signal output was connected to a two way splitter

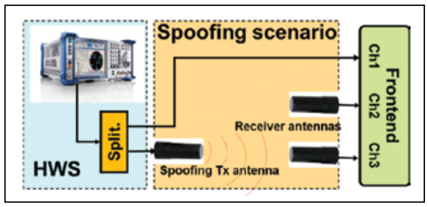

Figure 4: Data collection scenario for covered spoofing signal parameters characterization

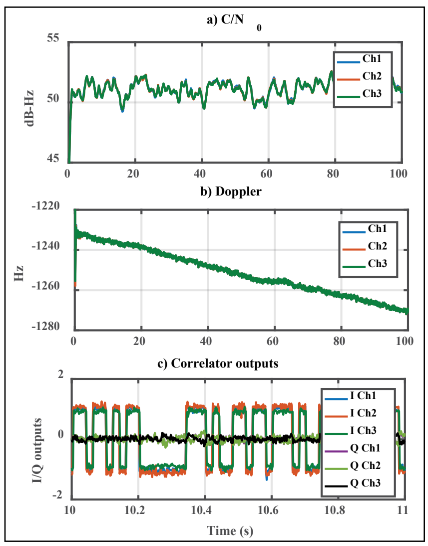

Figure 5: Different signal quality for direct connection and signal re-propagation scenarios (Ch1 and Ch2 signal propagated inside the case and Ch3 direct cable connection)

where one of the outputs was connected directly to one of the front-end channels. The other splitter's output was connected to the spoofing port to propagate signals inside the case which then received by the receiver antennas. These signals were sampled with the RF front-end as shown in Figure 4 in a phase coherent fashion. The IF samples captured by these three channels were processed by a software receiver. Figure 5 shows different signal quality measures namely C/N_0, Doppler values and I/Q outputs for the three channels for a given PRN. As shown the C/N_0 values from different channels matches very well. This observation indicates that there is minimal signal power loss due to signal propagation inside the case compared to the direct cable connection.

Also as shown the multipath effect on the received signal strength propagated inside the case is negligible. The counterfeit transmit antenna was closer to the receiver Ch1 antenna as shown in Figure 4. This fact did not affect the C/N_0 values neither due to the path loss nor due to multipath phase rotation. Figure 5b shows carrier Doppler values for the three channels. As shown all of the channels yield the same performance. Figure 5c shows the I and Q values of the correlator outputs. All the channels were operating with a PLL, hence all of the signal energy is concentrated in I branches. As shown the I and Q branches of different channels have the same signal level which verifies the proper signal level calibration. The observations shown in Figure 5 was for a given PRN and similar results were observed for other PRNs. The signal quality characterization for the covered spoofing scenario provided in Figure 5 was focused on individual PRN parameters. To further analyse the quality of code and carrier phase measurements in the covered spoofing attack the measurement outputs of the software receiver were converted to the RINEX format. The measurements from Ch1 (spoofing) and Ch3 (authentic) were passed to the RTKLIB software for carrier phase positioning. This is a zero-baseline test where Ch1 and Ch3 measurements were used as rover and base measurements, respectively. The carrier phase positioning results are shown in Figure 6. Figure 6a and Figure 6b shows the horizontal and vertical position errors respectively. As shown a fixed RTK solution with mm level positioning error can be achieved in this scenario.

Single antenna based spoofing detection metrics performance under the covered spoofing attack

In this section the outputs of some spoofing detection metrics implemented in the pre and post-despreading stages of a receiver in a covered spoofing attack are examined. To this end different metric outputs for direct cable connection as the authentic signals are compared to those of the spoofing signals propagated inside the spoofing case. Figure 7 shows SPCA and IF samples standard deviation (std) outputs. Each metric output is based on 1 s process of IF samples.

The SPCA outputs measures the amount of GNSS signal power in the band and since this amount is measurable in a clean data set the output of SPCA can be used to detect the extra signal energy in the GNSS bandwidth when both authentic and spoofing signals are present. However, in the covered spoofing case where the authentic signals are not present the output of the SPCA metric should be the same as the clean data set. As shown in Figure 7a the SPCA metric outputs have the same values in the case of authentic and covered spoofing attack. Figure 7b shows the normalized IF samples standard deviations for 60 s of IF samples. As shown the authentic and covered spoofing cases are not distinguishable based on this metric as well. Figure 8 shows post-despreading spoofing detection metrics namely signal quality monitoring (SQM) and phase lock indicator (PLI) for the authentic and covered spoofing cases for a given PRN.

A delta metric SQM outputs with monitoring correlator spacing of 0.4 chip was employed in this case. As shown the SQM outputs in both cases are identical with similar statistics shown in Figure 8a. PLI values are shown in Figure 8b for the authentic and covered spoofing cases. As shown PLI values are comparable in both of the authentic and spoofing cases.

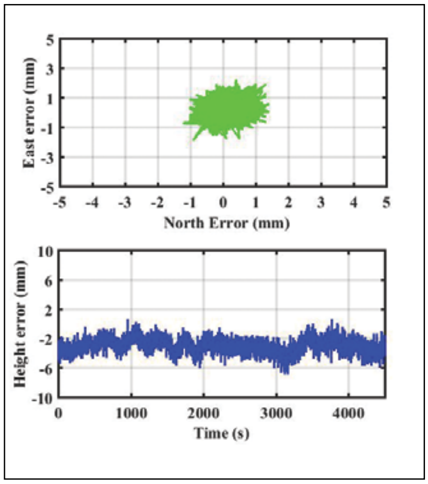

Figure 6: RTK horizontal and vertical solutions in a covered spoofing attack

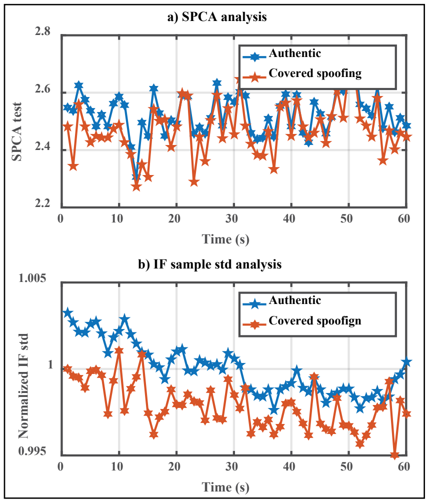

Figure 7: Pre-despreading spoofing detection metrics a) SPCA and b) IF sample std

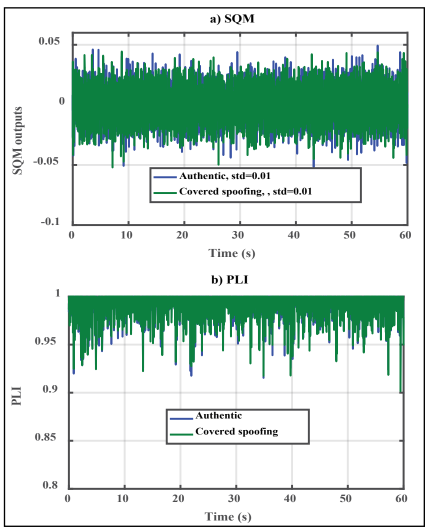

Figure 8: post-despreading spoofing detection metrics a) SQM, b) PLI

Multi antenna based spoofing detection metrics performance under the covered spoofing attack

As shown in the previous section the single antenna based spoofing detection metrics were not sensitive to the covered spoofing attack. This make sense since these types of counterfeit signal detection metrics rely on the power analyses or distortion on the correlation functions and none of these occur in the overlapped spoofing scenario.

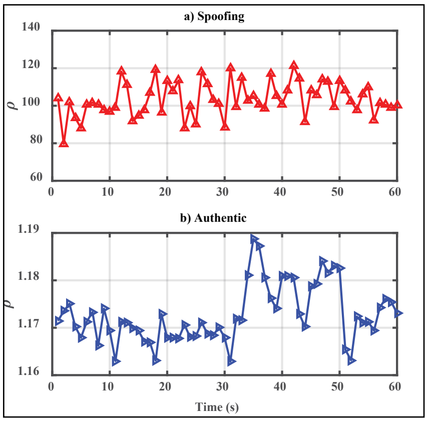

Figure 9: Highest-to-lowest ratio of eigenvalues (ρ) in spoofing and authentic cases

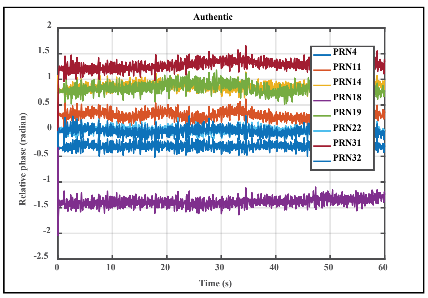

Figure 10: Relative phase of Ch1-Ch2 in the authentic case

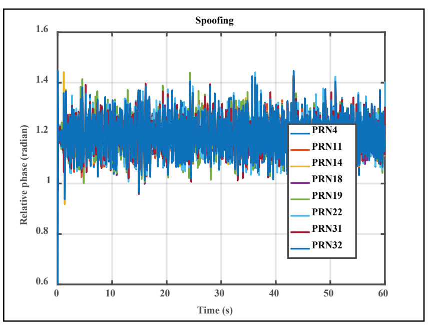

Figure 11: Relative phase of Ch1-Ch2 in the spoofing case

In this section the performance of antenna array processing for counterfeit signal detection is analysed.

It is assumed that the antenna array is not calibrated. More specifically the relative phase and gain of the antenna elements and the orientation of the array are unknown. To this end the IF samples output of the RF front-end was processed in two steps namely pre-despreading and post-despreading. In the pre-despreading stage the 2×2 spatial correlation matrix averaging over 1 s of data constructed. In the authentic signal scenario since all signals are transmitted from different directions the signal energy does not add up constructively and hence the eigenvalues of the spatial correlation matrix should have the same values. Whereas in the spoofing case since the spoofing signals are transmitted from a single source the signal energy adds up constructively and as such the eigenvalue corresponding to the spoofing and noise subspace should have much higher values than that of the noise only subspace. In this paper the ratio of the highest to lowest value of the eigenvalues (ρ) is considered to detect a spoofing event.

Figure 9 shows ρ for authentic and spoofing cases. Each value of ρ is based on 1 s spatial correlation process. As shown ρ in the spoofing scenario is about 100 times of that of the authentic scenario. It should be noted that the pre-despreading spoofing detection can detect any signal (e.g. jammer) transmitted from a single source.

In the post-despreading spatial spoofing detection the IF samples of the array were processed with a GNSS software receiver. The software receiver tracked the first channel data in PLL mode and used the tracking parameters (code, frequency and phase) to wipe-off the second channel data. The relative phase of Ch1-Ch2 can be measured by analyzing the in-phase and quadrature outputs of Ch2. The relative phase of Ch1-Ch2 at the correlator output is a function of the direction of arrival of satellite and relative path delay of the RF chain of Ch1-Ch2. In the spoofing case since all PRNs are arrived from the same direction the phase difference between Ch1 and Ch2 for all PRNs should be the same whereas in the authentic case since the direction of arrival of different PRNs varies the receiver should observe different values for Ch1-Ch2 relative phase. Figure 10 shows the relative phase of Ch1-Ch2 for various PRNs in the authentic case. As shown different PRNs have different relative phase values. In some cases (e.g. PRN 14 and PRN 19) the relative phase of Ch1-Ch2 have similar trend. This is due to the fact that they are located approximately in the same location or due to the inherent cone ambiguity of the linear array the method cannot distinguish signals coming from different angles located on the cone of ambiguity. This issue can be reduced by utilizing a planar array. Figure 11 shows the relative Ch1-Ch2 phase values for the covered spoofing case. As shown all values are overlapped which indicates all of the signals are transmitted form the same location where the covered spoofing attack can be detected.

Conclusions

A covered spoofing scenario was investigated in this paper where the reception of the authentic signals were blocked and the receiver antenna only exposed to the counterfeit signals. As shown the covered spoofing scenarios is relatively easy to implement while the signal quality was preserved. Different signal quality measures including C/N_0 Doppler and carrier tracking indicator were analysed. Based on the experimental results provided here the multipath due to signal propagation inside the spoofing case was not a concern. Various single antenna based spoofing detection metrics in the case of covered spoofing attack were analysed. The results revealed that these metrics are not sensitive to the detect such spoofing attack. A two-element antenna array was utilized to implement spatial processing in pre-despreading and post- despreading stages of a GNSS receiver. As shown the covered spoofing attack can be successfully detected using antenna array processing.

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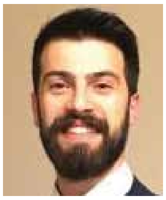
Segmentation of 3D photogrammetric point cloud

This study presents research in progress, which focuses on the segmentation and classification of 3D point clouds and orthoimages to generate 3D urban models



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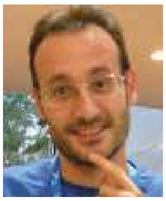

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3D modeling of cities has become very important as these models are being used in different studies including energy management, visibility analysis, 3D cadastre, urban planning, change detection, disaster management, etc. (Biljecki et al., 2015). 3D building models can be considered as one of the most important entities in the 3D city models and there are numerous ongoing studies from different disciplines, including vast majority of researchers from geomatics and computer sciences.

The two main concepts of reconstructing 3D building models can be given as procedural modeling (Musialski et al., 2013; Parish and Müller, 2001) and reality-based modeling (Toschi et al., 2017a), the latter including photogrammetry and Airborne Laser Scanning (Fig. 1). The concept of procedural modeling is based on creating rules (procedures) that reconstruct 3D models automatically (i.e. dimensions and location of starting point of a rectangular prism). On the other hand, reality-based modeling approaches rely on data gathered with 3D surveying techniques to derive 3D geometries from surveyed data. While procedural modeling concept holds the main advantages of data compression and savings from hardware usage, it comes at two important costs, i.e. low metric accuracy and issues with control ability on the model, especially for complex structures.

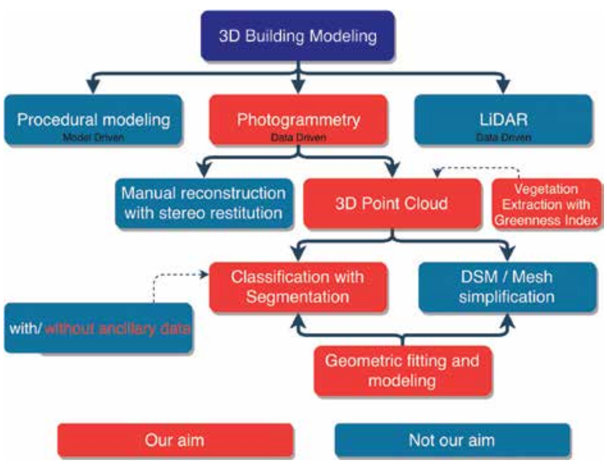

Figure 1. A schema of our photogrammetric-based approach for the generation of 3D building models.

There are many approaches presented in the literature for 3D building modeling, which rely on point clouds (Haala and Kada, 2010; He et al., 2012; Lafarge and Mallet, 2012; Sampath and Shan, 2010), often coupled with ancillary data such as building footprints. However, reliable footprints are not always available. Moreover, these existing methodologies are not found to be fully exploiting the accuracy potential of sensor data (Rottensteiner et al., 2014). For these reasons, we are motivated to develop a methodology to reconstruct 3D building models without relying on such ancillary data. The method focuses on the segmentation of photogrammetric point clouds and RGB orthophotos for the successive reconstruction of 3D building models. Using a semi-automated approach, we detect vegetation (and/or other) classes on the image and mask/separate these regions in the point cloud. Therefore, it becomes easier to process the rest of the point cloud for a segmentation and classification in order to extract the buildings from the point cloud.

The paper proposes a methodology to extract and model buildings from photogrammetric point clouds segmented with the support of orthophoto. After a review of related works, the developed methodology is presented. Results are discussed at the end of the paper.

Related work

In the last years, thanks to the availability of dense point clouds coming from LiDAR sensors or automated image matching (Remondino et al., 2014), there have been many studies on 3D building reconstruction from dense point clouds. Most of them are based on extraction of roofs, generally using ancillary data such as building footprints, and then fitting geometric primitives (Dorninger and Pfeifer, 2008; Malihi et al., 2016; Vosselman and Dijkman, 2001; Xiong et al., 2014). As our approach (Fig. 2) is based on orthophoto and point cloud segmentation, in the next sections, a state-of the-art of such methods is shortly given.

