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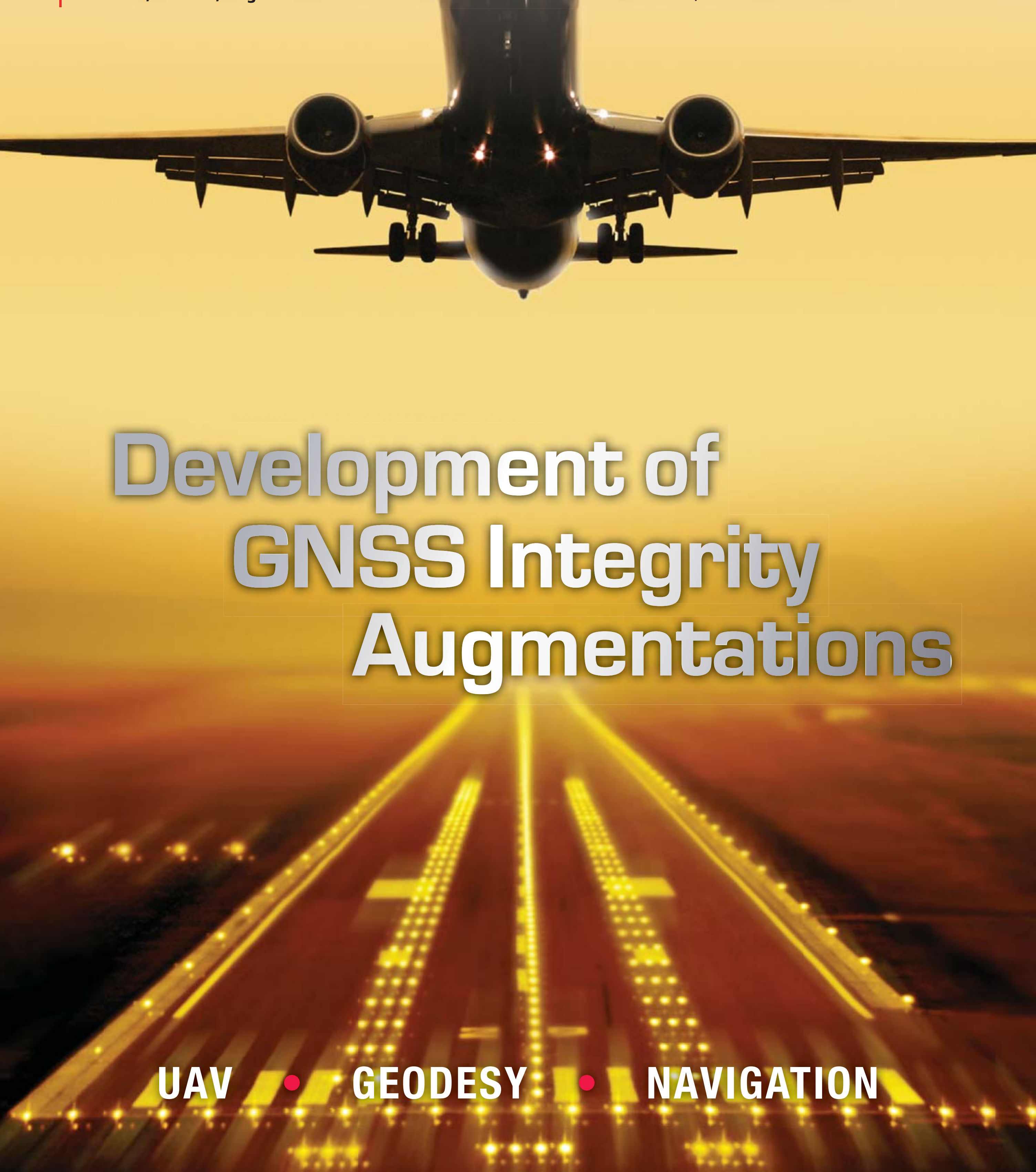

Development of GNSS Integrity Augmentations

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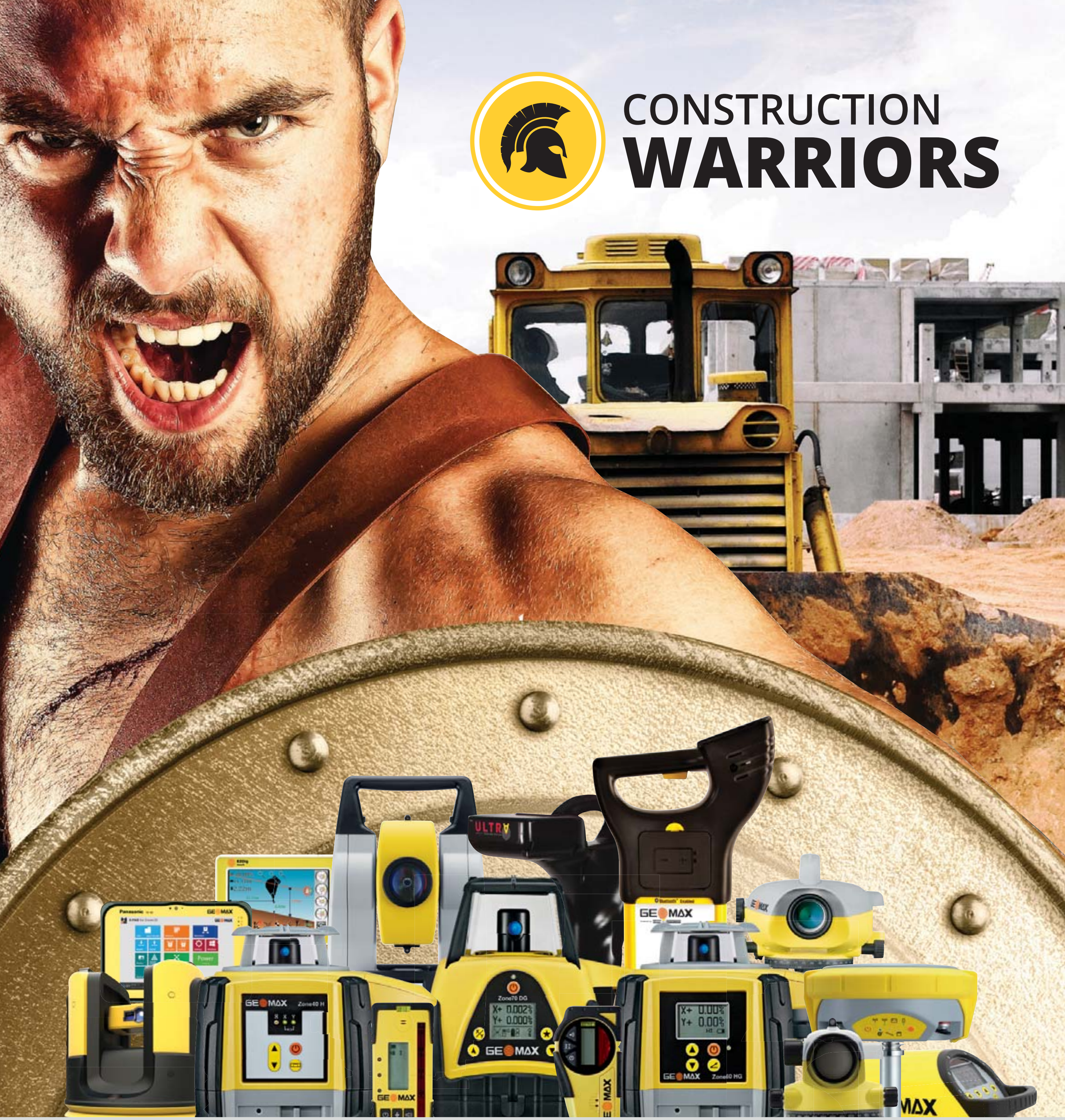
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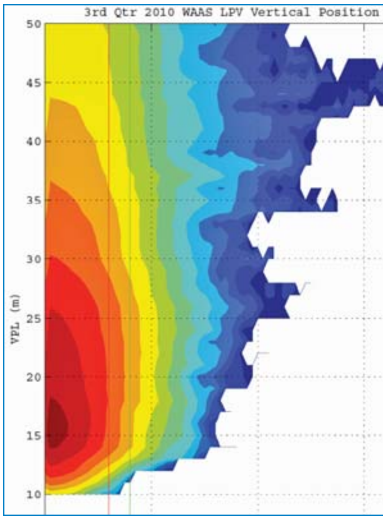

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Columns

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This issue of Coordinates is of 52 pages, including cover.