Image segmentation

The automatic analysis and segmentation of terrestrial, aerial and satellite 2D images into semantically defined classes (often referred to as "image classification" or "semantic labeling") has been an active area of research for photogrammetry, remote sensing and computer vision scientist since more than 30 years (Bajcsy and Tavakoli, 1976; Chaudhuri et al., 2018; Duarte et al., 2017; Kluckner et al., 2009; Teboul et al., 2010; Tokarczyk et al., 2015). In the literature image classification methods are normally

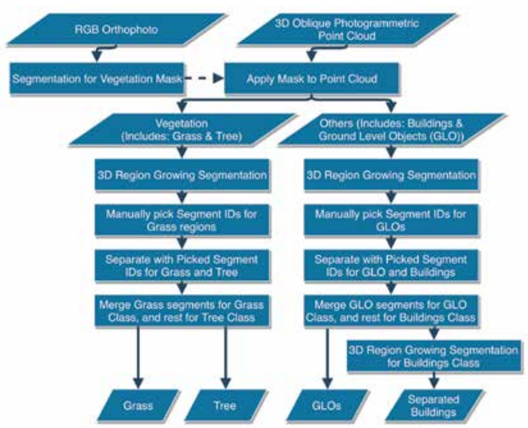

Figure 2. The developed methodology, based on orthoimage and point cloud processing, to identify buildings and geometrically model them.

divided in per-pixel approaches vs object-based analyses (the latter often called GEOBIA - Geographic Object Based Image Analysis) (Blaschke et al., 2014; Morel and Solimini, 2012). Semantically interpreted images, i.e. thematic raster maps of building envelopes, forests or entire urban areas are important for many tasks, such as mapping and navigation, trip planning, urban planning, environmental monitoring, traffic analysis, road network extraction, change detection, restoration, etc. In spite of a large number of publications, the task is far from solved. Indeed, Earth areas exhibit a large variety of reflectance patterns, with large intra-class variations and often also low interclass variation (Montoya-Zegarra et al., 2015). The situation gets even more challenging when dealing with high-resolution aerial (less than 20 cm) and terrestrial images where intra-class variability increases as many more small objects (street elements, façade structures, road signs and markings, car details, etc.) are visible. Segmentation and classification of 2D (geospatial) data is normally performed with data-driven / supervised approaches - based on classifiers like random forests, Markov Random Field (MRF), Conditional Random Fields (CRF), Support Vector Machines (SVM), Conditional Random Field (CNN), AdaBoost, maximum likelihood classifier, etc. (Schindler, 2012) - or unsupervised approaches based on K-means, Fuzzy c-means, AUTOCLASS, DBSCAN or expectation maximization (Estivill-Castro, 2002).

Point cloud segmentation

Point cloud segmentation is another challenging segmentation task as in the most cases there is vast amount of complex data. There have been different methodologies developed in order to solve this difficult task (Nguyen and Le, 2013; Woo et al., 2002). While some methodologies are developed with machine learning approach (Hackel et al., 2017; Kanezaki et al., 2016; Qi et al., 2017; Wu et al., 2015), some others relied on the geometric calculations, such as sample consensus based (Fischler and Bolles, 1981), combining images and 3D data (Adam et al., 2018), or region growing algorithms (Ushakov, 2018). There are also various studies on classification of aerial photogrammetric 3D point clouds (Becker et al., 2017), segmentation of unstructured point clouds (Dorninger and Nothegger, 2007), and some studies on segmentation of LiDAR point clouds as well (Douillard et al., 2011; Macher et al., 2017; Ramiya et al., 2017).

3D building models

Our aim is to reconstruct Level of Detail 2 (LoD2, (Biljecki et al., 2016)) 3D building models with optimum number of vertexes. For this reason, we are not using a method that creates a mesh using all the available points in the point cloud. Instead, we prefer to employ a method that generates lightweight polygonal surfaces. In the literature there are different kind of 3D building reconstruction methodologies, which we could classify based on the used data: footprints (Müller et al., 2006), sparse point clouds, procedural modeling (Müller et al., 2007; Parish and Müller, 2001; Vanegas et al., 2010), combined methodologies (Müller Arisona et al., 2013), hybrid representation (Hu et al., 2018) and deep learning approaches (Wichmann et al., 2018).

Data and methodology

We propose an automated methodology that aims to extract buildings from photogrammetric point clouds for 3D reconstruction purposes. The method combines a series of processes including: (i) vegetation masking through orthoimage segmentation, (ii) point cloud segmentation (vegetation, buildings, streets, ground level objects - GLO) with the aid of the image masking results and (iii) 3D reconstruction of the building class.

Employed data

We used two different datasets for developing and testing our method.

The first is derived from ISPRS benchmark dataset of Dortmund City Center (Nex et al., 2015). As the original dataset contains data from different sensors including terrestrial and aerial laser scanners, we only used the point cloud generated using oblique images acquired with the IGI PentaCam, with the GSD of 10cm in the nadir images, and 8-12cm in the oblique views. The average density of the cloud is ca 50 pts/sqm.

The second dataset was flown over the city of Bergamo (Italy) with a Vexcel UltraCam Osprey Prime by AVT Terramessflug, with average GSD of 12cm for both nadir and oblique images (Gerke et al., 2016; Toschi et al., 2017b). The resulting dense point cloud has an average density of 30 pts/sqm.

Segmentation of the orthophoto

We used Kohonen's Self-Organizing Map (SOM, Fig. 3), which is an Artificial Neural Network (ANN) designed for clustering the given data into number of clusters that is defined by the number of layers (González-Cuéllar and Obregón-Neira, 2013). By its design, SOM has an unsupervised approach for the training and with this training the network generates a map of the given data (Kohonen et al., 2001). The neuron's weights are calculated as:

$$W_v(s+1) = W_v(s) + \theta(u,v,s).\alpha(s).(D(t) - W_v(s))$$

where:

- Wv represents the weights for neuron v,
- s represents the index of the step,
- θ(u,v,s) stands for the function calculating the distance between neuron u and v in the step s,
- α(s) represents the learning rate and
- D(t) stands for the input vector.

The datasets used in our tests have very high-resolutions although, in most cases, pixel-based segmentation and classification are not ideal for such imagery. Yet, as our image segmentation goal is to separate only the vegetation from the others, pixel-based segmentation met our need. In order to segment the orthophotos, a SOM network is generated with 9 layers and image data is prepared as a data matrix, where each row vector of the matrix represents one band of the image. The original orthophoto and the generated vegetation masks for the Dortmund dataset are shown in Figure 4.

Segmentation of the 3D point cloud

The region growing segmentation algorithm built-in Point Cloud Library (PCL) (Rusu and Cousins, 2011) is used in order to segment 3D point cloud with the aim of classification into buildings and GLOs. The algorithm (Fig. 5) basically detects points which are generating a smooth surface if they gather together, and this is decided by comparing the surface normal of the neighbour points.

In order to make this comparison, the algorithm first calculates the curvature values for each point, which is based on normal. As the points with minimum curvature are placed in planar regions, all the points are sorted with respect to their curvature values in order to detect the seed points with minimum curvatures. The points are labelled till there are no unlabelled points left. Before applying the region growing segmentation to the point cloud, we project the vegetation mask previously generated onto the point cloud (Fig. 6). This allow to label points as vegetation or non- vegetation and to automatically generate a masked 3D point cloud (Fig. 7).

The region growing algorithm is then applied to the masked point cloud, adjusting minimum-maximum number of points

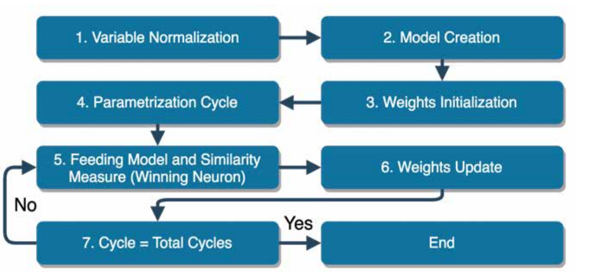

Figure 3. Network Operation of Kohonen's SOM.

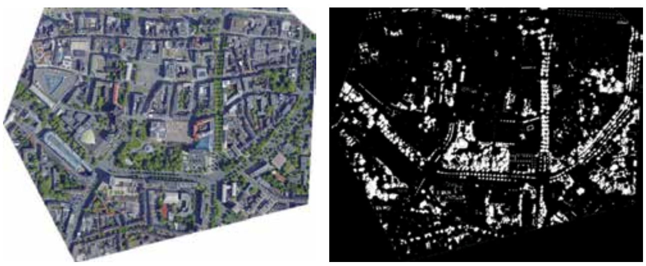

Figure 4. Original orthophoto (left) and the created mask (right) for Dortmund City Center.

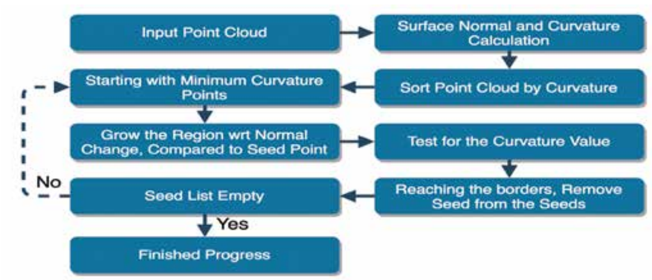

Figure 5. A brief summary of region growing algorithm

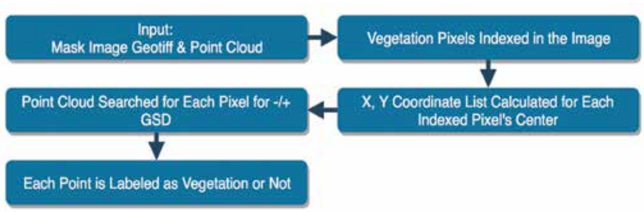

Figure 6. The process for the projection of vegetation mask to the cloud

per cluster, normal change threshold as well as curvature threshold. This allow to distinguish buildings, streets and GLO assigning a different ID per point. Merging all segments, a classified and segmented point cloud is obtained (Fig. 8).

3D building modeling

Once building structures are identified in the point cloud, the geometric modeling is performed using Mapple (Nan, 2018) and PolyFit (Nan and Wonka, 2017) tools. Mapple is a generic point cloud tool that can handle normal estimation, down sampling, interactive editing and other functions. Mapple is used to extract planar segments from the point cloud based on RANSAC algorithm (Fig. 9a). Then, accepting these preliminary planes as candidate faces, PolyFit, creates an optimized subset based on angle between adjacent planes ($\theta<10°$), and minimum number of points can support both of the segments (select minimum of number of points in segment 1 and 2, divide this amount by 5). Using this optimum subset of faces, a face selection is performed (Fig. 9c) based on the following parameters;

- *Fitting*, i.e. a measure for the fitting quality between the point cloud and the faces, calculated with respect to the percentage of points that are not used for the final model;

- *Point coverage*, i.e. a fraction related to bare areas in the model, calculated with respect to the surface areas, candidate faces and 2D α-shapes, which is basically a projection of points to the plane;

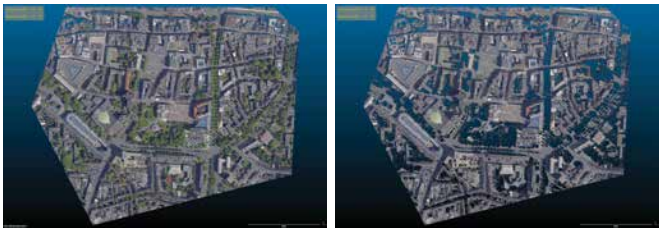

Figure 7. Original 3D point cloud of Dortmund City Center (left) and masked cloud showing everything but the vegetation (right).

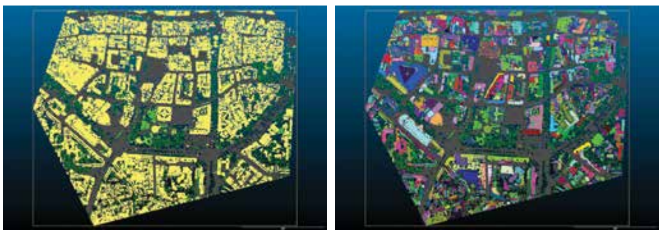

Figure 8. Classification and segmentation result for the point cloud of Dortmund City Center: classification (left) of buildings (yellow), vegetation (green) and GLOs (grey); final results (right) with separated buildings.

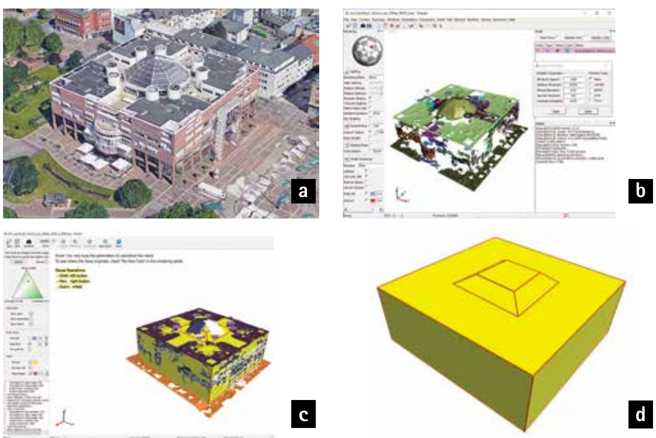

Figure 9: A building (City Hall) to be modelled from the dense point cloud (a); the Mapple tool with its parameter settings for primitive extraction (b); PolyFit interface (c); resulting 3D building model for the City Hall in Dortmund (d).

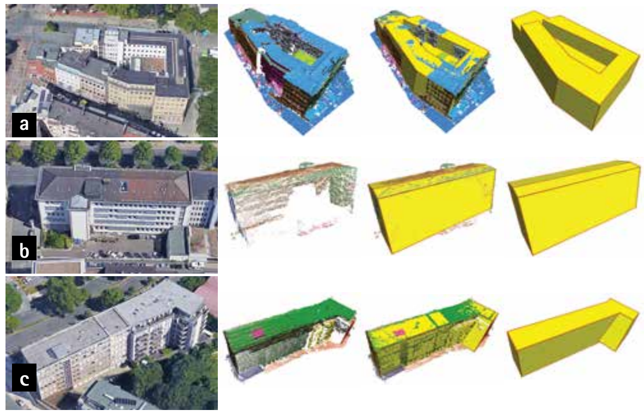

Figure 10. Examples of 3D reconstructions for different buildings extracted from the Dortmund point cloud. Some façade or roof details, if not well surveyed by the point cloud, are not correctly modelled.

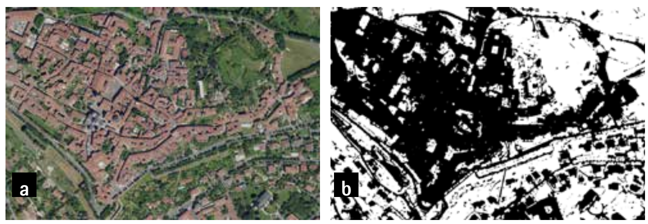

Figure 11. Original orthophoto (a) and the vegetation mask (b) for the Bergamo dataset

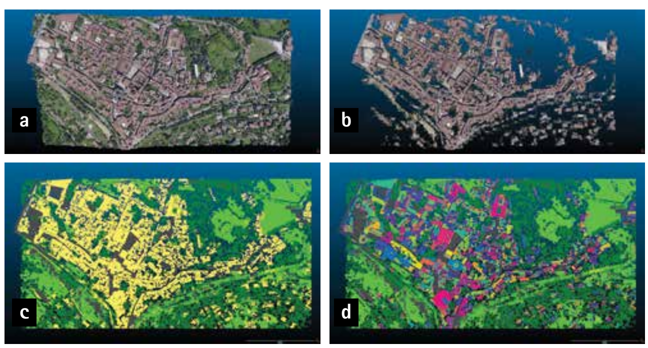

Figure 12. Original 3D point cloud (a) masked 3D point cloud (b), classification result (c) and classification results with separated buildings (d).

- *Model complexity*, i.e. a term to consider the holes and outgrowths, calculated as a ratio of sharp edges and total amount of intersections of the pairs.

These parameters can be adjusted in an iterative way during the 3D reconstruction process, which includes refinement, hypothesizing, confidence calculations and optimization procedures. Figure 9d and Figure 10 show examples of derived 3D building models from the Dortmund point cloud.

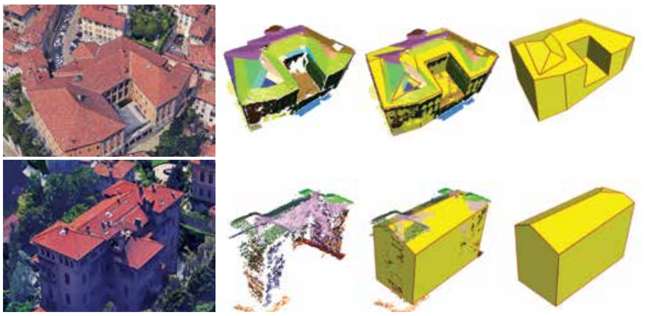

Figure 13. Examples of 3D reconstructions of different buildings from the Bergamo dataset: oblique view, planar areas of the cloud identified with RANSAC, optimized planar faces with geometric model and final 3D geometric model, respectively. Some problems are present in areas where the point density (or noise level) is not allowing a correct plane fitting

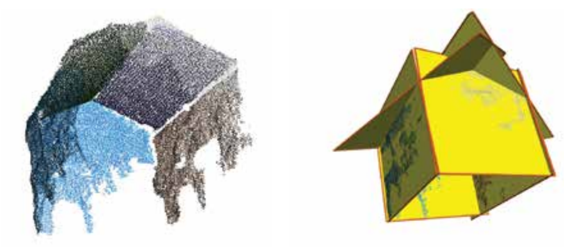

Figure 14. Input point cloud (left) and selected face candidates (right), where no face exists for the bottom of the building

Further results

The proposed methodology, which includes automated image segmentation for vegetation mask generation, separation of the point cloud using this mask, segmentation and classification of the separated point clouds, and 3D reconstruction, was tested also on the Bergamo datasets. The given orthophoto and generated vegetation mask are shown in the Figure 12b whereas the application of the image mask to the dense point cloud produced the segmented point cloud of Figure 12b. Separation of the vegetation makes it easier for the following steps of point cloud segmentation and classification. The classification results shown in Figure 12c-d, and 3D building reconstruction results shown in Figure 13 demonstrate that our methodology also provided significant results in case of dense urban areas. Yet, we faced some cases where we could not manage to reconstruct the building due to a lack of points representing the ground level. An example can be seen in Figure 14.