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Are relevant to safety-critical applications

To land, sea and air.

However, designing integrity augmentations

Have difficulties and challenges.

Sam Pullen shares some lessons learned (page no 8).

Bal Krishna, Editor
bal@mycoordinates.org

Lessons Learned from the Development of GNSS Integrity Augmentations

This paper summarizes some of the important lessons that I have learned over two decades of work on designing integrity augmentations for GPS to support civil aviation.

Sam Pullen
Stanford University
Stanford, USA

While GPS satellite failures that threaten integrity have historically been rare, the limited number of observed failures makes it difficult to build models that bound worst-case failure effects with certainty.

Research and development on methods for supporting "safety-of-life" applications with satellite navigation began well before the achievement of Initial Operational Capability (IOC) of the Global Positioning System (GPS) in 1993. It was known during the development of GPS that the systems that generate GPS ranging signals and navigation data were not designed to meet the very low failure probabilities required for applications like civil aviation. As a result, methods to combine redundant GPS ranging information and/or to augment GPS with information provided from ground reference systems were developed starting in the mid-1980's. Over the past thirty years, Space Based Augmentation Systems (SBAS), Ground Based Augmentations Systems (GBAS), and Receiver Autonomous Integrity Monitoring (RAIM) have been implemented to meet these requirements. Along the way, many worthwhile lessons have been learned.

This paper summarizes some of the important lessons that I have learned over two decades of work on designing integrity augmentations for GPS to support civil aviation. These lessons are intended to illustrate the difficulties inherent in designing integrity into existing systems while retaining sufficient continuity and availability to make the applications that they support economically feasible. These challenges are more than mathematical and require more than simply adding redundancy to mitigate the effects of individual failures.

Lesson 1: GPS and GNSS Satellite Anomalies are Rare

As noted above, the need for augmentation of GNSS comes from the fact that standalone GNSS is not designed to be robust against failures to the probabilities required of civil aviation and other safety-critical applications. Despite this, GPS has proven to have a very low failure rate, and this failure rate has decreased significantly since the initial commissioning of GPS. The fundamental reliability of GPS, as demonstrated over the previous two decades, is key to meeting the demands of these applications.

Failures of individual GNSS satellite measurements can be broken into two classes. The more common type are *unscheduled outages* or *unscheduled failures*, meaning the sudden and unexpected loss of measurements due to problems within the GNSS system. These outages put at risk the *continuity* of user applications because they are unforeseen. In other words, a user that needs measurements from a particular GNSS satellite to complete a given operation (this is known as a *critical satellite*) and unexpectedly loses that satellite would have to abort his or her operation, causing a loss of continuity. However, since the underlying failure is made evident by the loss of measurements from that satellite (or their being flagged as "unhealthy" by the GPS Operational Control Segment, or OCS), user safety is not threatened beyond any risk that applies to aborting the current operation. The second class of failures, which we can call *service failures*, do threaten safety because they are not immediately evident to users. In these cases, measurements continue being received without "unhealthy" warnings despite significant ranging errors.

For GPS L1 C/A code, upper bounds for both of these fault types failures are defined in [1]. The probability of unscheduled failures should be no greater than 0.0002 per satellite per hour, given that the satellite was healthy at the beginning of that hour. This probability represents a per-satellite Mean Time Between Outages (MTBO) of 5000 hours, or (at a maximum) slightly more than one unscheduled outage per satellite per year (8766 hours). The probability of service failures, defined in [1] as User Range Error (URE) exceeding 4.42 times the broadcast User Range Accuracy (URA) parameter in the GPS navigation message, is limited to 10^{-5} per hour per satellite. This probability is equivalent to no more than 3 service failures per year over the entire GPS constellation, assuming a maximum of 32 satellites and a maximum duration of service failures (before they are finally alerted by OCS) of 6 hours. Note that the multiplier of 4.42 corresponds to an exceedance probability of 10^{-5} for a two-sided standard Gaussian distribution.

Figure 1 (from [2]) examines the frequency and duration of unscheduled outages of GPS satellites from 1999 to 2011. Each box in this figure represents an unscheduled outage on a particular GPS satellite (indexed by SVN in increasing order on the *x*-axis), while the age of each satellite at the beginning and end of an outage is shown on the *y*-axis. The symbol used for each outage indicates the duration of the outage before the satellite was returned to service or (in about 7% of cases) retired. This figure shows that outages are significantly more common with older satellites as their equipment ages and becomes less reliable. Experience with and careful management of older satellites (many of which have lived much longer than their design lifetimes) has reduced the frequency of these outages, particularly in "primary" (as opposed to "spare") orbit slots. Over this period, the overall probability of unscheduled failures is about 6×10^{-5}, or much lower than the bounding probability of 2×10^{-4} given by [1]. Even focusing on SVN 25, which had unusually many outages as it aged, fell just within this probability over the last five years of its lifetime [2].

Figure 2 (from [3]) examines the potential for GPS service failures by plotting the distribution (1 minus the cumulative distribution function, or CDF) of URE estimated over time from IGS network station data (collected from 2008 to 2014) normalized by the broadcast one-sigma URA. Individual curves are shown for the GPS satellite types active since 2008 as well as the combination of all GPS satellites. All of these curves are exceeded by the standard Gaussian distribution (zero mean, unity variance) shown in red. This figure demonstrates that the broadcast URA bounds the actual URE for GPS satellites that are flagged healthy out to (and beyond) the probability of 10^{-5} cited in [1] and contains significant margin over the actual error distribution.

The database of GPS observations reported in [3] (and updated in [4]) also allows us to measure the number and duration of actual service failures, meaning specific events where healthy satellites had URE exceeding 4.42 times URA. Since 2008 (after a GPS OCS upgrade in 2007), the number of these events has been far below the three per year across the constellation allowed in [1]. Only five specific service failures have been identified from 2008 to 2015, inclusive (a span of 8 years). These occurred on five different GPS satellites at five different times, meaning that no times existed with multiple GPS service failures. The durations of these events were short, with an average time between onset of the service failure condition and removal from service (e.g., by being flagged as unhealthy or by broadcasting non-standard code, NSC) of about 21 minutes. Three of these events were diagnosed as satellite clock failures with maximum

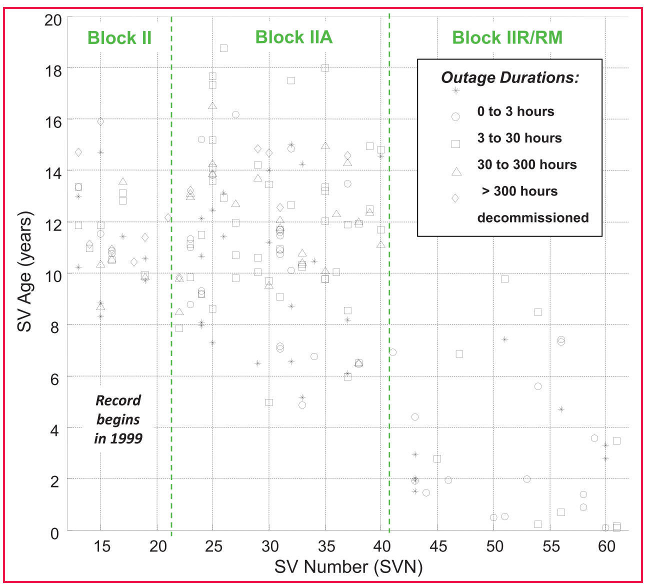

Figure 1: Unscheduled Outages of GPS Satellites from 1999 to 2011 [2]

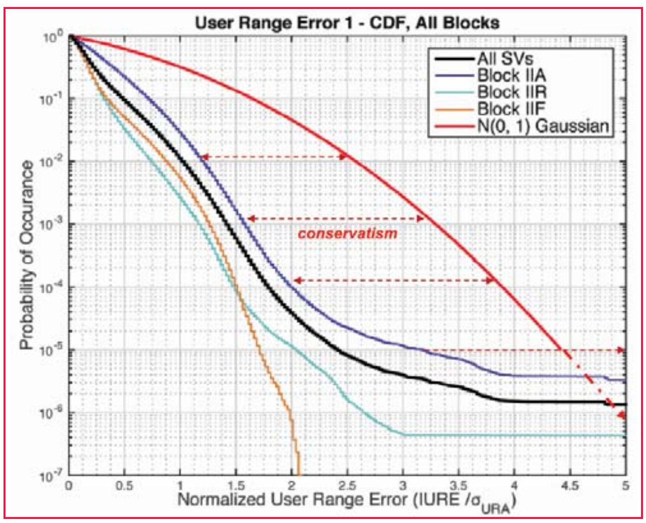

Figure 2: GPS User Range Error Observed from IGS Stations, 2008 – 2014 [3]

range errors of approximately 15 – 20 meters. The other two were determined to be errors in the broadcast ephemeris data, one of which (on PRN 19 on 17 June 2012) led to very large errors in the calculated satellite position in space [3].

From these results, the observed service failure onset probability (from 5 events over 8 years and an average of 31 active satellites) is about 2.3 × 10^{-6} per satellite per hour, which is well below the bounding probability of 10^{-5} from [1]. In addition, because the average service failure duration is much shorter than the maximum alerting time of 6 hours given in [1], the probability of any given satellite being in a service-failure state, known as P_{sat}, is about 8 × 10^{-7}, which again is much lower than the numbers that are often assumed.

The very low frequency of GPS satellite faults and their rapid resolution is a product of many years of experience with and improvements to GPS and its Operational Control Segment. Other GNSS constellations, such as Galileo, GLONASS, and Beidou, are either much younger or have had significant architecture changes over their history. The example of GPS suggests that other GNSS constellations can eventually achieve similar reliability, but this should not be taken for granted. Instead, data-analysis efforts similar to [3] should be conducted so that the performance of newer GNSS constellations can be validated. In the meantime, as with GPS in its earlier years, more conservative probabilities should be used.

Lesson 2: GNSS Anomalies are Difficult to Characterize with Certainty

The fact that GNSS (or at least GPS) satellite anomalies are so rare is a major asset to the design of safety-critical applications of GNSS. However, the very rarity of satellite anomalies makes it difficult to characterize the anomalies that could occur in a manner that allows us to confidently represent their worst-case impacts. In addition to the clock and ephemeris failure modes mentioned above, other satellite faults have either been observed once or twice or have been hypothesized and cannot be excluded. Examples of these include satellite signal deformation and satellite-generated code-carrier divergence. Because observed examples of these events are so few, fault models for these events must be developed by extrapolation (from the few observed events) and engineering judgment [5]. It is thus difficult to have confidence that these models cover all possible faults without being very conservative in constructing them.

Compared to GPS satellite clock failures, which are (or at least were in the past) far and away the most common failure type, large errors in the broadcast ephemeris information have been rare, with few (if any) being observed and confirmed prior to 2007. In the absence of such information, augmentation systems such as SBAS and GBAS needed to hypothesize what kind of failures could occur and what could cause them. Figure 3 (from [6]) summarizes the output of this process for GBAS. It divides potential satellite ephemeris failures into two classes. "Type B" represents an error in generating and broadcasting the ephemeris data for a satellite that has not been maneuvered (i.e., it remains in the same orbit as before), while "Type A" represents an error that is connected with a maneuver of a satellite into a different orbit. Type A, in particular, is divided into subclasses based on the different sequences of events needed to cause them and the way that they would appear to GBAS reference stations.

The fault classification and models illustrated in Figure 3 were derived before any examples of significant ephemeris faults were known. However, in April 2007, the Type-A2a event shown in Figure 4 (from [7]) occurred and provided a specific demonstration of what could happen. This fault was caused by a normal (and planned) maneuver of the affected satellite that was not proceeded by setting the satellite "unhealthy." As a result, when the satellite began its orbit maneuver, users tracking it observed range and position errors that grew and reached several hundred meters before the mistake was realized and the satellite flagged "unhealthy" (and thus unusable). The two ephemeris failures referred to above (from [3]) were observed in 2010 and 2012 and gave us examples of Type B events.

GNSS user safety can also be threatened by unusual behavior in the ionosphere and troposphere through which satellite signals must pass. Both SBAS and GBAS correct for ionospheric errors

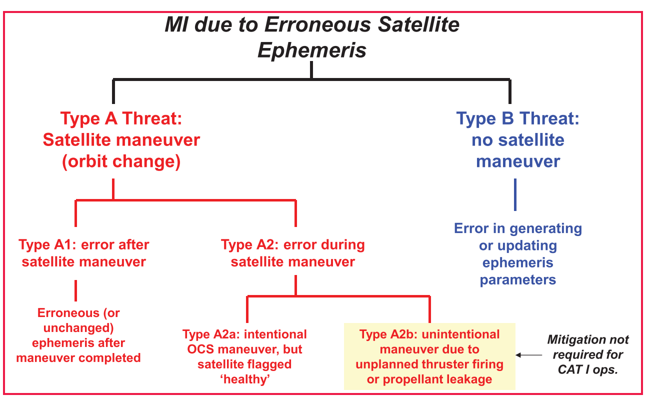

Figure 3: GBAS Threat Model Classification for Satellite Ephemeris Failures [6]

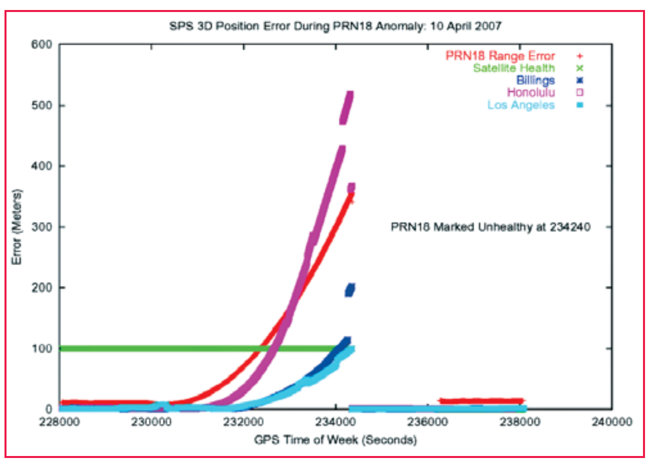

Figure 4: Ephemeris Fault on GPS PRN 18 in April 2007 [7]

in different ways, but these corrections can become erroneous under unusually active ionospheric conditions. For GBAS, ionospheric error removal is included as part of the application of pseudorange corrections by users. However, under very anomalous conditions, the spatial difference between ionospheric delays as measured by the GBAS ground system and those measured by users may reach several meters and become hazardous to aircraft precision approaches conducted using GBAS.

As with the GPS satellite failures discussed earlier, ionospheric anomalies severe enough to create spatial gradients threatening to GBAS users are very rare. As a result, threat models have been developed based on relatively few observed events. Figure 5 (from [8]) summarizes the threat model developed for GBAS use in the Conterminous U.S. (CONUS) based on data collected since 1999. The threat model bounds on spatial gradient as a function of satellite elevation were drawn to include all 99 observations shown on the plot. While 99 observations may seem like a lot, they all occurred on only four days and were all generated by the same physical event (the coronal mass ejection from the Sun that occurred in October of 2003). Furthermore, many of these observations come from multiple nearby reference stations observing the same gradient at about the same time, so they are not really independent. Many more observations than shown here exist for gradients below 200 mm/km, but these are not hazardous to GBAS and therefore do not have any impact on this threat model.