Conclusions

The paper reported an ongoing work for the identification and modelling of buildings in photogrammetric point clouds, without the aid of ancillary information such as footprints. The achieved results show that pixel-based orthophoto segmentation is successful even for high-resolution images to generate a vegetation mask. Such mask aids the classification of point clouds to identify man-made structures. The point cloud segmentation approach, based on region growing algorithm, shows that this method can be a proper way to distinguish objects within the point cloud (i.e. building roofs, facades, roads, pavements, trees, grass areas), thus, useful for classification and modelling purposes. The geometric reconstruction of buildings, based on RANSAC and plane fitting, produced successful results although, in case of low points on facades or roofs, the modelling is not completely correct.

Among all processes, there are two main tasks handled manually at the moment: the setting of the region growing parameters, and the setting of segment numbers from the point clouds after segmentation for merging them. However, as this is an ongoing research, these two steps are going to be automated in the future. As other future works, we would like to bring all functionalities into one environment and upscale the methodology to an entire city.

Acknowlegments

The authors are thankful to Liangliang Nan (3D Geoinformatics group, TU Delft, The Netherlands) for his kind support.

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The point cloud segmentation approach, based on region growing algorithm, shows that this method can be a proper way to distinguish objects within the point cloud (i.e. building roofs, facades, roads, pavements, trees, grass areas), thus, useful for classification and modelling purposes

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Deformation analisys of modern crustal strain

The seismicity of the Sofia area is of particular interest because of the great activity and the proximity to the city of Sofia, so it is necessary to carry out the research of crustal movements in the area

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Geological data show that the region of Central-west Bulgaria is characterized by the presence of active deformations and modern seismic activity. The southern region of Sofia shows a complex tectonics formed by the intersection of several active faults. The concentration of seismic activity is mainly located in the south-southeast parts of the region as a result of the geodynamic processes. The seismicity of the Sofia area is of particular interest because of the great activity and the proximity to the city of Sofia, so it is necessary to carry out the research of crustal movements in the area.

Deformation analysis of modern earth crustal movements

There are several estimation methods for the availability of new measurement technologies:

In Frank's method (Frank, 1966) stresses are calculated by the angular rotation of two mutually perpendicular axes, and tensions are assumed to spread equally in space. This method applies to triangular measurements in two or more epochs. The method requires different epoch measurements to have the same network configuration.

In a different network configuration, the Prescott method (Prescott, 1976) is applied. This is a widespread method, which assumes that tensions spread equally in both space and time. However, this method does not produce good results in the presence of heterogeneous data.

The Simultaneous Reduction Method (Bibby, 1982) estimates the velocities gradient by assuming that the gradient is a constant throughout the network. The advantage of these methods is that they evaluate unambiguously the desired parameters. These result in a spatially averaged velocity field.

Another alternative approach is to eliminate the assumption of a spatially unified velocity gradient and to estimate the velocities of the points directly. Combining terrestrial measurements with GPS makes it possible to obtain a unique velocity field, and can combine different terrestrial networks to obtain a unified solution. Several studies have shown that such technique is applicable (Snay and Drew, 1989, Grant, 1990).

We use the method described by Dong (Danan Dong, 1993) for the calculation of stresses in the earth's crust using theoretically stringent, practically efficient and flexible techniques for combining heterogeneous data. Point positions are

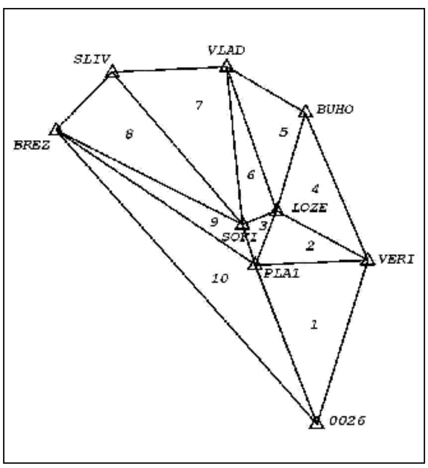

Fig. 1 Network sketch (Delaunay triangles)

Tabl.1. GPS epoch

GPS	epoch				
ID	1997	2000	2003	2005	2006
BREZ	X	X			
BUHO	X	X			
LOZE	X	X			
SLIV	X	X			
VERI	X	X			
VLAD	X	X			
PLA1	X	X			
TREB			X		
GURM			X		
KALN			X		
KOZN			X		
MACH			X		
KONO			X		
CHER			X		
0026			X	X	X

estimated as a function of time and also the field of velocities is obtained from different types of measurements at different times and in different network configurations.

GPS measurements used

For the study of active tectonic in the region several epochs of GPS measurements are used as shown ot Table. 1.

Processing data

The processing of GPS measurements has been done with the Bernese software version 4.2 (Bernese GPS software version 4.2). Coordinates of permanent stations used in the processing fix the coordinate and kinematic systems. In the study of the modern movements of the Earth's crust, interest in calculating velocities of the points, the accumulated strain and the magnitude and directions of the rotation in the network (Dimitrov N. 2013) (Dimitrov, Georgiev 2011). The principal strain axes and the sizes and directions of rotation in the network of elementary triangles have are calculated with FONDA (Forward Observation and Network Deformation Analysis) software.

Results

The principal strain axes and the magnitudes and directions of rotation in each Delaunay triangle have been obtained from the processing of the measurements. (Fig.2, Fig.3.)

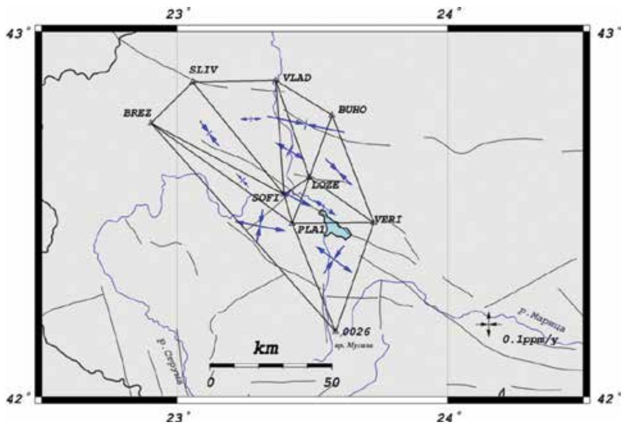

Fig.2. Principal strain axes.

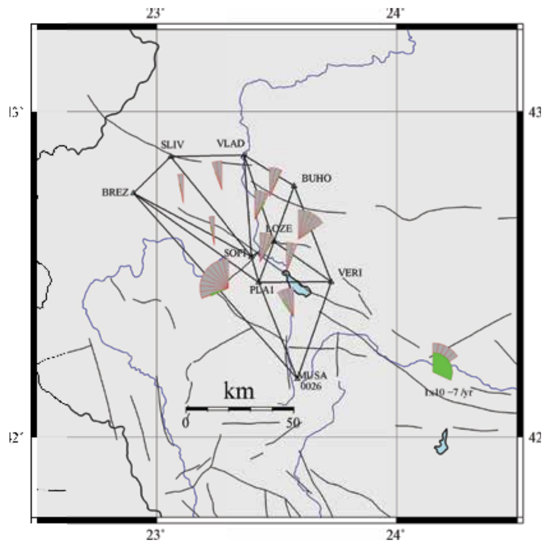

Fig.3. Rotation rates.

Conclusion

From the analysis of the results it is clear that rotations in the triangles north of the Iskar fault zone (northwest to southeast) are clockwise and those in the triangles located to the south of the fault zone are counter-clockwise. The difference in these directions, similar to result for strain and shows the existence of modern activity in the area. It may used to clarify the geological and tectonic environment. The obtained result for horizontal velocities, strain rate and rotation rate are in line with the overall north-south extension of southern Bulgaria and northern Greece - the South Balkan Extensive Area (Burchfiel et. All, 2000).

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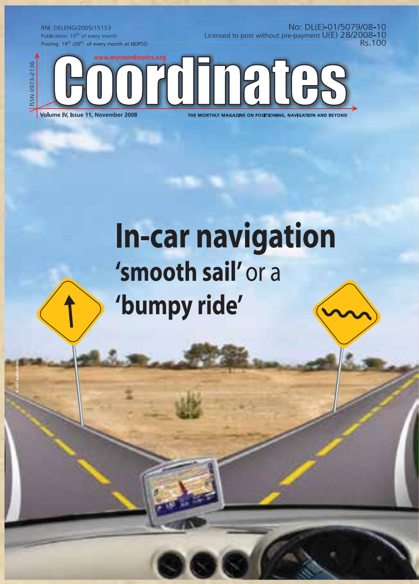
In Coordinates

10 years before...



mycoordinates.org/vol-4-issue-11-November-08/

Accurate geo-referencing and DSM generation with HRSI

Armin Gruen
ETH Zurich, Institute of Geodesy and Photogrammetry, Zurich, Switzerland

Satellite images are an interesting source for 3D mapping. However, they still do have a number of substantial disadvantages when compared to aerial images.

Navigation in India: smooth sail or a bumpy ride

Indian customers want cheap and best

Amit Prasad
Founder & MD, SatNav Technologies

Providing accurate and useful maps for Indian roads and cities is a formidable challenge

Shashank N Dhaneshwar
D.G.M.(Electronics)
Electronics, E & E, ERC, Tata Motors, Pune, India

We may see a repeat of the Telecom story in the navigation space

Shivalik Prasad
Vice President, MapmyIndia, India

Those who survive the initial bumpy ride would be there to reap the benefits later

Raghavendra Krishnamurthy
Group Manager, Bosch

"The whole industry has been overly optimistic"

Magnus Nilsson
Chief Executive Officer, Wayfinder

The last mile is still a challenge

Ashutosh Pande
MD Indian Operations, Sirf Technologies

PND in India definitely holds a lot of potential, but it will not be "bed of roses"

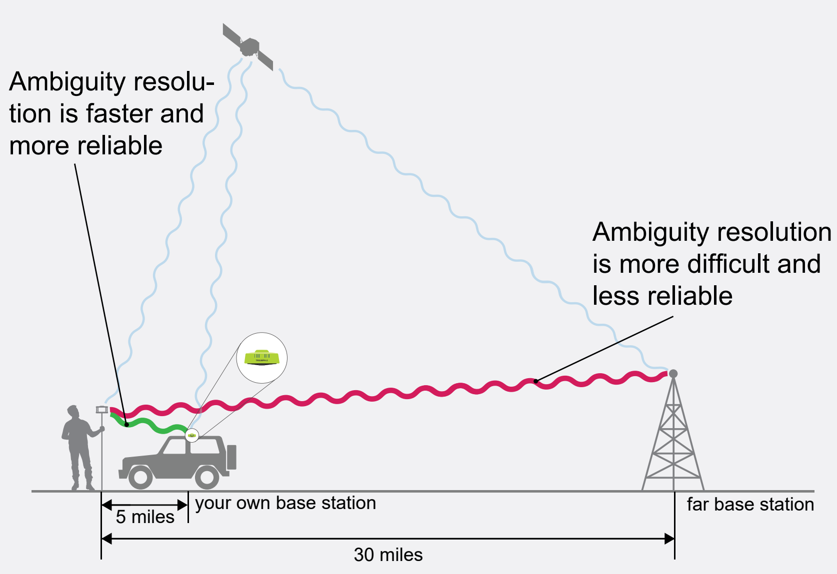
Alok Shankar
Managing Director, Brightpoint, India

JAVAD

www.javad.com

Front

Advantages of your own base station and short baselines



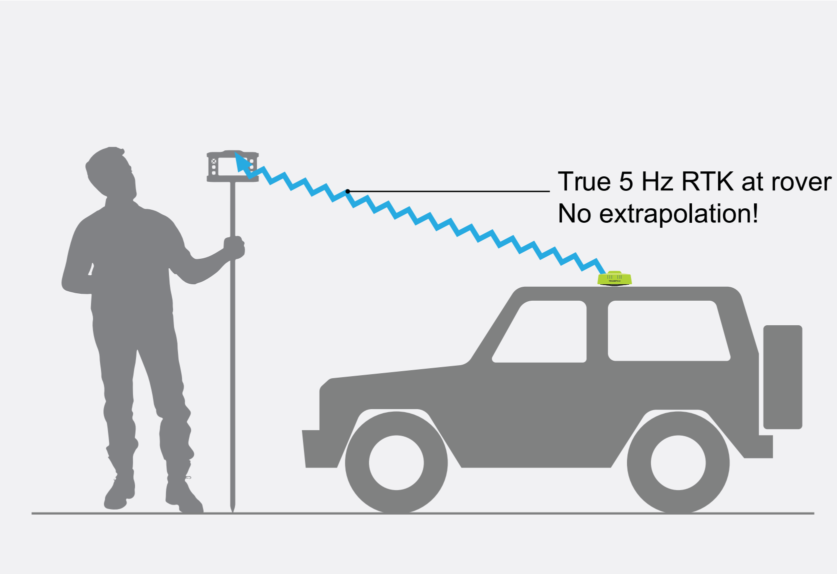
1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.

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

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

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

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



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

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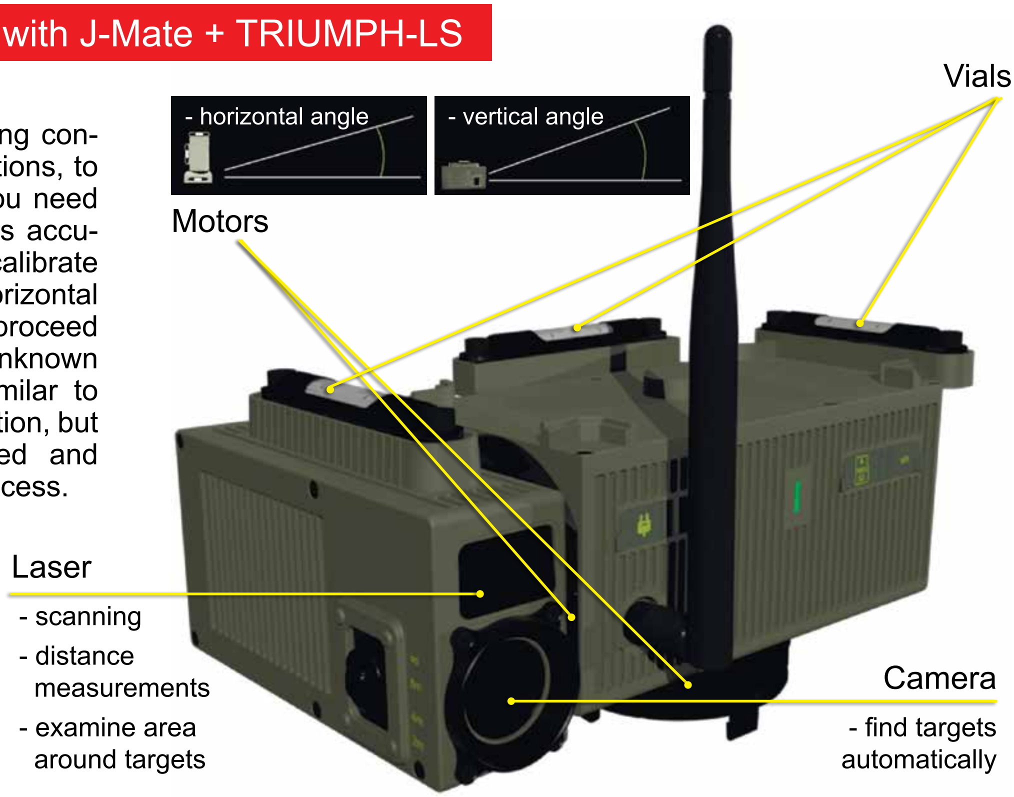
Why follow a workflow designed for yesterday's equipment?