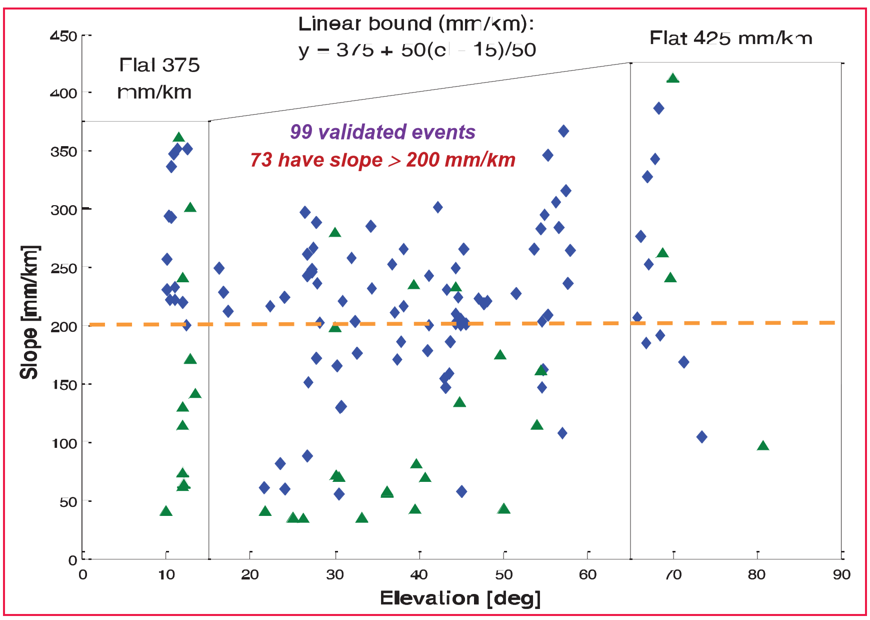

Figure 5: Anomalous Ionospheric Observations Used to Develop CONUS Threat Model [8]

Lesson 3: Safety Requirements for Civil Aviation are Unique, Complex, and Challenging to Meet

Performance requirements for civil aviation applications of GNSS and other navigation systems are specified in terms of accuracy, integrity, continuity, and availability. Of these, meeting integrity for GNSS applications normally implies meeting accuracy as well, but integrity and continuity directly conflict with each other. Integrity is the primary safety requirement, and it mandates that unsafe errors (as defined by each application) not be allowed to persist longer than a specified time to alert except for a specified loss-of-integrity probability (or "integrity risk"). Continuity affects both safety and operational efficiency and mandates that the probability of aborting an operation after it has begun is lower than a specified loss-of-continuity probability. The primary means of protecting integrity once an unsafe error is detected is to remove the affected measurements, but doing so increases the risk of loss of continuity. If an unsafe error is present, this is still appropriate (integrity takes precedence), but in practice, many integrity monitor alerts come from fault-free noise, better known as "false alarms." In short, adding monitoring to meet the integrity requirement comes at a cost in continuity.

Availability can be expressed as the probability that all other requirements are met at a given time and requires that both integrity and continuity be met simultaneously. This is a challenge for any safety-critical application but is especially so for civil aviation because of the way in which the integrity requirement is interpreted. The loss-of-integrity probability for civil aviation must be computed using a concept known as "specific risk," which is non-standard and can be complicated to interpret. It is easier to explain specific risk in contrast to the alternative of "average risk," which is more commonly encountered. Under average risk, if a failure event may take on many different sets of characteristics, only some of which may lead to loss of integrity (the "hazardous subset"), credit may be taken for the probability of falling outside the hazardous subset. This is important in practice, as the "hazardous subset" for many failure types is small. However, under specific risk, credit cannot be taken for this – the "worst-case" outcome of a particular fault mode, from the point of view of the system being evaluated, must be assumed to occur with a probability of 1 (given that the fault occurs) [9].

The need to quantify and bound the worst-case effects of each type of fault is what drives the need to create conservative fault models for civil aviation. As explained above, most GNSS fault models are based on few actual fault observations; thus it is difficult to conclude that the worst-case fault is simply the worst of the events that have been observed in the past. The worst-case fault is often derived from expert consensus as an extrapolation from the observed events plus a simplified physical model of how these events occur. The extrapolated model can be used to simulate the impact of the underlying fault on a particular GNSS application and to determine which combination of fault parameters gives the worst results for that application (it is not always obvious).

Lesson 4: Significant Design Conservatism is Needed to Verify that Civil Aviation Requirements are Met

The result of applying Lessons 1, 2, and 3 is that significant conservatism is needed in both the design of GNSS augmentations for civil aviation and the verification that these augmentations provide the required integrity and continuity. Lesson 1 shows that GPS failures to date, particularly those that might threaten integrity, are very rare. Unfortunately, they are not so rare that their probability can be neglected. As explained in Lesson 2, the consequence is that few examples of actual failure events exist to be used in modeling the range of possible failures. Absent a statistically significant number of events, a wide range of possibilities must be considered, and it is difficult to draw a line between what is possible (albeit rare) and what is "non-credible." Lesson 3 explains that, at least for civil aviation, the evaluation of integrity risk under each "credible" fault condition must be based on the worst-case combination of parameters that describe that fault.

Figure 6 (from [10]) illustrates the resulting conservatism from results of the U.S. Wide Area Augmentation System (WAAS), an example of SBAS, in the 3rd quarter of 2010. This is a "triangle plot" in which the actual WAAS vertical position errors (VPE) observed over a network of ground stations with known locations are compared to the vertical protection levels (VPL) computed at the same locations and times. Protection levels are an important concept in GNSS integrity – they express the maximum position error that could occur at the probability for which the protection level is derived, which is based on the specified integrity risk for that application (in this case, it is 10^{-7} per 150 seconds, corresponding to a typical LPV-200 aircraft precision approach).

What is notable is the ratio between the actual VPEs and the calculated VPLs, which are based on the user's satellite geometry and integrity parameters (bounding error sigma values) broadcast by WAAS. During this typical 3-month period for WAAS, the 95th and 99th-percentile vertical errors were 1.2 and 1.6 meters, respectively, while the maximum vertical error was about 7 meters in Barrow, Alaska, near the very edge of WAAS coverage. In contrast, typical VPLs were in the range of 15 to 30 meters and occasionally exceeded 35 meters, the limit for LPV-200 precision approaches. The reason for this gap is that VPL is not meant to reflect typical or even unusual conditions. Rather, it expresses the potential impact of the worst combination of parameters among all of the anomalous threat models that apply. For WAAS, this is driven by the worst possible ionospheric spatial decorrelation that might go unobserved. While this event is exceedingly improbable, it cannot be excluded from the "specific risk" calculation of civil aviation integrity.

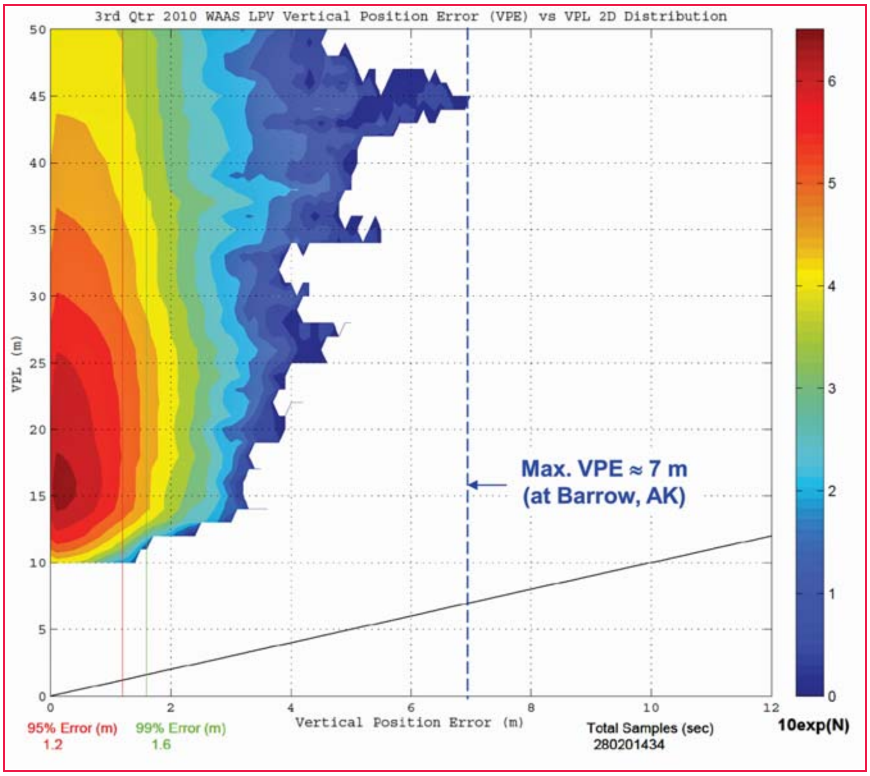

Figure 6: "Triangle Chart" of VPL vs. VPE for WAAS, 3rd Quarter of 2010 [10]

Summary

This paper describes lessons learned from my experience in the development of safety-critical GNSS applications for civil aviation. They show how the challenges to integrity and continuity design and verification differ from maximizing performance in typical GNSS environments. While GPS satellite failures that threaten integrity have historically been rare, the limited number of observed failures makes it difficult to build models that can be assured to bound worst-case failure events with certainty. The strict interpretation of integrity risk applied by civil aviation places great weight on these bounds, thus a great deal of conservatism must be introduced in the development of threat models and the application of them to the calculation of protection levels by users in real time.

The implementation of GNSS integrity to support civil aviation is highly relevant to other safety-critical applications on land, sea, and air, even if they do not share the same "specific risk" approach to safety assessment. Under the "average risk" interpretation, the development of threat models would focus less on the worst possible events and more on an appropriate probabilistic description of the range of possible events resulting from a given failure mode [5, 9]. The result would be significantly less conservatism and a smaller gap between nominal performance and integrity guarantees.

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Comprehension of the Eye of the Navigator

This article presents Eye Tracking data that has been collected on board the world's fastest littoral combat ship, compared with similar datasets collected in a bridge navigation simulator

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Dr Runar Ostnes
Associate Professor, Norwegian University of Science and Technology, Department for Advanced Maritime Operations, Norway

The increased use of technology and more advanced Integrated Navigation Systems (INS) has changed the focus of the Navigator. Electronic Chart and Display Information System (ECDIS) has become mandatory on most ships to provide the Officer of the Watch (OOW) with increased situational awareness (1). In earlier days, the navigator had to *find* and *fix* the position of the vessel using paper charts, peloruses, sextants, etc. (2), whereas nowadays the navigator's role is to *monitor* the position provided. Today the navigator's attention is drawn towards the ECDIS, where the position is provided most commonly by a Global Navigation Satellite System (GNSS) such as NAVSTAR Global Positioning System (GPS). The result is a new generation of navigators, who in turn are very comfortable with the use of computers (3). The trust in the position given by the GPS is found to be high, and research has shown that it takes time before the navigator detects an error in the position source (4, 5). This phenomenon may be described as a «PlayStation-mode», and the Maritime Accident Investigation Branch (MAIB) has recently introduced the term ECDIS-assisted groundings (6). To avoid ECDIS-assisted groundings, the navigator has to perform continuous integrity monitoring of the system, primarily through visual comparison of the ships' surroundings with how its position is presented in the ECDIS; e.g. a position fix with multiple bearings. Integrity monitoring can also be performed in the INS, known as conventional control (7). An example is comparison of the RADAR and the ECDIS with the use of RADAR overlay.

The layout and functional design of a navigation bridge has been through a paradigm shift with the introduction of electronic navigation aids to assist the navigator in planning and performing a safe passage. However, statistics show that navigational error still accounts for half the accidents in Norwegian littoral waters (8). It is therefore imperative that those of us who thrive in the maritime domain, learn how to better understand user behavior, and to use this knowledge to develop integrated navigation systems that further support the navigator in planning, monitoring and controlling the safety of navigation and progress of the ship. To improve performance, the user must identify which tasks to prioritize and separate each into primary and secondary tasks (9). Knowing this, a scanning pattern can be constructed which will limit fixation and improve performance.

This article reviews the use of maritime simulators in navigation training, and identifies possible areas for improvement in human system integration (HSI) and graphical user interface (GUI) by the use of Eye Tracking data. The Eye Tracking data has been reviewed by the author in an earlier article, where the data collected suggested that field study data is similar to simulator study data, and thus simulator navigation training is efficient and should be further developed (10).

Method

Skjold-class Corvette

The Skjold-class coastal Corvette was inaugurated by the Royal Norwegian Navy (RNoN) in 2010 and is designed to operate along the Norwegian coastline (Figure 1). The vessel is 50 meters long and is characterized by its stealth design and catamaran hull. The vessel can operate in speed up to 60 knots, making the Skjold-class the fastest armed ship in the world (11).

The many fjords, underwater reefs and a large amount of skerries characterize the Norwegian coastline. Weather conditions can be harsh, and especially the Artic environment with its strong winds, high seas and preticipation makes navigation in this area extremely challenging.

Participants

Four experienced navigators participated in the field study and live study. All participants are graduates from the Royal Norwegian Naval Academy (RNoNA), and have the theory for Deck Officer Certificate class 1. Median age of the participants is 30 years.

Navigation Bridge Simulator

The Royal Norwegian Navy Navigation Competence Centre (NavComCen) contains a simulator system (NavSim) consisting of seven separate bridge layouts. The simulators are used in education of new navigators and in scenario-based training of existing navigators. One of these cubicles is an exact replica of the Skjold-class corvette bridge, with the same layout, design, hardware and software (1:1 Skjold-class bridge simulator) as shown in Figure 2. The visual scene is constructed by seven LED-projectors providing a seamless 210-degree picture in front, and two 42” flat screens that generates an aft view image for the navigation team, all in 1280x1024 resolution.

Figure 1: Skjold-class Corvette in Norwegian littoral waters

Figure 2: Skjold-class bridge navigation simulator with AOIs outlined

Eye Tracking

The data set is collected by second-generation ETG from SensoMotoric Instruments (SMI ETG 2w©). The SMI ETG can record native, binocular eye tracking up to 120 Hz with a gaze tracking accuracy of 0,5°. Gaze tracking range is limited to 80° horizontal angle and 60° vertical angle, with a resolution of 1280x960. SMI ETG 2w© is compatible with contact lenses and most vision correction spectacles, and it is possible to conduct live validation of gaze tracking quality. Calibration is performed with the use of one or three-point calibration process, and it is possible to conduct calibration when processing the data in BeGaze. The data set generation is a manual process using the BeGaze software from SMI (12).

Eye Tracking equipment has been used to evaluate, understand and improve the training process on ships’ navigational bridge simulator (10).

Procedure

Participants were instructed to conduct a standard watch and to perform route monitoring as normal. Route planning was prepared in advance of the trials, and was not within the scope of this research project. All participants were accustomed with both the Skjold class Bridge and the use of the simulator. Each participant conducted 2-4 trials in the live study and in the simulator, and each trial had a median of 10 minutes. 16 datasets were collected among the participants with a total duration of 2 hours and 36 minutes.

Restrictions in availability of databases in the simulator made it necessary to conduct the simulator study and the field study in two different parts of Norway. However, the simulator study area and the field study area are similar enough in topography, navigational challenges to require the same sets of skill and behaviour of the navigators.

Results

Before analysing the data in BeGaze, Areas of Interest (AOI) were defined (Figure 2). The definition of the AOIs was generated in a pre-study in the simulator, where eye movement data was analysed to identify which areas on the bridge held the navigators` attention. This resulted in the establishment of seven AOIs:

1. Outside (out the bridge window), AOI_O
2. ECDIS, AOI_E
3. Route Monitor window, AOI_M (Lower right corner of ECDIS, ref Fig. 7)
4. RADAR, AOI_R
5. Display (Electromagnetic Log repeater, EML), AOI_D
6. Consoles (Throttle and autopilot), AOI_C
7. White space (Area left outside of the AOIs), AOI_W

Nine Key Performance Indicators (KPI) was generated for the AOIs:

1. Sequence: Order of gaze hits into the AOIs based on entry time. Lowest entry time – first in Sequence.
2. Entry time: Average duration for the first fixation in the AOI. Identify time spent on first fixation in the AOI.
3. Dwell time: The sum of all fixations and saccades within the AOI. Identify the visual attention for the participant.
4. Hit ratio: How many subjects looked at least one time into the AOI. Identify the use of AOIs.
5. Revisits: How many visits the subjects made into the AOI. Identify the use of AOIs with regards to glances.
6. Revisitors: Number of subjects with more than one visit in AOI. Identify number of subjects that looked into the AOI at least 2 times.
7. Average fixation: The average of the fixation time in the specific AOI. E.g. identify mental and cognitive workload.
8. First fixation: In ms how long the first fixation for selected subject in AOI lasted. E.g. identify patterns and workloads.
9. Fixation count: Number of all fixations in AOI. E.g. identify complexity of AOI.