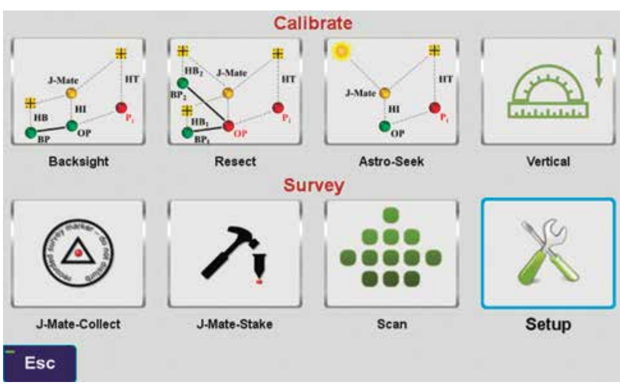
This is J-Mate

J-Mate features a **camera** that can also find targets automatically, and a **laser module** for accurate distance measurements. It scans and examines the area around the intended target to ensure reliable identification. Two **precision encoders** measure vertical and horizontal angles to the target. Three **precision vials** allow a visual check on levelness of the instrument.

Take control with J-Mate + TRIUMPH-LS

Similar to using conventional total stations, to use the J-Mate you need first to establish its accurate position and calibrate its vertical and horizontal encoders. Then proceed to shoot the unknown points. This is similar to using any total station, but we have improved and automated the process.





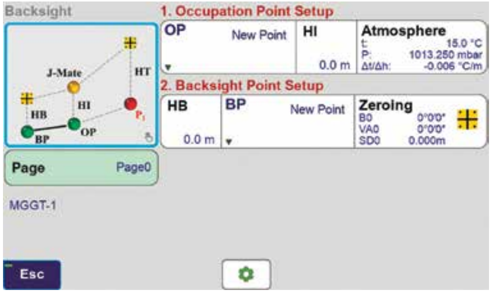
With J-Mate you can establish your occupied position via three different ways: 1) Backsight; 2) Resection; or 3) our new Astro-Seek (more of that later).

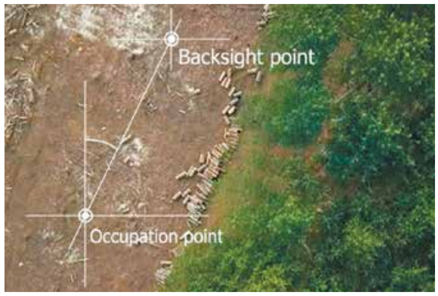
When you click the Setup icon of the J-Mate screen you get access to parameters that tunes J-Mate to your desire.

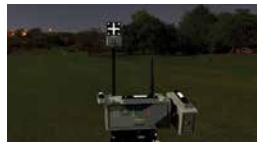
After the J-Mate is calibrated, you can proceed with your work as normal via the Collect or Stake icon.

Backsight icon

If GNSS signals are available at the job site, click the J-Mate Backsight icon.



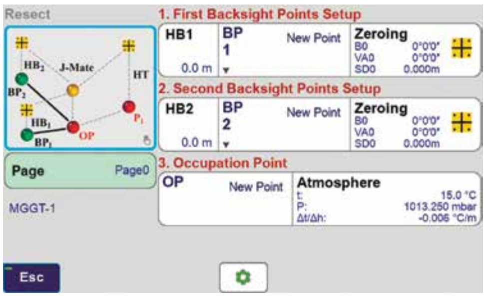


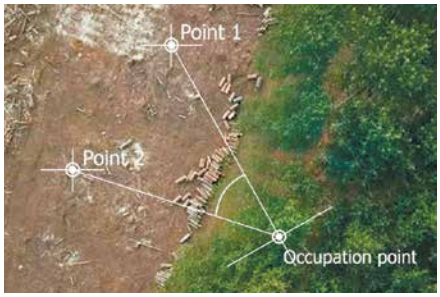


This screen appears which guides you to determine the accurate positions of the Occupation Point and the Backsight Point, to establish an azimuth and calibrate the J-Mate angular encoders.

Resect icon

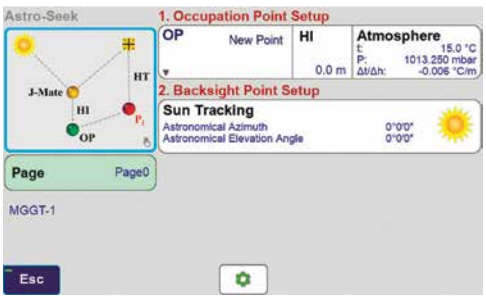
If GNSS signals are not available at the Occupation Point, click the “J-Mate-Resect” icon





Shoot two or more known points to establish an accurate position and calibrate the encoders. Then continue to shoot the unknown points.

Astro-Seek icon

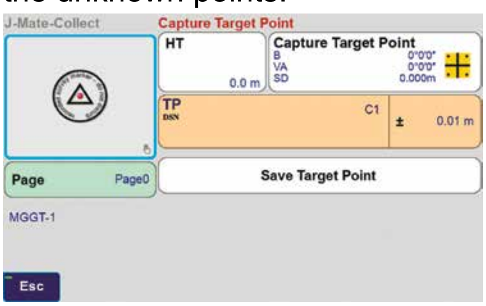


And now our new feature!

We have added a new innovative feature to the J-Mate that it can automatically calibrate itself via its automatic Sun or other astronomical objects-Seeking feature.

J-Mate-Collect

After calibration is performed, click the J-Mate-Collect icon to shoot the unknown points.



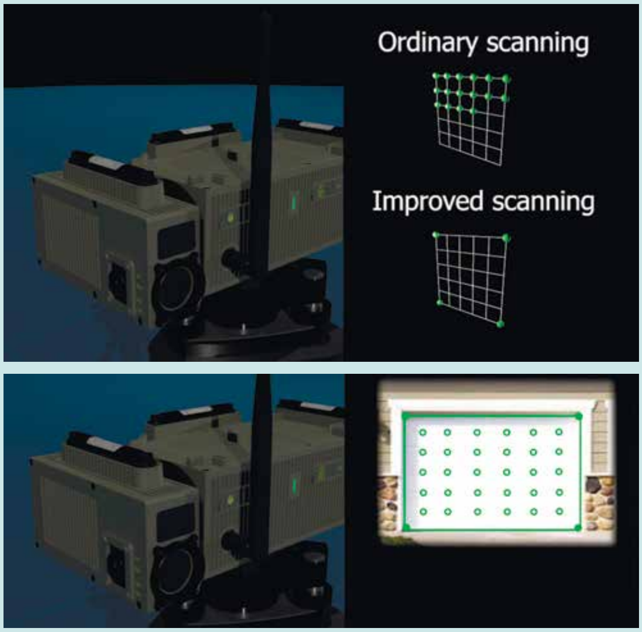
J-Mate-Stake

Click the J-Mate-Stake icon to use for stakeout.

The functions and features of the J-Mate stakeout are very similar to our conventional GNSS stakeout: RTK solutions guide you to the stake points. But with the J-Mate the camera follows the “+” sign that you carry and then the encoders and laser measurements (shown on screenshots) provide guidance to the stakeout features. This is similar to Visual Stakeout and other useful and innovative features of our TRIUMPH-LS GNSS RTK stakeout.

Smart laser scanner

J-Mate is also a camera-aided, smart laser scanner. The camera identifies redundant points that do not need to be scanned, but instead can be copied or interpolated from other readings without loss of information. That is, if the camera identifies a completely uniform flat area, it only scans the four corners of that area and interpolates in between. This feature can increase the effective speed of the scanner to much higher than its native 10-points-per-second speed.



The scanning feature can also be used to find items like wires and poles and "closest-in-view" items and shoot them automatically.

Seize the day with J-Mate + TRIUMPH-LS

And all components fit in this small carrying case.

So we have a "**Total GNSS**" with a "**Robotic Total Station**" and a "**Smart Laser Scanner**". We call it our **"Total Solution"** and it can be operated by one person to perform jobs.

Hybrid RTK

Triple-Check your RTK results and ...

It triple checks the accuracy of RTK solutions by post-processing and CORS processing. In addition, if RTK can’t a get fix (because of bad environment or bad communication with Base) Hybrid RTK comes to your rescue... automatically.

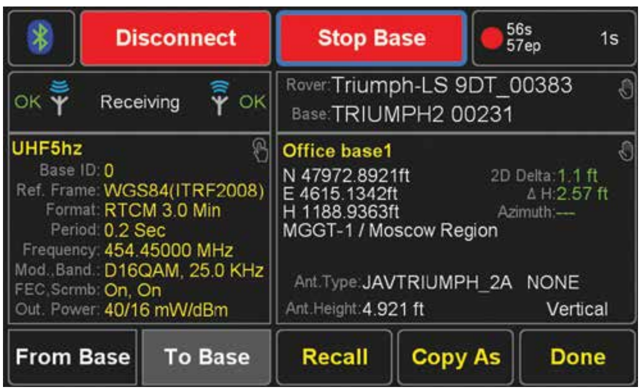
Nine Automatic Steps of Hybrid RTK

Confidence and Speed... Unlimited!

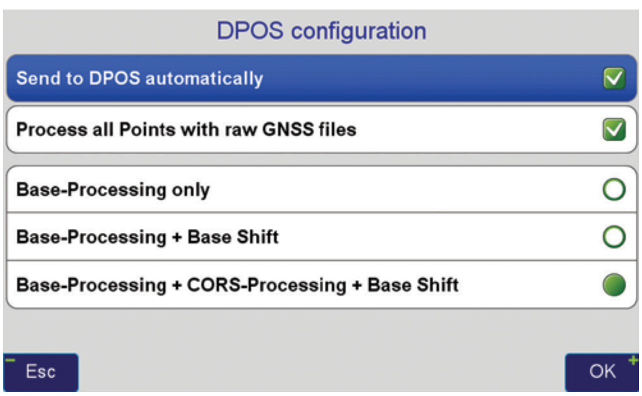
You do this

1 Downloading base data.

When your RTK job is finished, go to your base and in Base/Rover screen click “Stop Base”. Base data will be downloaded to TRIUMPH-LS via fast Bluetooth automatically. All of the following steps will be performed automatically too when WiFi/Internet connection is established.



DPOS options



Automated steps

2 Base data downloaded.

3 Awaiting DPOS server connection.

4 Rover points and base data sent to DPOS. Awaiting DPOS to process base-rover.

5 Rover points processed with base (relative).

6 Base data sent to DPOS to be processed with CORS data. Awaiting CORS data.

7 Base processed with CORS and corrections applied. (Absolute)

8 Base and rover points sent for CORS processing.

9 Rover points individually processed with CORS data.


Where Have You Been With Your TRIUMPH-LS Lately
"Got some shots that he could not get with our gr5's."
"I often get 2 days of work done, in a day."
"Truly amazing with a 4" grape vine directly overhead and the tree cover."
"The LS has increased our productivity 2:1."
"I got some ridiculous 'fixes' today in some horrible situations. Reset receiver, moved around, etc. Tried to get a bad fix but had a hard time doing it."
"I often get 2 days of work done, in a day."
"Btw, pardon my French, but holy shit. I got some ridiculous 'fixes' today in some horrible situations. Reset receiver, moved around, etc. Tried to get a bad fix but had a hard time doing it."
"Since I got the Javad system, I go places NEVER BEFORE possible, and WITH confidence, because, the quality checks are there."
"This thing is bad ass!"

Its4land - Developing innovative geospatial tools for fit-for-purpose land rights mapping

The its4land project builds on strategic collaborations between the EU and East Africa to deliver innovative, scalable, and transferrable ICT solutions

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In Sub-Saharan Africa, and also in many developing regions, there are numerous activities for land tenure recording; however, the results are deviating from the experts' expectations (Zevenbergen et al., 2013). With the challenges of incomplete recordation and escalated land disputes, an innovation for fast, accurate and cost effective land rights mapping is clearly needed.

A new generation of innovative land tenure tools which are scalable, transparent and applicable in conventional institutions are emerging (de Vries et al., 2015). Therefore, the main aim of the of "its4land", a European Commission Horizon 2020 project, is to develop innovative tools that respond to the continuum of land rights, fit-for-purpose approach, and provide cadastral intelligence.

The innovation process is based on four emergent geospatial technologies: smart sketch maps, Unmanned Aerial Vehicles (UAVs), automated feature extraction, as well as sharing and publishing through geocloud services. The aim is to combine these innovative technologies with the specific needs, market opportunities and readiness of end-users in the domain of land tenure information recording in East Africa. Moreover, the tools target both top-down and bottom-up approaches and thus potentially support formal land registration processes, as well as informal community based land resource documentation. The project consists of a four year work plan, €3.9M funding, and eight consortium partners collaborating with stakeholders from Ethiopia, Kenya, and Rwanda that cover different land uses such as urban, peri-urban, rural smallholder, and (former) pastoralists. Major technical tasks include tool development, prototyping, and demonstration for local, national, regional, and international interest groups. However, equal emphasis is placed on needs assessment, as well as governance, capacity and business modelling.

This paper reports recent achievements, findings and challenges faced during the first half of the its4land project, as well as the potential opportunity for integrating all aspects of the project into a unique its4land toolbox. The paper concludes with future plans and ideas for the development of a sustainable business model for commercialization of the integrated suite of land tenure recording tools within the end-user markets.

Background

"The its4land project is a 'Research and Innovation Action' and is formally governed through the European Commission's Horizon 2020 Industrial Leadership program focused on international partnership building in low and middle income countries through the development of new technologies. More specifically the 'Leadership in enabling and industrial technologies – Information and Communication Technologies ICT (H2020- EU.2.1.1.)', under the call H2020-ICT-2015. The specific topic is 'International partnership building in low and middle income countries' ICT-39- 2015. As part of the global aim of the project can is also the idea of reinforcing strategic collaboration between the EU and Eastern Africa. It also aims to demonstrate how multi-sectorial, multi-national, and multidisciplinary design work can take place.

The consortium is multi-sectorial, multi-national, and multidisciplinary. It includes SMEs and researchers from 3 EU countries and 3 East African countries which are from Belgium (KUL – KU Leuven), Ethiopia (BDU-Bahir Dar University), Germany (WWU-University of Muenster; Hansa Luftbild), Kenya (Technical University of Kenya) the Netherlands (University of Twente), and Rwanda (INES Ruhengeri; ESRI Rwanda). In addition to technology development, the transdisciplinary work also develops supportive models for governance, capacity development, and business capitalization. Moreover, gender sensitive analysis is also incorporated.

Independent to European Commission project oversight, the project includes a dedicated Advisory Board (AB), Valorization Panels (VP), and communications and dissemination channels. The project also maintains its own ICT infrastructure to support project management, internal communications, and data management. The setup seeks to cover the depth and breadth of the land tool sector. The project operates in multiple locations across East Africa, with all case locations having different foci and including a mix of livelihoods and landscapes such as urban, peri-urban, rural smallholder, and (former) pastoralist areas.

Rwanda

In Rwanda there were huge changes with regards to land which aimed to regularize all existing lands under private, leasehold, and state tenures (Biraro, 2015a). To achieve this, a fit-for-purpose approach was used to rapidly record the whole country with an accuracy of 1-5m. More than 10 million land parcels were registered between 2009 and 2013. The challenge still remaining is how to keep the system up-to-date (Biraro, 2015b). As discussed also by Ho et al (2017) in Musanze, up-to-date land information is needed to balance the demand for urbanization and expand tourism. However, there are some economic and administrative factors that affect its realization due to current mechanisms and processes which do not actively facilitate data integration with the cadastral map to support decision-making processes. During field visits, the its4land team observed that basic topographic information such as buildings, plots and visible infrastructure, etc. is still missing – data which is important for planning at all levels. Therefore, selecting a suitable geospatial technology which can be used for maintaining and updating land information in a fast and affordable way can potentially contribute to this challenge. In this context a lot of research has been conducted worldwide, and also in Rwanda, on using Unmanned Aerial Vehicles (UAVs) (Koeva et al., 2016).

Kenya

In Kenya, pastoralism constitutes 84% of the country's total land use (Lengoiboni et. al, 2011). Therefore, one of the main challenges for the its4land project is to find the most suitable solution for recognizing pastoralist land rights, most of which has been held under customary tenure arrangements, which up till 2016, were not constitutionally recognized as a legal tenure type. However, such land use is temporally and spatially dynamic. This is exacerbated by colonial and post-colonial land reforms that sought to privatize land rights but weak land governance systems have resulted in poor quality land information. This has led to a lack of transparency over land dealings, resulting in chronic land related conflict in the country. An aim for its4land in Kenya is to leverage the geospatial technologies to not only contribute to mapping pastoral land rights, but more generally to contribute to improving the quality of land information in the country.

Ethiopia

Its4land project in Ethiopia is focused on two different cases: peri-urban and rural landscapes. Bahir Dar is one of the fastest growing cities with dominant peri-urban territories where the growth is in all directions. In Ethiopia the urban and rural land administration is separated in different institutions. Moreover, with this complexities in the landscape to distinguish a clear boundaries is quite challenging. For establishing cadaster and land administration system in the urban areas different donors, stakeholders and authorities are joining their forces. After the analysis of the possible available tools, the usage of high-resolution UAV images, geocloud services, usage of sketchmaps and automatic techniques for boundary delineation are seen as potential solutions to improve existing designs.

In the rural areas high level land degradation and land fragmentation can be observed. For reducing poverty and enhancing land productivity, responsible land consolidation is seen as a solution (Bennett and Alemie, 2016). Therefore, in the rural areas in Ethiopia there is a clear opportunity for providing local stakeholders with information such as: up-to-date images and tools for recording land data to help in the consolidation process.

Contextualization-get needs

From the very beginning of the project the partners from KU Leuven started with their major task to capture the specific needs, market opportunities, and readiness of end-users in the domain of land tenure information recording. In 2017, they engaged with 57 organizations and community groups across the three case countries (more than 100 individuals) – Ethiopia, Kenya and Rwanda – seeking to identify relevant land issues, document land tenure information needs, readiness requirements for using its4land technologies and potential market opportunities.

The data collected indicate that cadastral data is still recognized as a critical land information need. This encapsulates common conventional requirements (e.g. accurate spatial data, tenure systems and inherent rights, restrictions and responsibilities (RRRs), and a range of socio-economic attributes of the right holder. The history of land-based conflict in these countries directed the need to acquire other ownership evidence (e.g. history of acquisition, neighbors, etc.) to support unambiguous determination of land tenure RRRs. Poor expropriation and compensation practices also stimulated the desire among communities for other property data (e.g. type of crops, fixtures on land, irrigation systems, etc.). Rwanda offered a point of difference: a centralized government focused on balancing urban-regional growth linked land information needs to development objectives. Therefore needs were focused on improving the quality of non-cadastral data and integrating this with the cadastral fabric for more insightful decision-making. In addition, since Rwanda's national land tenure regularization program has provided the government with a good source of data for decision-making, stakeholders agreed on the need to maintain the quality of cadastral data and improve data management especially data accessibility.

To meet these needs, UAV technology was considered to be of greatest potential to exploit. The other its4land tools – smart sketchmaps, automated feature extraction and geocloud services – had less clear innovation pathways, attributed to the difficulties that stakeholders often had in understanding the concepts behind the technologies, and often based their perceptions on the more familiar aspects of the technologies. Common readiness requirements identified included strategic requirements (align need with policies, political will and change leadership); structural and/or governance requirements (develop appropriate frameworks to direct action at a national level coordinate and manage new relationships between stakeholders for using the technologies and their data); organizational requirements (local changes that build organizational capacity including technical elements).

There was limited insight into potential market opportunities, with stakeholders generally believing that the likely 'market' for the its4land technologies lay in producing land information as a public good. In the short term, the main market will be the public sector; however, sound land information can lead to the development of secondary markets such as location-based goods and services in the private sector. The its4land technologies also likely face competition for resources in each of the countries, e.g. donor-funded certification and a rural land information system in Ethiopia, other fit-for-purpose technology testing in Kenya, and a reliance on proprietary GIS systems in Rwanda. In all countries, innovation will also likely disrupt existing workflows and processes.

Results – innovative tools for land recording

Software tool for recording land tenure information based on hand-drawn sketch maps

The work of the project partners from the University of Munster is related to the implementation of a sketch based geospatial data recording tool, called Smart SkeMa, especially tailored to capturing land tenure data from a local perspective. The main components of the work are (i) developing a domain model of concepts used in the description of land resources and tenures within localized contexts (e.g. at community level or within cultural groups); (ii) developing spatial models for representing sketch maps as records of land tenure information; (iii) developing methods for recognition of land tenure sketch maps and for embedding the sketch maps within existing spatial data sets (sketch map alignment).

The development of Smart SkeMa has been informed, in part, by data collected during field visits to Kenya and Ethiopia. These data were used primarily for the development of the domain model and the modules for recognition and interpretation of sketch maps.

Data collection - Field visits to Kajiado, Kenya and Bahir-Dar Ethiopia

Data collection was performed in workshops organized with communities. In Kenya the target community were pastoralists in Kajiado county and Ethiopia the community were an agricultural settlement on the outskirts of Bahir-Dar city in Amhara state. Each workshop consisted of an introductory lecture about mapping and how communities can develop their own land records using simple hand drawn maps. Then we carried out open discussions prompting the participants to discuss specific issues that they considered important and which could be more easily illustrated using maps. Some of the issues discussed included mapping of vegetation or water areas and some participants wondered whether these kinds of maps could be used for tracking changes in vegetation patterns.

Focusing on such land issues, spatial information was collected via freehand sketches and through discussions with participants. During the group discussions participants also contributed additional information or missing information in the prepared maps. From the two field visits to Kenya and Ethiopia, 73 sketch maps at two different scales were collected. Out of the 73 sketch maps, 44 are large area sketch maps while the remaining sketch maps contain detailed local information. This data was used in the design processes for both the domain model and the sketch recognition tool.

Object recognition system

For the sketch recognition part, three well-known matching approaches in the area of computer vision: template based matching, supervised learning using Haar cascades (Viola P, et al., 2001) and Histogram of Oriented Gradients (HOG) together with Support Vector Machines (SVM) were explored (Dalal N, et al., 2005). The quality of the images of sketch maps taken with a mobile phone could be further improved by applying the stroke detection technique of Epshtein et al. (2010).

Domain modelling

Domain model, termed the Maasai of Southern Kenyan Ontology (MSKO), was developed, by documenting concepts related to land usage in the Maasai culture in general from the literature and some concepts specific to the communities that were visited. The initial outcome, which was a glossary of terms, has been extended into a formal OWL ontology using Protégé as the modelling tool. Important concepts are annotated with images to clearly illustrate the associated concept for each term. The images and field data informed the design of the visual symbols to be used during sketching exercises.

Qualitative representation of land tenure maps

In the second quarter, the focus was more on current tasks especially on implementing the qualitative representations of input maps. These are necessary as an interface between the sketch map and the base map data. As with the sketch recognition work, all the components in python were implemented using Jupyter notebooks to provide better accessibility of the work. This work entirely technically involving the study of different ways to abstract away the details of numeric spatial representations (vector or raster) to obtain more cognitively plausible representations – such representations that preserve topology but do not guarantee preservation of distances.

Looking ahead

During the discussions with different stakeholders, it became apparent that while almost all stakeholders found the idea of smart sketch maps interesting, many of them did not fully grasp how it would work in detail. As such, a main goal for the project is to complete an initial demo that supports an end-to-end community mapping workflow. This will enable the engagement of potential users and open opportunities to test the tool in a real world application context.

In order to make the tool useful for local authorities as well we are also generalizing the MSKO domain model and linking it with the Land Administration Domain Model (LADM). A final step in this journey will be to provide simple user interfaces for interacting with each of the Smart SkeMa's components.

UAV- driven workflows for land tenure data acquisition

The team from University of Twente (ITC) designs, tests and validates a UAV driven land administration workflow. In order to do so, a logical approach studying first policy and legal developments regarding UAV regulations in general and focus on regulatory frameworks for UAV flights in East Africa in particular has been followed. Based on the outcomes of this legal prerequisite, a phase of test flights and prototyping provides guidelines to design efficient operational workflows which meet the needs of respective users. Data acquisition workflows encompass the whole operational UAV procedure including flight planning and preparation, field work, data processing and quality assessment. Key aspects concern regulatory frameworks, the minimization of ground measurements and the implementation of the UAV workflow into each country context.

After a detailed analysis of the existing UAVs, a fixed wing UAV DT18 PPK by DelairTech was selected. One of the main reasons refers to its capabilities for mapping large areas. With a flight time of up to 90min the UAV can capture more than 1 km² during one flight with a ground sampling distance of less than 3cm. This UAV allows for direct georeferencing which tremendously minimizes the time and costs for ground surveying / truthing activities. A data quality assessment of the tests flights performed in Toulouse revealed 5-8cm absolute geometric accuracy. Each of the above-mentioned African countries received the same UAV and pilot training.

UAV legislation

With Rwanda, Kenya and Ethiopia, all African case locations of its4land present a different setup when it comes to UAV regulations. Rwanda enacted its regulations in April 2016 whereas Kenya just gazetted its UAV regulations in November 2017. Although at a slow pace, Ethiopia is heading into the right direction to enforce a legislation that deals with UAV flights. A comprehensive research investigation of the current status of UAV regulations in a global context is outlined in Stöcker et al. (2017). The outcomes can help to approach relevant stakeholders and to provide guidance for upcoming flights even if legal frameworks are not yet enacted. At the time being, Rwanda showcases the best status: the its4land drone was quickly released from customs and is already registered at Rwanda Civil Aviation Authority (RCAA). Two dedicated pilots are in the process to receive their official Rwandan UAV pilot license which requires a CAA-approved practical and theoretical flight assessment. The third and final step to reach full implementation refers to the operator certification which requires a special license for the institution that operates the UAV. Here, INES Ruhengeri will strive to obtain this certification in the next three months. In the meantime, a local Rwandan UAV- company named Charis UAS Ltd. is certified to operate the DT18 for the its4land project. In Kenya, before the UAV regulations became legally binding (Nov 2017), the only way to commence UAV flights was the possession of a special flight permission. This exemption was granted for the its4land partner at the Technical University of Kenya and includes as special flight permission for three weeks at a given location. The release of the UAV equipment from customs as well as the legal flight permission in Ethiopia involves the biggest challenge as the use and import of UAVs is strictly forbidden. Sensitization and communication with respective authorities are ongoing.

UAV data collection

Several test flights with the DT18 PPK in Germany provide sufficient data to evaluate influencing parameter on the data quality as well as initial conclusions of technological opportunities and limitations of the UAV equipment. Different ground truthing strategies as well as various processing scenarios reveal valuable insights to guide initial test flights in Rwanda and Kenya. Time consuming field work to measure high quantities of GCPs becomes obsolete and makes large-scale UAV mapping a more feasible solution for practitioners that require high geometric accuracies (Stöcker et al. 2017). After a successful maiden flight in Rwanda, potential use cases are discussed with the authorities. Additionally, several data collection flights were completed in collaboration with Charis UAS and both the peri-urban as well as the urban study area in Rwanda are already captured with UAV images. Besides Rwanda, the special flight permissions for Kenya allows to conduct UAV data collection missions in the rural Maasai land and in peri-urban Kisumu.

Looking ahead

Data collection activities will increase in the next months. This rich database with various contexts, use cases and UAV flight settings will provide a profound basis to gain insight into UAV driven data acquisition workflows. Besides the research for the prototype of the UAV-based mapping workflow, knowledge transfer and capacity building in the African partner countries will play a key role. Presentations, workshops and customized tutorials will help to establish the UAV technology in the countries.

Tool for automated delineation of visible cadastral boundaries from UAV data

This innovation led by University of Twente (ITC) aims to design and implement a tool for automated boundary delineation for cadastral mapping. This is done by supporting the delineation of visible cadastral boundaries through automatically extracted features from UAV data. The tool is designed to delineate physical objects demarcating visible boundaries, which are assumed to make up a large portion of all cadastral boundaries. Those visible boundaries bear the potential to be extractable with computer vision methods (Bennett et al., 2010; Crommelinck et al., 2016; Zevenbergen and Bennett, 2015). Such an approach cannot deliver complete matching – as some cadastral boundaries are only social and not visible to optical sensors – however, even 50% matching would radically alter tenure mapping in terms of cost and effort.

The current functioning of the tool consists of (i) a methodology that automatically extracts and processes candidate cadastral boundary features from UAV data, and (ii) a procedure for a subsequent interactive delineation (Figure 1). Part (i) consists of two state-of-the-art computer vision methods, namely gPb contour detection and SLIC superpixels, as well as a machine learning part assigning costs to each outline according to local boundary knowledge. Part (ii) allows a user-guided delineation by calculating least-cost paths along previously extracted and weighted lines. The approach has been tested on visible road outlines in two UAV datasets from Germany. Results show that all roads can be delineated comprehensively. Compared to manual delineation, the number of clicks per 100 m is reduced by up to 86%, while obtaining a similar localization quality. The approach shows promising

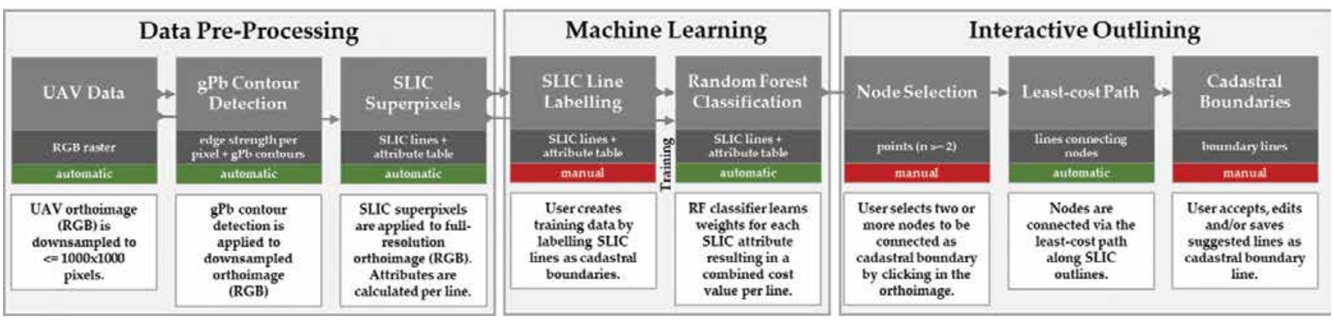

Figure 1. Delineation workflow for automated delineation of visible cadastral boundaries.

results to reduce the effort of manual delineation that is currently employed for indirect (cadastral) surveying.

The theoretical foundation for the tool development has been described and published (Crommelinck, S. et. al. 2016). The same applies for investigations on the state-of-the-art computer vision approaches, namely gPb contour detection and SLIC superpixels, that have been evaluated separately and determined as efficient for UAV-based cadastral mapping (Crommelinck, S. et. al. 2017a; Crommelinck, S. et. al. 2017b).

Future work will focus on the tool's transferability to different scenarios and its in-field applicability.

Tool integration

Publish and share

One of the primary tasks of the partners from Hansa Luftbuild is the development of a technical platform for hosting and integrating the results, methods and tools developed by the other project partners. The technical platform is considered as the publish and share platform. It can be considered on the on hand as a runtime environment for the tools developed in its4land and on the other as provider of integrating data and information in existing LAS or other tools. The implementation follows a toolbox approach. Publish and share provides a framework of common APIs and services used by all its4land tools. Following the toolbox approach user can select those its4land tools fitting best to his tasks. The publish and share framework can further be used to implement additional tools and methods.

The other main aspect of publish and share is the dissemination and share of data created by its4land tools to external user or systems. This will be done by service interfaces based on standards from OGC and W3C. The modeling of the interfaces follows the concepts introduces by LADM. External systems like LAS or planning systems can use this to integrate data into their own process, based on the specific national rules. The current focus is characterized by matching requirements from the investigation made by KU Leuven related with the needs and preparing a consolidated understanding of the proposed demonstrator platform. Major efforts has been made in the joined work with colleagues developing the tool for hand-made sketch maps in adapting LADM for qualitative data and creating qualitative extended spatial reference data from this input source. An algorithm to process semantic recognized sketched object and transform corresponding qualitative representations into (approximate) metric coordinates was developed. A proof of concept implementation of the algorithm was done.

The adapted version of the land administration domain model (LADM) forms the basis for organizing and integrating qualitative described data. The already developed algorithm to create (approximate) shapes for sketched objects will be developed to prototype level and integrated into the publish and share platform. This will allow using standard interfaces like OGC WFS/WMS, REST or GeoJSON by separating the internal model of qualitative described land tenure information and their representation.

The work will then focus on integration of the tools developed by the other partners into the publish and share platform. To follow the paradigm of geocloud, the tools will be encapsulated as services with an appropriate API. The usage scenarios and workflows to combine the its4land tools with land administration systems will be defined and implemented.

Govern and grow

To support scaling and sustainable use of the its4land technologies, KU Leuven is undertaking ongoing activities that deals specifically with the development of a governance model (including a model for capacity development) to support the use of innovative tools. Aligning with the fit-for-purpose approach, this will be done especially with the aim to meet stakeholders' needs and the creation and partial implementation of a capacity development model in order to strengthen the necessary skills and competencies so that the innovation process can have sustainable effects.

During the last months, the researchers of KU Leuven were focused on defining governance and capacity development, which aims to formulate an operational definition for governance and capacity development for the use of the its4land technologies. Therefore, a literature study was conducted to provide a short yet concise overview on widespread governance and capacity development definitions. This overview shed a light on a wide array of definitions, while specifically focusing on the theories and ideological standpoints useful for the its4land tools.

In order to extend and validate the gathered literature information and to avoid that western approaches and terms will be inappropriately imposed to the African context a panel of experts from valorization partners, exploitation managers and work package leaders were approached to give their views on the first version of the working definitions through an online survey. Their suggestions and recommendations were analyzed to refine and finalize the working definitions of governance and capacity development for the use of the its4land tools. From these activities, governance of the its4land tools is defined as *"the process of interactively steering the land tenure society to sustain the use of the its4land tools"* Capacity development for the its4land tools is defined as *"The development of knowledge, skills and attitudes in individuals and networks of people that are relevant for the uptake and sustained use of the its4land tools".*

The next phase 'Review of governance and capacity development models' aims to get a better interdisciplinary understanding of existing models of governance and capacity development. This involves an extensive literature review of contemporary publications on governance and capacity development models. Simultaneously, field work for empirical data collection will take place around this period. By the end of 2018, this theoretical review can be used for the development of the conceptual governance and capacity development models. These models will seek to draw on influences from other models for application to the its4land context, while being sensitive to the need to integrate different indicators from micro, meso and macro levels.