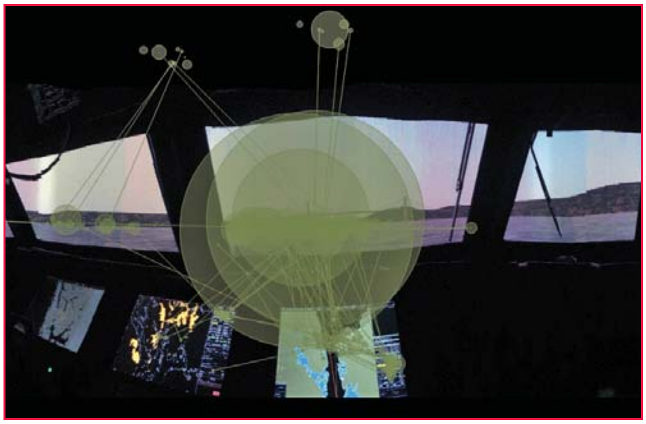

Figure 3: Scanpath participant 1

Fixation is defined as the state when the eye remains still over a period of time (in this study <80ms). *Saccade* is defined as the rapid motion from one fixation to another (13).

By analyzing the Eye Tracking data, statistics were generated which could be further analyzed. These statistics consisted of KPI data in the AOIs, scanpaths, focus maps, heat maps and sequence charts (10).

Human Machine Interface

Human factor related considerations is identified as a top priority in military systems design to reduce life cycle costs and optimize human and system performance (14). One of these goals are met through Human Factors Engineering (HFE) in order to maximize the users' ability to perform at required levels for operation, maintenance and support by considering human capabilities and limitations and eliminating design-induced errors (15). An electronic system should be able to communicate information about its status to an operator through displays and the operator will evaluate these inputs before communicating how he or she wants the machine's status to change by manipulating controls. The ECDIS is designed to enhance safety of navigation, and should provide the navigator with better situational awareness and free time for the navigator to monitor the surroundings of the ship. In order to optimize the navigators scan pattern it should be possible to adjust the information order (GUI) and the placement of the displays (layout) related to the operator.

Bridge Design

By analyzing scanpaths, focus maps and sequence charts in the Eye Tracker data collected, interesting observations concerning human machine interface were made. Lingering focus on certain displays or instruments steals time and attention from the primary focus area of the navigator (outside the windows), and can be identified by analyzing scanpaths and sequence charts (16). This includes the general design of the bridge as well as the graphical user interface (GUI) of the ECDIS software (SW).

Furthermore, possible improvements in the general arrangement of the bridge design can be revealed through the use of visualization related techniques to annotate regions or objects on the stimulus that are of special interest to the user (16).

Scanpath refers to the fairly abstract concept of a fixed path that is characteristic to a specific participant and viewing pattern (13). In Figure 3 the scanpath of participant 1 is visualized, and the duration of the fixation is shown by the size of the circles. The data collected reveals that the primary gaze area for the navigator is outside of the ship (AOI_O), explicitly expressed by the Dwell time statistics. Figure 4 shows the dwell time for the navigator to be 59,7% in the field study, and 56,4% in the simulator study in AOI_O (10).

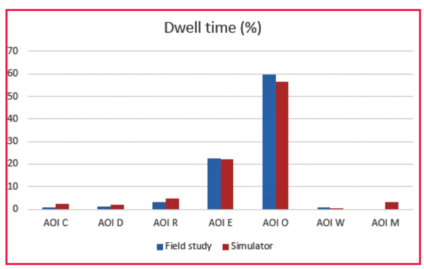

Figure 4: Dwell time in the defined Ares of Interest (AOI)

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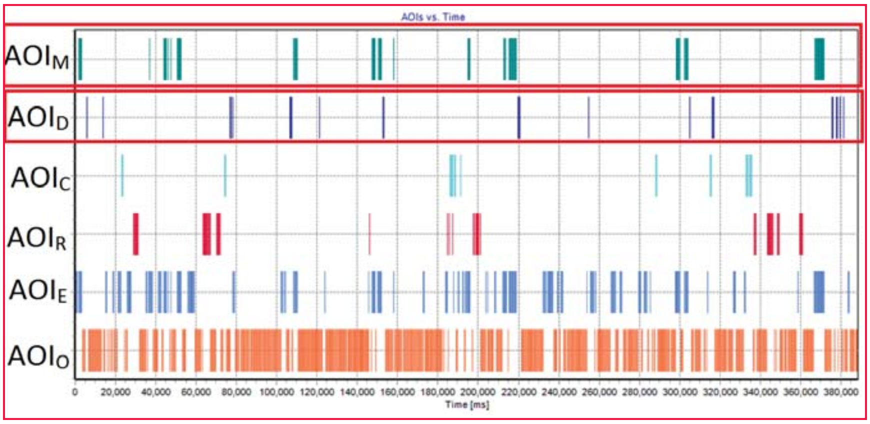

Figure 5: Sequence chart participant 1, AOI_M and AOI_D highlighted

Figure 6: HMI electromagnetic log, reset trip button highlighted in red

The primary task for the navigator is to conduct a safe passage. Monitoring the surroundings and controlling the INS is an important task, and every navigators` attention should be focused mainly to the outside of the ship (3). Sequence charts illustrates the visual fixation periods within an AOI along the timeline (13). Figure 5 shows the distribution of visual attention of the navigator for each of the AOIs. By highlighting the

Display area (AOI_D), together with analyzing the dwell time for AOI_D, there is an indication that the time spent focusing on AOI_D in some periods are substantial and disturbs the desired focus on AOI_O.

AOI_D consist of an electromagnetic log (Figure 6). The electromagnetic log is designed so that you have to press and hold a button for 2 seconds in order to reset the trip meter. The navigator resets this button for every change of course typically during the turning phase of the ship, which is a critical phase for conduction of safe navigation. The illustration in Figure 4 indicates a less than optimal design since it removes the navigator's attention from what should have been the primary area of interest, outside the window of the bridge (AOI_O).

The reset-button is co-located with five other identical buttons (Figure 6) and is therefore difficult to find unless you look directly at the instrument. The sub-optimal design of the buttons, along with the placement of the instrument, marks it as one of the time-stealing displays for a Skjold bridge navigator. It is also important to highlight that this procedure is conducted in the turning phase of the ship, which is a critical phase of the passage. A less time consuming placement could be to place the reset-button on the Arm Rest Panel (ARP), closer to the navigators' fingertips.

Graphical user interface (GUI)

Concerning graphical user interface (GUI) on a modern ship's bridge, the ECDIS SW is of particular interest to analyze. A typical scanpath (Figure 7) illustrates how much visual attention is given to the lower right corner of the ECDIS GUI, which is the Route Monitor window (AOI_M).

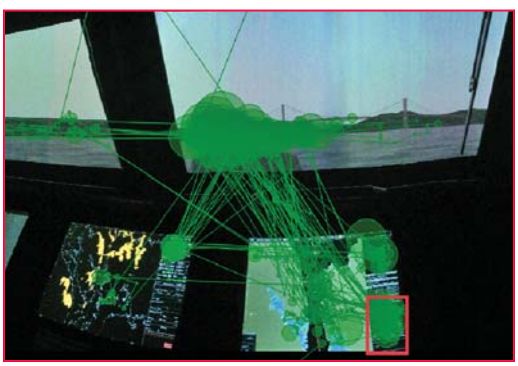

Figure 7: Scanpath participant 4

The Route Monitor window (AOI_M) informs the navigator of critical information such as turning point and heading mark, and is shown in Figure 8.