Capitalize

The last phase of the project involves the development of a sustainable business model for commercialization of the integrated suite of land tenure recording tools, within the end-user markets. Using the results from the technical work done in the project and in parallel with the work covering the development of sustainable governance and capacity building models, actor preferences (local communities, government, investors, and small and medium-sized enterprises) will be combined with products and services. This will be done in order to define a range of business model scenarios for the different sectors and case contexts. The results of the project will be commercialized and marketed as appropriate, as products or services, and offered to the public. In order to reach the above mentioned aim a valorization panel has been established with members from the three East African countries. During the field works of the colleagues from KU Leuven meetings were held with these members who were informed and updated about the project objectives and its progress.

Six exploitable results were identified by the project partners in a workshop on 16 October 2017. These results will form the basis in the exploitation and business modelling process which is now taking shape. The project partners are making use of the European Commission offered Common Exploitation Booster (CEB) support services in order to develop a business plan. These services aim to bridge the gap between research results and exploitation by helping the project partners in raising awareness on exploitation possibilities and exploitation planning. They also clarify issues, explore solutions and actions, and anticipate possible conflicts for a successful exploitation. In addition, they set up roadmaps for the long-term sustainability of the project results; and create value out of the novel knowledge.

Conclusions

All eight consortium partners of its4land project are collaborating to create new innovative tools that further support faster, cheaper, easier, and more responsible land rights mapping. This collaboration is particularly needed during fieldwork in Africa. Regular management, technical meetings and workshops are also organized. As an example, a CEB workshop is planned, which will be run by a senior expert from the META Group (under contract by the European Commission). After the workshop, the its4land business plan will be developed. The major tasks that were completed for the project during the past two years were related with assessing the specific needs, market opportunities, and readiness of end-users in the domain of land tenure information recording to support activities of the whole project. The work was focused in the case study locations in the three East African countries. The major achievements include the following: all the activities on contextualization were completed; the first version of the smart sketch maps ontology was done, UAVs for Land Rights A Guide to Regulatory Practice was written; a prototype for the automated boundary delineation was developed, UAV flight permission in Rwanda and Kenya were received; findings from its4land work were published in scientific journals, conference papers, posters and media.

Significant impact was also achieved in terms of establishing strong partnership with technology SMEs, linking more coherently with other Eastern African technology projects, utilizing our network to better interact with top-down and bottom-up users; and setting up media partnerships with reputable global geospatial industry publications, ICT advances, end-user understandings, enhancing innovation capacity etc. Overall, the results of the project are supporting not only Eastern African countries, governments, NGOs, and academia – but, also European Union (EU) technology, SME, and government sectors. This is done mainly by advancing EU geo ICT strengths, creating new and exploitable land tenure tools and strengthening EU-Eastern African partnerships. In the next period, the focus will be on knowledge sharing, global market access and potential social and environmental impact, mobile image processing and qualitative data processing platform, implementation of qualitative representation of sketchmap, documentation of extended LADM, writing of a technical report and manual on key flight scenarios and development of a business model.

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Converts static scans into immersive 360° imagery

NavVis can now automatically convert E57 point cloud files into interactive, realistic 360° walkthroughs, following the latest software upgrade to IndoorViewer. It is a web-based application that displays realistic digital twins using 360° panoramic images, point clouds and maps generated by 3D scanning devices. Users can move around digital twins of scanned spaces as if they are on site and use the interactive functionality to add, search for and route to geo-tagged information and take accurate measurements.

The intuitive user interface and functionality has made NavVis IndoorViewer a valuable deliverable for laser scanning professionals who want to extend the use of point clouds beyond BIM models and building plans to a wider range of building stakeholders who would also benefit from 3D scan data. *www.navvis.com*

Russia to launch egyptian remote sensing satellite

Russia will launch an EgyptSat-A earth remote sensing satellite on a Soyuz-2.1b carrier rocket on December 27, a source in the Russian space industry told Sputnik.

The EgyptSat-A is being built by Russia's Rocket and Space Corporation Energia (RSC Energia) for Egypt's National Authority for Remote Sensing and Space Sciences under a deal worth $100 million.

"Roscosmos has approved December 27 as the launch date for the earth remote sensing satellite built by RSC Energia under a contract with Egypt," *https://sputniknews.com*

KhalifaSat successfully launches into space from Japan

The most sophisticated satellite built by the UAE was successfully launched from an island off the southern tip of Japan this morning, in a new landmark for the country's space programme. KhalifaSat, the first satellite designed, tested and manufactured entirely by Emirati engineers, was designed and built at the Space Technology Laboratories, at the Mohammed bin Rashid Space Centre in Dubai.

Its role will be to beam high-quality images to the ground station in the emirate. The pictures will help governments and private companies across the globe with climate changes, disaster relief, urban planning, and more.*www.thenational.ae*

Vietnam to launch MicroDragon earth observation satellite

MicroDragon, a miniaturized satellite developed by Vietnamese engineers, is scheduled to be launched in December with the assistance of Japan. The launch was announced on October 18 by the Vietnam National Space Center (VNSC), as part of a joint Vietnam-Japan project on disaster and climate change prevention using earth observation satellites.

According to VNSC Deputy Director Vu Anh Tuan, the project has helped establish a disaster warning, resource management, and environmental monitoring system by developing the infrastructure of the VNSC and transferring satellite manufacturing technology. Vietnam's earth observation satellite is expected to provide imagery of a specific area within 6-12 hours, compared with at least two days when ordering from a satellite imagery provider.

The satellite will be used as a tool to help with preventing and mitigating the impact of natural disasters and climate change as well as managing natural resources. Prior to MicroDragon, Vietnam had previously built PicoDragon, weighing 1 kilogram and was launched into orbit in November 2013. In the future, Vietnam plans to manufacture LOTUSat-1 and LOTUSat-2, two radar satellites weighing approximately 600 kilograms each. *www.satellitetoday.com*

Saudi Arabia completes SaudiSat-5 RS satellites

King Abdulaziz City for Science and Technology (KACST) of Saudi Arabia has completed the development and manufacture of the SaudiSat-5A and SaudiSat-5B remote sensing satellites. Both are the second generation of Saudi-made Earth observation satellites, replacing the SaudiSat-2 (launched in 2004) and SaudiSat-3 (launched in 2007) remote sensing satellites that were also manufactured by KACST, SpaceWatch.Global reports.

The two 200 kg high-resolution Earth observation satellites are to be launched later this year from China, via a Long March 2D launch vehicle from the Jiuquan Satellite Launch Centre in the Gobi Desert.

The SaudiSat-5 satellites will be used to provide high-resolution images of the planet's surface from low-Earth orbit, and will help with urban planning, monitoring movements and changes on the Earth's surface. They should also provide Saudi government agencies with services - in particular high-resolution satellite imagery. *https://gbtimes.com*

Maxar technologies' digitalglobe partners with vodafone

DigitalGlobe, a Maxar Technologies company has announced the release of Sensing4Farming, an Internet of Things (IoT) product for smart, digital and precision agriculture created in partnership with Vodafone Spain, part of Vodafone Group, one of the world's largest telecommunications companies. Sensing4Farming provides crucial insights about crop health to farmers, agronomists, and agrobusinesses via computer, mobile phone or tablet to optimize agriculture productions. *www.DigitalGlobe.com.*

Government of Canada to invest $7.2 million in exactEarth

exactEarth Ltd., a leading provider of Satellite-AIS data services has announced that the Government of Canada ("GoC") will make an investment of $7.2 million over three-years to support the development, management and expansion of exactView RT, the Company's real-time Satellite-AIS service. The investment is being made through the GoC's Strategic Innovation Fund ("SIF"), a program designed to support businesses across all sectors of the economy by encouraging R&D that will accelerate the commercialization of innovative products, processes and services and will facilitate the growth of innovative firms. *investors.exactearth.com*

senseFly and IN-FLIGHT Data join forces

IN-FLIGHT Data, in collaboration with senseFly, completed North America's first urban BVLOS UAS (drone) project in a major city. The project, carried out in the city of Calgary, Alberta, was commissioned to collect mapping data to support the development of a new graveyard site, the city's first new cemetery since 1940.

The mapping of the area, completed using a senseFly eBee Plus fixed-wing drone, saw IN-FLIGHT Data's team conduct a total of 414 km (257 mi) BVLOS operations at an average distance of 2.35 km (1.46 mi) from the pilot, and began as part of IN-FLIGHT Data's wider BVLOS UAS operations trial earlier this year.

Restricted ground access to the site meant that remotely launched drone operations were the obvious option. Since the site was situated near a protected nature reserve and bird sanctuary, drone use also minimised the project's environmental impact, negating the need to drive vehicles onto the site and disturb wildlife

Raytheon delivers first SeeMe satellite to DARPA

Raytheon Company has delivered the first Space Enabled Effects for Military Engagements, or SeeMe, satellite to DARPA. Assembled on the company's advanced missile production lines, the new SeeMe satellite will provide greater situational awareness to soldiers on the ground.

DARPA's SeeMe program is designed to show that small satellites can be built affordably to give small squads timely tactical imagery directly from a small satellite. A future constellation of small satellites would deliver high-resolution images of precise locations of interest to the soldier's handheld device. *raytheon.com*

For India's second moon mission, isro tests cryogenic engine

India successfully tested the cryogenic engine for the heavy rocket that would launch the country's second moon mission on January 3, 2019, the space agency said.

"The cryogenic engine of the Geo Satellite Launch Vehicle (GSLV MK-III) in the upper stage has been tested for the Chandrayaan-2 Mission," said the state-run Indian Space Research Organisation (ISRO) in a statement here.

The crucial test was conducted recently for 25 seconds at the space agency's propulsion complex in Tamil Nadu's Mahendragiri, 685km southwest of Chennai.

The second lunar mission will be launched from the rocketport at Sriharikota in Andhra Pradesh, about 90km northeast of Chennai, with a lander and rover a decade after the first moon mission in October 2008 around its orbit. *www.ndtv.com/*

Australian space agency signs MoUs with counterparts in Canada, UK

The Australian Space Agency has formally entered into Memorandums of Understanding (MoUs) with counterpart agencies in Canada and the United Kingdom, as part of the Australia's plan to launch a "vibrant new space industry", according to a press release from the Department of Industry, Innovation and Science.

These MoUs will "help all three nations develop their respective space programs and take advantage of the rapidly-expanding global space industry," said the press release.

It is also investing more than $260 million to develop world-leading core satellite infrastructure and technologies, including better GPS for Australian business and regional Australians and improved access to satellite imagery. *www.spacetechasia.com*

Kinesis keeps markovitz fleet on track with integrated telematics

UK building supply company M Markovitz is using Kinesis telematics to track and manage its fleet of delivery trucks and staff cars. Integrated with fuel cards from UK Fuels, Kinesis delivers real time GPS monitoring of a vehicle's exact location improving customer service with more accurate ETA notifications. It also uses Kinesis driver performance data, fuel analysis, geofencing and is trialling the use of the Kinesis Maintenance App.

The location of delivery trucks, updated every 30 seconds and displayed using an easy to interpret map screen, is boosting customer service with more accurate and timely communications. Delivery ETAs can be calculated and shared at the start of day, updated, and resent, if required, as drivers complete their schedules. *www.kinesisfleet.com*

Garmin's latest watch features GPS, GLONASS and Galileo

Garmin is now offering a GPS, GLONASS and Galileo watch called Instinct, which is a strong and durable watch with GNSS support, plus built-in 3-axis compass, barometric altimeter and wrist-based heart rate sensor. The multi-GNSS feature helps users track their location in challenging environments.

Fujitsu and Ericsson team up on 5G partnership

Fujitsu Limited and Ericsson have entered an agreement to deliver end-to-end 5G network solutions and related services under a strategic partnership. The two companies are joining forces to develop this based on their combined portfolios – spanning radio access and core network – for the dynamic 5G market in Japan, connecting communications service providers to the global 5G ecosystem.

The two companies aim to initially provide systems and solutions for the Japanese market, and seek to further expand their collaboration to other customers globally. *www.ericsson.com*

Microsoft to invest $40 million in AI technology for humanitarian issues

Microsoft will invest $40 million to apply artificial intelligence to humanitarian issues, the third program in a previously announced series of AI initiatives.

The project, AI for Humanitarian Action, follows a $50 million pledge in AI for Earth and a $25 million investment in AI for Accessibility.

The humanitarian program will focus on disaster-response issues, needs of children across the world, issues affecting refugees and the broad category of human rights. *www.seattletimes.com*

HERE announces HERE XYZ

HERE Technologies has announced the availability of HERE XYZ, a real-time, interoperable and open location data management service. The service, currently in beta, fills a major gap for mapmakers and developers of location-aware applications by providing live access to uploaded data, complete flexibility in rendering tools, and cloud services to share your location data with the world in an instant.

HERE XYZ is built for a broad range of developers and users, from students to small and medium businesses, large enterprises, data journalists and cartographers. Developers in large organizations can make rich, interactive maps and location-aware applications that benefit from the robust tools and capabilities of HERE XYZ. *www.here.com*

Lockheed Martin partners with new Australian Institute of Machine Learning

A team of researchers from Lockheed Martin's Science Technology Engineering Leadership and Research Laboratory in Melbourne will move to Adelaide, South Australia to be co-located with Australian Institute for Machine Learning researchers.

The partnership will support honours, doctoral and post-doctoral R&D programs in the areas of national security – including next-generation machine reasoning for automated information processing and decision support – and advanced algorithm development for air, sea, land, cyber and space systems. *http://theleadsouthaustralia.com*

Honeywell partners with Fetch Robotics to deliver autonomous mobile robots

Honeywell has announced a strategic collaboration with Fetch Robotics to provide distribution centers with autonomous mobile robots to help them more effectively fulfill growing volumes of e-commerce orders.

The initiative enables Honeywell Intelligrated's customers to increase productivity and boost labor efficiency by deploying Fetch Robotics' autonomous mobile robotics, which operate safely alongside people to transport items through distribution centers without human guidance or fixed paths. By adding this offering to its smart robotics portfolio, Honeywell Intelligrated can provide customers with a range of flexible automation solutions that can be tailored to address current and future operational needs.

Momenta receives a new round of funding

Momenta, a China-based autonomous driving company, has announced that it has secured a new round of funding from industry-leading strategic investors and government funds at a valuation north of $1 billion, making Momenta the first autonomous driving unicorn company in China.

Momenta has world-class deep learning experts, including the authors of the most advanced image recognition frameworks, Faster R-CNN and ResNet, and winners of ImageNet 2015, ImageNet 2017, MS COCO Challenge and many other competitions. The team has grown significantly within the past two years with 80% of the Momenta team being researchers and developers.

Honda joins with cruise and general motors to build new autonomous vehicle

Cruise and General Motors Co. have announced that they have joined forces with Honda to pursue the shared goal of transforming mobility through the large-scale deployment of autonomous vehicle technology.

Honda will work jointly with Cruise and General Motors to fund and develop a purpose-built autonomous vehicle for Cruise that can serve a wide variety of use cases and be manufactured at high volume for global deployment. In addition, they will explore global opportunities for commercial deployment of the Cruise network. *www.gm.com*

First autonomous shuttle drives on Canada's public roads

Keolis Canada and the City of Candiac, with the manufacturer NAVYA, financial support from the Québec Government, the collaboration of Propulsion Québec, the Cluster for Electric and Smart Transportation and the Technopôle IVÉO have officially announced the first long-term demonstration project of a 100% electric autonomous shuttle on public roads in Canada.

The NAVYA Autonom Shuttle will operate in mixed traffic, this is a first step towards integrating autonomous shuttles into shared transportation solutions, in addition to complement the existing transport offer. The pilot project will begin in the summer 2018 for a period of 12 months, including 8 months at the service of citizens. During the winter, a research and development project to test the shuttle in Québec cold weather conditions will take place without passengers on board.

For this project, Keolis has obtained financial support of 350,000 $ from the Ministry of Economy, Science and Innovation as part of the measure to support demonstration projects in the action plan in favor of the industry of ground transportation and sustainable mobility.

Dr Yu Jiao receives Parkinson Award

The Institute of Navigation's (ION) Satellite Division presented Dr. Yu Jiao with its Bradford W. Parkinson Award on September 28, 2018 at the ION GNSS+ Conference (Miami, Florida).

Dr. Jiao was recognized for graduate student excellence in Global Navigation Satellite Systems in her thesis, "Low-Latitude Ionospheric Scintillation Signal Simulation, Characterization and Detection on GPS Signals."