The information in the Route Monitor window is a combination of number and letters, providing quick and intuitive feedback for the navigator to interpret. The information which is of highest importance for the navigator is marked with red boxes and numbered accordingly in Figure 8:

1. Information regarding turning point and next heading mark
2. Time to Wheel over Point
3. Next course
4. Next leg distance
5. Cross track distance from planned leg

The sequence chart in Figure 5 illustrates how the navigator's attention is drawn from looking outside (AOI_O) to focus on ECDIS (AOI_E), and especially on the Route Monitor window (AOI_M) in the lower right corner of the ECDIS GUI. Comparisons of the participants' scanpath and sequence chart suggests that the operation of extracting information from the Route Monitor window is time consuming, and therefore reduces time spent looking outside (AOI_O). Some reasons for this may be the size of the numbers and

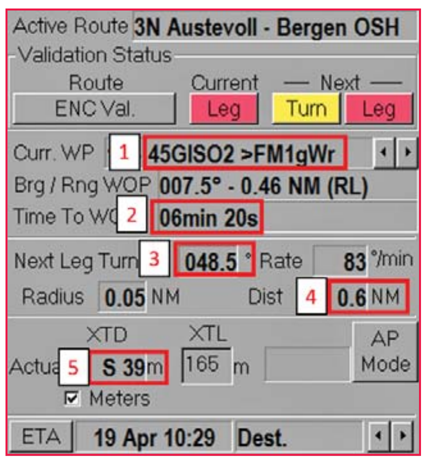

Figure 8: Route monitor window with highlighted information

letters, which the navigators express are difficult and time consuming to read and process, and the location of the Route Monitor window (lower right corner of ECDIS GUI) which may increase the information extraction time. These observations suggest that the Skjold class ECDIS Route Monitor GUI should be remodeled and tested for usability in order to minimize time used to extract this information.

Discussion

Science is based on empiricism, which means pursuing knowledge by observation. These observations can range from uncontrolled, direct observations within natural settings to tightly controlled experiments in artificial settings. Measurements are said to be reliable if we get similar values when we measure the same thing more than once (9). The research performed in earlier studies (10) shows that there is enough similarity between the Skjold simulator and the actual vessel to make them sufficiently comparable concerning the navigator's attention, fixation and behavior. This suggests that proper design in a bridge simulator can enable valid tests as to how well a navigator will perform in a real environment with the requirements and demands found there. It may also allow for redesign (if necessary) of the simulator navigation systems after analyzing the test results. Ultimately, this may result in improved software and hardware capabilities and remodeling of the bridge's general arrangement. As long as there is a proven similarity between the simulator environment and the ship bridge itself, you will ensure that the design can be fitted on real systems in real environments.

Conclusion

The use of Eye Tracking equipment as a tool to develop maritime navigation has a clear potential. Data from Eye Tracking can be analyzed to identify pros and cons concerning bridge layout and GUI to identify visual attention thieves. Analyzing different data sources such as scanpath, sequence charts and KPIs from the eye tracking data set, gives valuable insight about bridge design and layout of bridge equipment and identifying poor GUIs which disrupts the primary task of the navigator.

Ship's bridge design that are sufficiently comparable in a simulator and onboard will make it possible to perform unobtrusive tests and observations in a simulator that will inform training interventions and optimize bridge design.

Future work

Scanpaths can provide valuable information of a navigator's area of interest and subsequent behavior. An ideal scanpath, of the task of interest, would be presented as a straight line from one object to a specified target, and deviance from this ideal scanpath can be interpreted as a hindrance to desired visual attention. Future work should look into, and suggest, recommendations for optimal visual scanning of the surroundings of the maritime navigator.

This topics and findings in this article also indicates a strong potential for future simulator studies in order to optimize the ECDIS GUI.

Acknowledgment

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The integration of UAVs into the civilian airspace will open up a new market

Comprehensive policy and regulations are needed to be formulated immediately to reap the benefits of UAVs

Siddappaji B
Scientist E, ADE, Defence Research and Development Organization (DRDO), India

Unmanned Aerial Vehicles (UAVs) are making significant impact for their continuing technological innovations and their diverse applications both in military and commercial field. In the military, UAVs are used for Net-Centric Operations (NCO) missions as an intelligent sensor grid such as persistence intelligence gathering, Surveillance and Reconnaissance (ISR) and Target Acquisition (TA), the acquired data will be transferred to Command and Control (C2) via robust secure Datalink which may be with in line of sight or beyond line of sight for decision making and action will be taken to attack target using precision weapon shooter grid. Hence in the sensor grid UAVs are more beneficial than ground radars, manned fighters/helicopters, satellites due to real time data dissemination such as video and still images to C2 grid for increased combat power and real-time battle field situation awareness. At a time data can be shared to various grids/ operational commanders in real time which are dispersed in the geographical locations thousands of kilometers away hence reducing the cycle time between sensors to shooter grid. UAVs, C2 and shooter grid need not be located nearby which may be vulnerable to enemy. The cost of UAVs is a fraction cost that of a manned aircraft/helicopter or satellite which makes UAVs more economical for military missions.

Commercial

In the Commercial scenario small UAVs landscape is emerging steadily such as border surveillance, disaster response, firefighting, law enforcement, precision agriculture, news coverage, land mapping and personal use to mention a few. Small UAVs or drones are available in the market which is fully equipped with an HD camera controllable with an iPad for about $300.

Recently 7-eleven company from US delivered a chicken sandwich, donuts, hotcoffee and candy to the customer's order through UAV/drone. The company partnered with UAV startup flirtey for the delivery, the drone flew autonomously to one mile from the 7-eleven stores in the Reno to the family house using GPS. After drone reached the house, it hovered above, while lowering the container to the family's backyard using a rope.This has been a legally delivered package by drone to the US resident who placed an order from retailer. Delivery of goods can be made efficiently and rapidly.

UAVs increase our human potential; they execute dull, dirty and dangerous tasks safely and efficiently, saving time, saving money and sometime saving life. Around the world UAVs help farmers manage their crops, monitor or spray costs using advanced imaging technologies. Farmers can detect drought, disease, stress in the crops well in advance which leads to saving of money and reducing environmental impact. In Japan around 1500 small UAVs are being used for their rice field for monitoring crops and spray control.

UAVs are very useful and economical in enhancing public safety, helping route clearance for convoys, traffic control,and rescue operations by police and for crowd control. UAVs are very effective for firefighters surveying fires and detecting hotspots hence escape routes can be planned in real-time. In India Uttar Pradesh and Karnataka states police have purchased small UAVs for crowd control and for traffic situational awareness.

In the manmade and natural disasters UAVs play a significant role in mitigating and monitoring effectively. They aid in search and rescue efforts to identify survivors and recover those lost in the disaster and help in making assessing the damage due to disasters such as, Tsunami, cloud burst, nuclear biological chemical hazards and floods which are frequent in Asian countries.

UAVs are very economical for environmental/government organizations for monitoring forests for illegal logging, deforestation and wildlife protection as they give real-time and early warning for decision bodies to take immediate action. UAVs gather information from reserve forests and help in conducting environmental impact assessments specifically where ground operations are very tedious and manpower intensive in difficult and inaccessible terrain and vegetation.

UAVs can provide job opportunities to the young engineers in various fields when drones employed in the large scale. Cinematography and personal use is another emerging usage of drones. Hence economic benefits of UAVs to the nation are enormous.

Challenges

As UAVs are making significant contributions in the commercial sector, the integration of UAVs is one of the challenging task to policymakers as there are no comprehensive policy and regulations, which are need to be formulated immediately to reap the benefits of UAVs. Military, Research organizations are allowed to use the airspace for UAVs, but commercial organizations are not permitted to put UAVs in to the sky. As such integration raises some fundamental questions that require a major policy rethink on airspace management and control and overall safety of UAVs, such as: How and who will coordinate unmanned and manned flights in a mixed airspace, Identification of UAVs, legal regulations, Collision avoidance and cyber security which are need to be addressed. Another important aspect is functional integrity of UAV components and redundancy which need to be addressed for safe operation.

The integration of UAVs in to the civilian airspace will open up a new market for UAV technology, creating new jobs, boost local economies and tax revenues, reinvigorate manufacturing bases and advance India as spearhead in UAV technologies and innovations.