The Bradford W. Parkinson Award is granted annually to recognize an outstanding graduate student in the field of GNSS, and is presented in honor of Bradford W. Parkinson for his leadership in establishing the U.S. Global Positioning System and for his work on behalf of the Satellite Division of The Institute of Navigation. *www.ion.org.*

Date of orbiting Glonass satellite to be set after next launch from Plesetsk

The date of launching another satellite Glonass-M will be set after the next launch from the Plesetsk space site in the Arkhangelsk Region, a source in the space rocket industry has told TASS. The Information Satellite Systems Reshetnev company earlier addressed the corporation Roscosmos with a proposal for orbiting a Glonass-M satellite from Plesetsk in November 2018, but Roscosmos and the Defense Ministry have not made up their mind yet. *http://tass.com/science/1027380*

GNSS-based emergency warning service successfully tested with QZSS

In the framework of GNSS cooperation between the European Union (EU) and Japan, a test was recently conducted of a GNSS-based global Emergency Warning Service using Japan's Quasi-Zenith Satellite System (QZSS), which delivered impressive results.

The EU is looking into the potential for deploying a new, global, emergency warning service (EWS) based on Galileo, as part of the EU Horizon 2020-funded GRALLE project (Galileo-based Reliable Automatic and Low Latent Emergency warning service), according to a European Global Navigation Satellite Systems Agency (GSA).

As the service should be based on a common alert protocol, one of the elements of the project is the development of a common alert messaging standard with QZSS, Japan's satellite-based augmentation system (SBAS). This was the reason behind the recent test of the system with QZSS in a suburb of Melbourne, Australia.

Google launches motorbike mode navigation in Kenya, first for Africa

Google, said it would offer Motorbike Mode on Google Maps in Kenya, offering the voice navigation service for bike riders in Africa for the first time.

Kenyan roads are full of motorcycles taxis, known as boda bodas, that are much cheaper rides to car taxis.

Google, already provides the service in India.

Google will also launch its Street View service in Kenya for the first time, allowing users to virtually explore via its images 9,500 km (6,000 miles) of roads in cities such as Nairobi and holiday destinations such as Malindi on the coast. *www.yahoo.com*

US Army to introduce new requirements for GPS receivers in weapon systems

The Army is drafting new rules for the use of GPS receivers in weapon systems and will create a training program for soldiers that operate these systems. Army is looking for ways to make weapon systems more secure against electronic attacks aimed at GPS signals.

The Army's goal is to protect systems and soldiers when they fight in "contested environments" where adversaries might attempt to disrupt GPS signals, said Willie Nelson, director of the Army's assured positioning, navigation and timing cross-functional team.

GPS signals are susceptible to interference such as jamming and spoofing. Nelson's office is writing a "capability development document" to address the need for assured PNT. *https://spacenews.com*

China launches 2 BeiDou-3 navigation satellites

China recently launched twin BeiDou-3 navigation satellites on a Long March-3B carrier rocket from Xichang Satellite Launch Center in Sichuan Province. The satellites entered their planned orbit after flying more than three hours, and will work with the 14 BeiDou-3 satellites already in orbit. The satellites are the 39th and 40th of the BeiDou navigation system, and the 15th and 16th of the BeiDou-3 family. *www.satellitetoday.com*

Russian scientists develop high-precision laser for satellite navigation

Scientists from ITMO University developed a laser for precise measurement of the distance between the moon and Earth. The short pulse duration and high power of this laser help to reduce errors in determining the distance to the moon to just a few millimeters. This data can be used to specify the coordinates of artificial satellites in accordance with the lunar mass influence to make navigation systems more accurate.

Both GPS and GLONASS systems are based on accurate measurement of the distance between a terrestrial object and several artificial satellites. Satellite coordinates must be as accurate as possible to ensure precise object location. Additionally, the moon's mass affects satellite trajectories. Therefore, lunar coordinates must be taken into account when calculating satellite position. The lunar coordinates are obtained by measuring the distance to the moon with laser locators.

Scientists from ITMO University's Research Institute of Laser Physics have developed a laser for a lunar locator capable of measuring the distance to the moon with a margin of error of a few millimeters. The laser boasts a relatively small size, low radiation divergence and a unique combination of short pulse duration, high pulse energy and high pulse repetition rate. The laser pulse duration is 64 picoseconds, which is almost 16 billion times less than one second. The laser's beam divergence, which determines radiation brightness at large distances, is close to the theoretical limit; it is several times lower than the indicators described for similar devices.

The new laser will be used in a lunar laser locator of the GLONASS navigation system. This will make it possible to correct satellite coordinates calculating in real-time, making the Russian navigational system more accurate. The margin of error when locating users may be reduced to 10 cm. *https://phys.org*

Goa, India to use GPS technology for Garbage Management

The high-level task force on solid waste management in Goa has approved the creation of a smartphone app –Black Spot Mobile Application to ensure that data about garbage blackspots are mapped and cleared across the state.

The authority felt the need of a mobile-based black spot tracker to monitor garbage dumping sites.

When a resident notices a blackspot he has to turn on the GPS, open the application and click the photo of that particular spot. The captured photo will contain metadata and will be geo- tagged. Then the app's software will process the data and identify the jurisdiction. After some time an SMS and email will be sent to the village panchayat or municipal body to pick up the garbage. *https://timesofindia.indiatimes.com*

GMV wins 250 million euro ground control contract for Galileo

Spanish company GMV won a 250 million euro ($290 million) contract recently to maintain and upgrade the ground control system for Europe's satellite navigation fleet Galileo over the next three years. The company's contract with the European Space Agency, signed in September, marks the biggest deal for GMV and the biggest for Spain's space industry. *https://spacenews.com*

European commission to make use of Galileo signals mandatory in smartphones

The European Commission (EC) is working to mandate that smartphones in the European Union (EU) should be equipped to use Galileo signals as well as other signals. This is a part of a broad space strategy that was launched in October 2016 to strengthen the EU's space program and maximize the benefits.

"The current practice of establishing caller location, which is based on cell-ID positioning, whilst available and guaranteed under the Universal Services Directive, is not accurate enough as it provides caller location based on the serving cell-tower of a mobile phone, which may not necessarily be the closest cell-tower," according to a discussion paper. "This area is dependent on the angle of coverage and cell radius. The latter can vary from 550 meters to several kilometers. In certain cases, notably in mountains and cities, this can lead to significant errors in positioning emergency callers."

FCC to vote on allowing US devices to use Galileo

The U.S. Federal Communications Commission will vote in November on whether to allow U.S. devices to access Galileo.

"Enabling the Galileo system to work in concert with the U.S. GPS constellation should make GPS more precise, reliable and resilient for American consumers and businesses alike," said FCC Chairman Ajit Pai.

In 2015, the National Telecommunications and Information Administration (NTIA) submitted to the FCC a request from the European Commission to waive certain of the commission's earth station licensing rules to permit non-federal U.S. receive-only earth stations to operate with Galileo.

The NTIA recommended grant of the requested waivers, and the International Bureau issued a Public Notice seeking comment on the potential public interest benefits and technical issues associated with the waiver request.

The FCC is proposing to waive its licensing requirements for non-federal operations with Galileo signals known as E1 and E5, subject to certain technical constraints, officials said.

The FCC includes conditions to ensure users of satellite-based positioning, navigation and timing services in the United States will benefit from Galileo signals. The systems are interoperable under a 2004 agreement.

Ordnance Survey releases first fully automated product

Ordnance Survey (OS) has released its first fully automated product derived from large scale source data, which means with the single press of a button OS can create a premium national dataset using the most up-to-date OS source data in just eight days.

The OS project team defined several objectives which included delivering efficiencies to OS by replacing the highly manual process of maintaining the product, improving the product currency, and implementing a'framework' system which could be re-used for other OS products. The development also introduced four core principles, which were fundamental to the project. These consisted of: trusting the data source (OS's geospatial database of half a billion features), only using commercial off-the-shelf tools (COTS), creating full end-to-end automation and delivering data quality which meets the needs of the end user.

The team delivered a fully automated map production process solution utilising range of the latest technologies, including Esri ModelBuilder and Python for geo-processing, Esri ArcGIS for publication of map images, as well as end-to-end system orchestration delivered by Workflow Manager. The solution also relies on the Azure cloud environment for data processing.

Boundless partners with the united nations on the UN open GIS initiative

Boundless have announced its partnership with the United Nations (UN) to support its UN Open GIS Initiative, which aides UN operations around the world through open source geospatial software and services. With Boundless' technology, the UN can leverage a hybrid architecture approach and maintain interoperability with existing software systems to maximize the value of its open technology and open data in global peacekeeping and other UN operations.

The UN Open GIS Initiative aims to identify and develop open source geospatial software and services that meet the requirements of UN operations, taking full advantage of the expertise of mission partners including member states, technology contributing countries, international organizations, academia, NGOs and the private sector. The scope of the initiative covers software development for the entire lifecycle of geospatial information at the enterprise level, from data collection, management and sharing to geospatial analysis and web and mobile applications. The initiative also focuses on the technology's sustainability and eventual transfer from the UN to other potential user groups as well as developing countries. *boundlessgeo.com*

Bentley systems releases open-source library: iModel.js

Bentley Systems has announced the initial release of its iModel.js library, an open-source initiative to improve the accessibility, for both visualization and analytical visibility, of infrastructure digital twins. It can be used by developers and IT professionals to quickly and easily create immersive applications that connect their infrastructure digital twins with the rest of their digital world. It is the cornerstone of Bentley's just-announced iTwin™ Services that combine iModelHub, reality modeling, and web-enabling software technologies within a Connected Data Environment (CDE) for infrastructure engineering. *www.bentley.com*

Global Mapper adds online access to NEXTMap One™ Elevation Data

Blue Marble Geographics has announced the immediate availability of NEXTMap® worldwide elevation data, including Intermap's newest generation NEXTMap One, as an online streaming service within Global Mapper. Developed by Intermap Technologies®, NEXTMap One offers both Digital Terrain Model (DTM) and Digital Surface Model (DSM) datasets at one-meter resolution for detailed analysis. With an active NEXTMap subscription, Global Mapper users can quickly and easily render these 3D datasets for an area of interest and make use of the software's extensive terrain and 3D analysis capabilities for contour generation, viewshed analysis, volume calculation, and much more. *bluemarblegeo.com*

Pointfuse launches New Point Cloud Processing Software

Pointfuse has released the latest version of its point cloud conversion software. Its 2018 version features a new cloud based data processing service, called Pointfuse Bolt, together with ground-breaking auto classification features and support for new laser scanning hardware and software formats. Designed to promote and support the practice of frequent capture it is set to disrupt workflows in mapping, modelling and measurement by supporting the development of intelligent, 'living' models that are easy to consume and easy to share. *http://pointfuse.com*

BAE : to deliver geospatial data under NGAs Janus programme

BAE Systems is one of two companies selected by the US National Geospatial-Intelligence Agency (NGA) to produce and deliver geospatial data to support the NGA, combatant commanders, and other government organisations.

The 10-year indefinite delivery/indefinite quantity (IDIQ) Janus contracts, worth up to USD1.52 billion, are designed to help NGA strengthen near real-time access to commercially created geospatial data, enriched content, and community-sourced information in a cost-effective manner to improve decision-making timelines, BAE Systems said. *www.marketscreener.com*

New tool developed by Esri and USGS

A new tool that gives users the most detailed view yet of the world's islands is now available from the USGS and Esri. And it's as close as your computer or cellphone. The Global Islands Explorer (GIE) is an online app that can help a variety of users, from researchers to policy-makers to the interested public, to locate and access basic information on hundreds of thousands of islands across the globe. The GIE is a web-based tool that allows the user to search for islands by name or by zooming in on a map of global islands. The island coastlines can be displayed on top of a number of different backdrop images like topographic base maps, satellite imagery, or an uncluttered light grey canvas. *https://doi.org*

Genesys initiates aerial survey for Jaipur's 3D city model project

Genesys International Corporation has started the mapping of the city of Jaipur using an array of latest technologies to create 3D models of each and every structure in the Jaipur Development Authority area having over 1 million buildings spread over 3000 square kilo meters.

For the first time in the country, a latest hybrid aerial camera system will be used which has Nadir, Oblique and Lidar sensors. The project flagged off by the Government of Rajasthan and RajCOMP Info Services (RISL) will aid the planning and development of Jaipur city. *https://m.dailyhunt.in*

Finance ministry, India launches " Jan Dhan Darshak"

Department of Financial Services (DFS), Ministry of Finance and National Informatics Centre (NIC), India has jointly developed a mobile app called Jan Dhan Darshak as a part of financial inclusion (FI) initiative . As the name suggests, this app will act as a guide for the common people in locating a financial service touch point at a given location in the country.

Jan Dhan Darshak app will be in a unique position to provide a citizen centric platform for locating financial service touch points across all providers such as banks, post office, CSC, etc. These services could be availed as per the needs and convenience of the common people. While over 5 lakh FI touch points (Bank branches, ATMs, Post Offices) have been mapped on this App, approx. 1.35 lakh Bank Mitras would be on-boarded by early December 2018. *http://pib.nic.in*

Punjab, India GIS portal

Tapping the IT potential for bringing efficiency, transparency and accountability in the Public Works Department, PWD Minister Punjab launched the Punjab Roads GIS Portal and Punjab Sarak Sewa (PSS) Mobile App recently.

PWD department with the technical support of NIC has prepared the GIS portal of Punjab roads wherein the details of all the roads as to whether they are State roads, National highways, roads of Mandi Board, link roads, District roads etc is available. Besides the other attributes of the roads like the length, width, crust thickness, year of construction, cost incurred and last repair undertaken would also be available. This will help the department to spruce up its work as availability of digital data will expedite planning / implementation. *http://punjab.gov.in*

Kalashnikov gunmaker creates satellite navigation signal suppressing system for drones

ZALA AERO, part of the Kalashnikov Group, has demonstrated a new device of satellite navigation signal suppression for UAVs.

The compact module is placed under an unmanned aerial vehicle's wing and suppresses the signal of satellite navigation systems within a radius of up to 5km, and also blocks the operation of all devices that use satellite navigational systems for navigation.

The satellite navigation signal suppressing system has been developed for Special Operations forces. The system can be used to neutralize an enemy's equipment that may pose a threat to defended facilities.

The new system will expand the range of electronic warfare devices developed by ZALA. It comprises the REX-1 anti-drone rifle and the ZONT man-portable device. The new satellite navigation signal suppressing system has undergone successful trials and proven its efficiency. *http://tass.com/defense/1027589*

DJI Rolls out Phantom 4 RTK Surveying Drone

DJI has announced the global rollout of the Phantom 4 RTK, a high-precision drone designed for surveying, mapping and inspection. According to DJI, a real-time kinematic (RTK) module is integrated directly into the drone, providing real-time, centimeter-level positioning data.

The RTK module can provide positioning accuracy of 1cm+1ppm (horizontal) and 1.5cm+1ppm (vertical). In addition, the drone can get 5-centimeter absolute horizontal accuracy of photogrammetric models, says DJI.

DroneShield Launches DroneNode Drone Security Device

DroneShield Ltd. has announced the launch of the additional product DroneNode, in response to end-user requirements. It is an evolution of the company's existing Drone Cannon product, a portable, compact and inconspicuous counterdrone jamming device which can be utilized at large outdoor events by law enforcement without raising public concern. This product is particularly relevant given the recent drone attacks, heightening the awareness of law enforcement globally to potential threats to high profile political targets. *www.suas-global.com*

FAA expands restrictions on drones near high-priority Navy bases

The Federal Aviation Administration (FAA) is expanding its efforts to keep drones from operating near high-priority Navy bases.

Drones will be required to maintain a distance of at least 3,000 feet laterally and 1,000 feet vertically from vessels operating in the vicinity of Naval Base Kitsap in Washington and Naval Submarine Base Kings Bay in Georgia.

The new regulation comes at the request of the Department of Defense and the U.S. Coast Guard, which have expressed concerns about drone overflights near sensitive locations for years. A separate FAA notice issued advises to drone operators to remain clear of DoD and Department of Energy facilities, mobile assets, and Coast Guard vessels nationwide. *https://abcnews.go.com*

Skycatch Edge1 now available worldwide

Skycatch has announced the first-of-its-class, on-premise data processing and GNSS base station, the Skycatch Edge1. Tested and optimized for the Skycatch Explore1 and DJI Phantom 4 RTK drones, the self-positioning Edge1 allows commercial drone users the ability to process and receive data without the need for internet or cellular connectivity. *www.skycatch.com*

PAE ISR Partners with NASA for 2020 Unmanned Aircraft Demo

PAE ISR, LLC, the original equipment manufacturer of the Resolute Eagle, signed a cooperative agreement with NASA to conduct a demonstration in the National Airspace System in 2020 and work toward full integration of unmanned aerial systems into the NAS.

The Resolute Eagle platform has the range and endurance to provide line of sight, beyond visual line of sight, and satellite communications-based beyond line of sight operating capabilities, enabling it to support a wide range of military, law enforcement, homeland security, humanitarian, and commercial missions.

The single, reconfigurable aircraft comes in two configurations—standard and vertical take-off and landing—with a flight endurance of 12 to 18+ hours depending on configuration. *PAEISR.com.*

FLIR announces DroneSense-FLIR Edition

FLIR announced the new DroneSense-FLIR Edition. This drone flight management software platform, designed for public safety applications, is the first collaborative product to result from a recent strategic investment in DroneSense. FLIR invested in the Austin, Texas-based unmanned aircraft system (UAS) software developer in April 2018. It is the only software platform to combine thermal and visual imaging processing with flight data planning and management capabilities, with the goal of improving incident and routine non-emergency response management for public safety organizations. *FLIR.com/DroneSense.*

EU 'GLAD-2' develop low-cost nav for UAVs

A European Union-funded initiative has developed a low-cost positioning and navigation system for unmanned aerial systems (UAS).

Using multiple antennas, the device is based on off-the-shelf components and advanced data-fusion algorithms. It fuses GNSS and inertial data to enable accurate and reliable navigation. The EU-funded Horizon 2020 GLAD-2 project developed the system. The work involved in-depth analysis of algorithms, hardware and software redesign, exhaustive refinement and repeated in-field testing.

Researchers used low-cost GNSS receivers, together with advanced data fusion with an inertial measurement unit, and barometer data to enhance the attitude and position of UAS in harsh GNSS environments. The system also avoided the use of magnetometers, making it immune to magnetic fields, and removing the need for system calibration when the magnetic environment is modified.

Engineers selected different GNSS antennas and measured their performance according to technical and economic criteria. A multi-antenna approach enabled UAS to take accurate headings without suffering the usual problems inherent to magnetometers.

Skyfish unveils on-board computing module

UAV technology developer Skyfish has introduced the company's computing platform for commercial drones that fully automates crucial infrastructure inspection and measurement tasks for the first time, giving drone service, communication infrastructure, and energy providers unrivalled performance and accuracy. *www.skyfish.ai/*

Drone Delivery Canada Integrates into Controlled Airspace

DDC's BVLOS Pilot Project commenced on September 17, 2018 and was completed on September 28, 2018. The Pilot Project flight operations were conducted in both day time and evenings on a set of approved flight paths. Throughout the Pilot Project, DDC worked closely with Transport Canada and NAV CANADA to ensure safety while also demonstrating the efficiency and efficacy of its Sparrow drone as well as its proprietary FLYTE management system. DDC is pleased to report that no flight safety incidents occurred, and each mission was completed successfully.

DDC's Sparrow X1000 cargo drone and DDC's proprietary FLYTE management system successfully delivered medical supplies, dry blood spots kits for HIV, Hepatitis C and general blood chemistry testing, as well as food, automotive parts and general parcels for many of DDC's customers which were present for the Pilot Project. These flights were conducted both to and from Moosonee and Moose Factory. *www.dronedeliverycanada.com*

Unifly and Terra Drone co-develop UTM system with Hitachi

Hitachi has launched a drone platform solution expanding their existing infrastructure inspection services portfolio with an AI-assisted, drone-based service. Moving from pilot controlled flights to automated drone flights Beyond Visual Line of Sight (BVLOS) is key to realizing the full potential of these drone applications. To that end, Hitachi provides a drone flight management system and drone maintenance services to support safe and secure autonomous drone flights.

In August 2018, Hitachi was awarded the contract for the development of the "Fukushima Robot Test Field" drone flight management system. The "Fukushima Robot Test Field" is the only test center with a drone operations management function at the Japanese large-scale demonstration laboratory. The goal of the test center is to further advance BVLOS drone flights.

Unifly and Terra Drone provide the technical UTM backbone to ensure safe BVLOS drone flights at the test center.

MSAB and URSA introduce XRY Drone

XRY Drone lets investigators extract and analyze data from popular drone models being used for illegal activity - to reveal flight paths, origin, behavior and other critical information that can identify operators. Police, corrections agencies, border control and military organizations around the globe are developing methods to counter the growing threat from drones. When a drone engaged in illegal activity is recovered, investigators need to extract, decode and view the data - to get actionable intelligence that can help lead them to the operators and organizers. *www.msab.com*

Eos supports Haiti Outreach in its sustainable water initiative

Eos Positioning Systems, Inc.® (Eos) is giving back to the global water community by supporting Haiti Outreach's sustainable water initiative. Haiti Outreach is a 21-year-old nonprofit organization dedicated to helping Haiti become a developed country. Haiti Outreach collaborates with individual Haitian communities to create and maintain access to potable water through community outreach, well digging, and distribution-network development. Haiti Outreach's community-led initiatives are heavily planned and prioritized, thanks to comprehensive field data collection and advanced geospatial analysis.

The Eos Arrow Gold GNSS receiver helps Haiti Outreach build and improve potable water distribution networks by providing accurate subfoot elevations required for hydraulic modeling simulations. The GNSS receiver uses Atlas® satellite-based corrections to provide real-time decimeter (three to five centimeters) location throughout the country.

Spectra Precision is now Spectra Geospatial

Spectra Precision has announced the launch of a new brand identity and name for its survey and GIS suite of solutions. The organization will now be known as Spectra® Geospatial.

Spectra Geospatial delivers quality products to the survey, GIS and construction markets. Focusing on the specific needs of the market, the Spectra Geospatial brand offers a complete product portfolio including GNSS, GIS, optical total stations, data collection hardware, field and office software.

New generation of manual total station by Leica

Leica Geosystems has launched the new manual total stations, the Leica FlexLine series. Building on the FlexLine series legacy of quality, durability and low total cost of ownership, the new Leica

Galileo update

Four more galileo satellites brought online

According to the European Global Navigation Satellite Systems Agency (GSA), Galileo Satellites GSAT0215, GSAT0216, GSAT0217, and GSAT0218, launched in December 2017, have been commissioned for operational use.

Since October 12, all Galileo satellites that were launched last year (in December) are usable for service provision, according to the GSA. GUs 2018023, 2018019, 2018020 and 2018018 announced the commissioning of Galileo satellites GSAT0215 (E21), GSAT0216 (E25), GSAT02017 (E27) and GSAT0218 (E31), increasing the number of satellites that are available for service provision to 18.

Galileo satellites Nicole (GSAT0215), Zofia (GSAT0216), Alexandre (GSAT0217) and Irina (GSAT0218), were launched on December 12, 2017 at 18:36 UTC, from the Guiana Space Centre (CSG) – Europe's Spaceport in French Guiana — with a nominal duration of 3 hours, 55 minutes and 45 seconds from lift-off to separation of the satellites.

Contract signing to boost performance and security of Galileo services

ESA has awarded a new framework contract and two new work orders to Thales Alenia Space in France, to upgrade the Galileo Mission Segment – that element of the worldwide Galileo ground segment dedicated to delivering navigation services – and the Galileo Security Monitoring Centre (GSMC) near Paris, as well as to implement a second GSMC in Spain, near Madrid.

The constellation in orbit is only one element of the overall satellite navigation system – the tip of the Galileo iceberg. At the same time as the satellites were being built, tested and launched, a global ground segment was put in place.

Establishing Galileo's ground segment was among the most complex developments ever undertaken by ESA, having to fulfil strict levels of performance, security and safety.

The first work order contracts Thales Alenia Space as prime contractor to undertake all necessary activities to upgrade the Galileo Mission Segment and the GSMC as part of Galileo's exploitation phase.

This work includes upgrading Galileo's system architecture to provide more accurate navigation products for broadcast by Galileo satellites, updating obsolescent elements in the current system and improving operability linked to the provision of services and enhanced robustness.

It also includes the construction of additional uplink stations – tasked with uplinking the latest navigation messages to the Galileo constellation – at the existing Galileo ground station sites of Papeete in French Polynesia and Svalbard in Norway. A new sensor station – providing a ground-based measurement of Galileo signal quality and precise satellite position – will also be installed at Wallis Island in the Pacific. The work order will also augment the capabilities for implementation of the Public Regulated Service (PRS), the single most accurate and secure class of Galileo signals. *www.esa.int*

FlexLine TS03, TS07 and TS10 models are designed to improve productivity in the field by automatically capturing height. Replacing the former manual total stations (Leica FlexLine TS02, TS06, TS09 and Leica Viva TS11), the new series is designed for reliability through extensive testing and comes standard with the latest in UX-focused software, Leica FlexField or Leica Captivate. Enabling quicker field-to-office data sharing, the TS07 and TS10 also offer integration of mobile data devices. *leica-geosystems.com*

M.App Enterprise 2018

Hexagon's Geospatial division announces a new version of M.App Enterprise for 2018, M.App Enterprise 16.5. This privately-hosted solution allows organizations to deploy Hexagon Smart M.Apps that dynamically address their location-based business problems. It is the ideal platform to monitor assets, evaluate changes, and take action, with the new release now including a native mobile client. The mobile workflow enables managers to assign tasks to field workers when it's necessary to act.

Hexagon acquire Bricsys

Its CAD platform, BricsCAD, supports 2D/3D general, mechanical, and sheet metal design and building information modelling (BIM) in one system. It's 100% based on the de facto standard design format (.dwg), providing designers, engineers, and BIM professionals powerful access to the huge potential of vertical CAD applications created by thousands of third-party developers. Bricsys also offers its own set of time-saving, artificial intelligence-driven add-ons – from conceptual modelling to seamless BIM workflows and cloud connectivity. Headquartered in Ghent, Belgium, Bricsys will be fully consolidated, operating within Hexagon's PPM division.

Unicore introduces GNSS/INS high-precision board, CLAP-B

Unicore Communications has launched CLAP-B, a multi-GNSS/MEMS integrated inertial navigation board, which integrates a miniaturized high-performance inertial measurement unit (IMU) on a compact high performance GNSS board. The high-accuracy GNSS positioning coupled with a high-precision gyro and accelerometer provides stable, continuous three-dimensional position, velocity and attitude, as well as original acceleration and angular velocity measurements, even in GNSS-denied environments.

New version of Inpho Software Suite

Trimble has announced a new version of its Inpho office software suite for photogrammetry. The suite includes two new capabilities:

- MATCH-3DX software for the creation of rich 3D point clouds and true orthomosaics
- MATCH-3DX Meshing add-on for the generation of photorealistic textured meses

Inpho version 9 combines the classical photogrammetric capabilities of the existing MATCH-T DSM product with modern 3D workflows.

Nomad® 5 handheld computer

Nomad® 5 handheld computer is the next generation of its rugged Nomad series of handhelds. Built for tasks such as data collection, asset management and inspections, it is designed to make the work of professional field teams easier, more productive and efficient.

The Nomad 5 is flexible and easy to use—an all-in-one versatile package that features a streamlined form factor, a 5-inch sunlight-readable touch screen and an Android™ 8.1 operating system. Intuitive to operate straight out of the box, it is certified to military (MIL-STD-810G) specifications for ruggedness and includes an all-day, user-replaceable battery, programmable hard keys, and a powerful 2.2 GHz Qualcomm® processor.

Pointfuse launches new laser scanning software suite

Pointfuse has released Pointfuse 2018 a new suite of laser scanning software which includes a cloud based data processing service called Pointfuse Bolt. Designed to promote and support the practice of frequent capture of digitized 'as built' data, it will help BIM practitioners create intelligent data that is easy to consume and easy to share. Pointfuse Bolt sits alongside other new developments that are set to disrupt workflows in digital construction by supporting the development of a living model helping to minimize project risk and mitigate unnecessary costs. *http://pointfuse.com*

VeraChoke GNSS antenna by Tallysman

Tallysman has introduced a high-accuracy choke ring antenna: the Tallysman VeraChoke. Adapting existing innovations on its patented VeraPhase antenna, Tallysman's VeraChoke offers a choice in form factor for reference and monitoring applications.

Swift Navigation introduces Starling

Swift Navigation has announced the availability of its Starling™ Positioning Engine with Broadcom's industry-leading dual-frequency GNSS receiver chip, the BCM47755. It is capable of delivering centimeter accuracy with minimal power consumption and small footprint for rapidly expanding precise positioning applications. It is a modular and portable GNSS high-precision positioning engine that leverages Swift's Skylark™ Cloud Corrections Service. *swiftnav.com*

DT Research introduces DT301T Rugged RTK Tablet

DT Research, the leading designer and manufacturer of purpose-built computing solutions for vertical markets, has announced the DT301T Rugged RTK Tablet (DT301T-RTK), a lightweight military-grade tablet that is purpose-built for GIS mapping applications with Real Time Kinematic (RTK) satellite navigation used to enhance the precision of position data derived from satellite-based positioning systems. This unique tablet enables 3D Point Cloud creation with centimeter-level accuracy – meeting the high standards required for scientific-grade evidence in court.

The DT301T-RTK is military-grade with an IP65 rating, yet lightweight - offering the versatility to be used in the field, office and vehicles. A dual frequency GNSS module is built into the tablet, which uses real-time reference points within 1 – 2-centimeter accuracy to position 3D point clouds created from aerial photogrammetry, using GPS, GLONASS and GALILEO receivers. *www.dtri.com*

SBG systems' navsight land/air solution

SBG Systems has released the Navsight Land/Air Solution, a full high performance inertial navigation solution designed to make surveyors' mobile data collection easier, whether it is mobile mapping, GIS, or road inspection. Built on a proven technology, Navsight strengthens SBG Systems position as leading innovator on the mobile positioning market.

Navsight Land/Air Solution consists in an Inertial Measurement Unit available at two different performance levels, and connected to Navsight, a rugged equipment embedding the fusion intelligence, the GNSS receiver, and all connections to external equipment such as LiDAR, cameras, computer, etc.

Navsight Land/Air Solution is the result of more than 10 years of experience in the mobile positioning industry, especially in the unmanned industry where position reliability is mandatory. SBG renown expertise lies in the fusion algorithms allowing the company to get the best performance from inertial, odometer, and GNSS technologies, excluding false GNSS fix, and improving the trajectory in complicated areas such as urban canyons, forest, and tunnels. The Navsight Land/Air Solution supports all GNSS constellations, RTK, and every Precise Point Positioning services (Omnistar, TerraStar, etc.).

SBG IMU are easy to install, as the sensor alignment and lever arms are automatically estimated and validated. Once connected to the Navsight processing unit, the web interface guides the user to configure the solution. *www.sbg-systems.com*

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16-18 Jan
Rotterdam, the Netherlands
https://tusexpo.com

GeoInsurance Europe 2019
22-23 January
London, UK
https://geo-ins-eu.coriniumintelligence.com

Cognizant Autonomous Systems for Safety Critical Applications (CASSCA) 2019
28-29 January
Reston, VA USA
www.ion.org

International LiDAR Mapping Forum (ILMF)
28 - 30 January
Denver, United States
www.lidarmap.org

International Technical Meeting (ITM)/ Precise Time and Time Interval Systems and Applications (PTTI) 2019
28-31 January
Reston, VA USA
www.ion.org

March 2019

2019 URSI Asia Pacific Radio Science Conference
9 - 15 March
New Delhi, India
www.aprasc2019.com

Munich Satellite Navigation Summit
25 - 27 March
Munich, Germany
www.munich-satellite-navigation-summit.org

Land and Poverty Conference 2019
25 - 29 March
Washington, DC, USA
www.worldbank.org

April 2019

Pacific PNT
8-11, April
Honolulu, HI USA
www.ion.org

European Navigation Conference 2019
9 - 12 April
Warsaw, Poland
http://enc2019.eu

FIG Working Week 2019
22 - 26 April
Hanoi, Vietnam
www.fig.net/fig2019

AUVSI Xponential 2019
29 April - 2 May
Chicago, United States
www.auvsi.org/events/xponential/auvsi-xponential-2019

May 2019

13th Annual BasÌŒeka GNSS Conference,
5 - 8 May
BasÌŒeka,Krk Island, Croatia

4th Joint International Symposium on Deformation Monitoring and Analysis
15 - 17 May
Athens, Greece
http://jisdm2019.survey.ntua.gr

Geo Business 2019
21 - 22 May
London, UK
www.GeoBusinessShow.com

June 2019

HxGN LIVE 2019
11 - 14 June
Las Vegas, USA
https://hxgnlive.com/2019

TransNav 2019
12 - 14 June
Gdynia, Poland
http://transnav.am.gdynia.pl

July 2019

Esri User Conference
8 - 12 July
San Diego, California
www.esri.com

August 2019

The South-East Asia Survey Congress(SEASC) 2019
15 - 19 August
Darwin, Australia
https://sssi.org.au

September 2019

GI4DM
3 - 6 September
Prague, Czech Republic
www.gi4dm2019.org

Intergeo 2019
17 - 19 September
Stuttgart, Germany
www.intergeo.de

ION GNSS+2019
16 - 20 September
Miami, Florida, USA
www.ion.org

ISDE 11
24 - 27 September
Florence, Italy
digitalearth2019.eu

Interdrone
3-6 September 2019
Las Vegas, USA
www.interdrone.com

October 2019

Commercial UAV Expo Americas
28 - 30 October
Las Vegas, USA
www.expouav.com

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LabSat 3 WIDEBAND

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- Galileo: E1 / E1a / E5a / E5b / E6
- SBAS: WAAS, EGNOS , GAGAN, MSAS, SDCM
- IRNSS

www.labsat.co.uk