The U.S. commercial drone community gets back to business

Professionals can now employ the technology without fear of running into regulatory trouble

Patrick Egan
Editor, the Americas desk for www.sUASNews.com and Professor of Broadcast TV and Motion Picture Drone Production at the Academy of Art University in San Francisco, California

14 CFR Part 107 give's us legal and level access to the NAS (National Airspace System). Sure, you could jump through all of the arbitrary hoops to get a Sec. 333 exemption but in reality, the best estimates had about 10% of holders being in regulatory compliance. FAR 107 put's the onus on the drone PIC (Pilot In Command), welcome to the aviation community. As of August 29th you will able to test for a remote pilot certificate, fly to an altitude of 400' AGL during daylight hours five miles from an airport at speeds less than 100 miles an hour. There are other details and stipulations in AC 107-2. I would suggest doing a search for the document or visiting www.faa.gov/uas/

The U.S. drone folks have been operating in a gray-market blue-sky environment. The national regulatory picture has been cloudy since 2007 when the FAA issued its policy clarification regarding UAS. People would claim that they were just amateurs and hobbyists innovators, or that the FAA had no jurisdiction over drones for a whole host of supposedly plausible reasons. Well, the naysaying and feigning intentions for flying and confusion is over.

We've heard the promise of drones and wild forecast for drone industry valuation, proliferation and salary estimates. Most of those statements and claims were unsubstantiated and were made without interviewing professionals in many of those industries that drones supposedly held the most promise. Everyone can understand and account for a plus or minus factor, but some of the estimates thrown around left a wide margin between potential and reality. The reality part challenges the licensed drone operators to prove some of the tall claims made heretofore.

Sure, many industries will benefit as drones have always held promise for self-guided data collection as well as complementing existing businesses that can add new services for their clients. Professionals can now employ the technology without fear of running into regulatory trouble. That said, the regulatory burden was always the wildcard we'd have to contend with, but now we have a rule, and it is favorable, and it is time for the commercial drone community to show what good they can do.

> Many industries will benefit as drones have always held promise for self-guided data collection as well as complementing existing businesses

IoT and Drones: A tale of two technologies

If we put IoT elements side-by-side with elements of the drone ecosystem, it becomes remarkably noticeable that the drone economy provides almost identical value proposition as the IoT

Biren Gandhi
Distinguished Strategist, Cisco

IoT is powered by four foundational elements:

People

Although people are increasingly connecting together through smart devices and social media, IoT emergence is expected to fuel even more accelerated adoption of wearable gadgets, digestible sensor pills, custom body parts, connected apparel and similar technologies.

Process

Processes will play a pivotal role in how all the other IoT elements — people, data, and things —interact with one another to deliver societal benefits and economic value. End-to-end automation of technology, business, organizational and other processes delivering right information to right entities at the right time could trigger explosive growth for Internet of Everything.

	IoT Ecosystem	Drone Ecosystem
People	Connecting people in more relevant, valuable ways	Connecting people through collaboration for remote expert, public safety, and emergency response scenarios.
Process	Delivering right information to the right entity at the right time	High cost, manual, error-prone workflows converted to efficient, autonomous mission plans.
Data	Converting data into actionable information, knowledge and wisdom	Data processing layers - on drones, at the ground station, at network aggregation points, in the cloud - modeled after Fog Computing paradigm.
Things	Physical objects connected to internet and one another for smarter decisions	Variety of LiDAR, ultrasonic, infrared etc. sensors and telemetry data streams.

Data

Data is considered new currency if leveraged appropriately in the form of information, knowledge and wisdom. It may not be surprising to see IoT data volumes surpass the traffic generated by today's most popular social media sites – combined.

Things

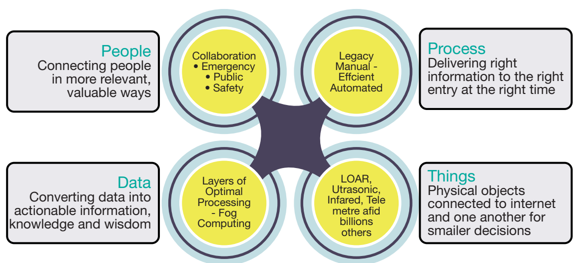
Things represent the "T" in IoT — devices, sensors, actuators, meters — that connect to the network and to one another to enable smarter decision making at appropriate points in the network.

If we put (IoT) elements side-by-side with elements of the drone ecosystem, it becomes remarkably noticeable that the drone economy provides almost identical value proposition as the IoT. Inspired by these amazing parallels between IoT and drone eco systems, Cisco believes drones could be holding keys to unlocking hidden treasure of sensory automation, unmanned operations and end-to-end business intelligence.

The sky is quite literally the limit!
http://blogs.cisco.com/digital/ioe-and-drones-a-tale-of-two-technologies

Internet of Things: People, Process, Data, Things

Drones: IoT Principles in Action




We give you more than just a Buzz ...
Patents
PATENTS
Integrated Magnetic Locator with TRIUMPH-LS
...We give you a Smart Tip!

Front

This is the Smart Tip

It replaces the tip on the bottom of your rover rod/monopod.

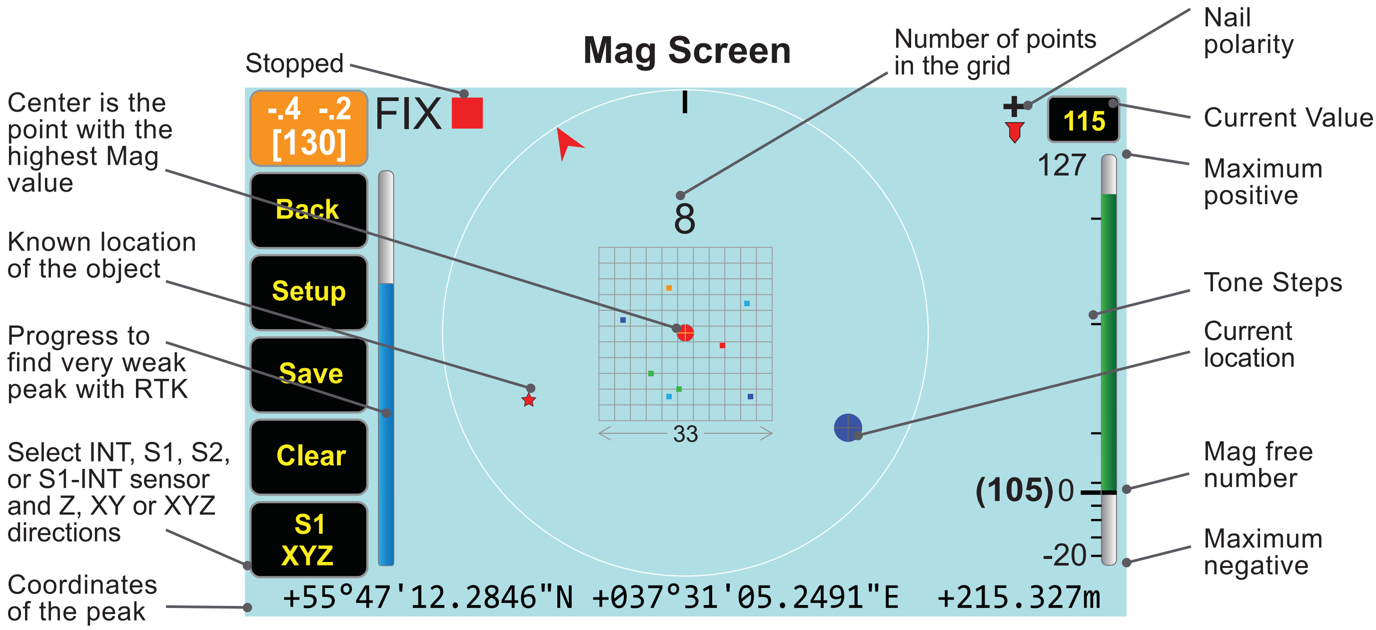
It has two magnetic sensors inside which send magnetic values to the TRIUMPH-LS via Bluetooth 100 times per second.

TRIUMPH-LS scans the field and plots the 2D and 3D magnetic characteristics and the shape and the centre of the objects under the ground and it guides you to it.

Integrated magnetic locator in TRIUMPH-LS

FL

Mag Screen



To see Mag screens you must first click the A/V hardware button and pair the TRIUMPH-LS with your Smart Tip (and to the Bluetooth headset, if you want to.)

In Action screens of Collect or Stake, click the icon to get to the Mag screen.

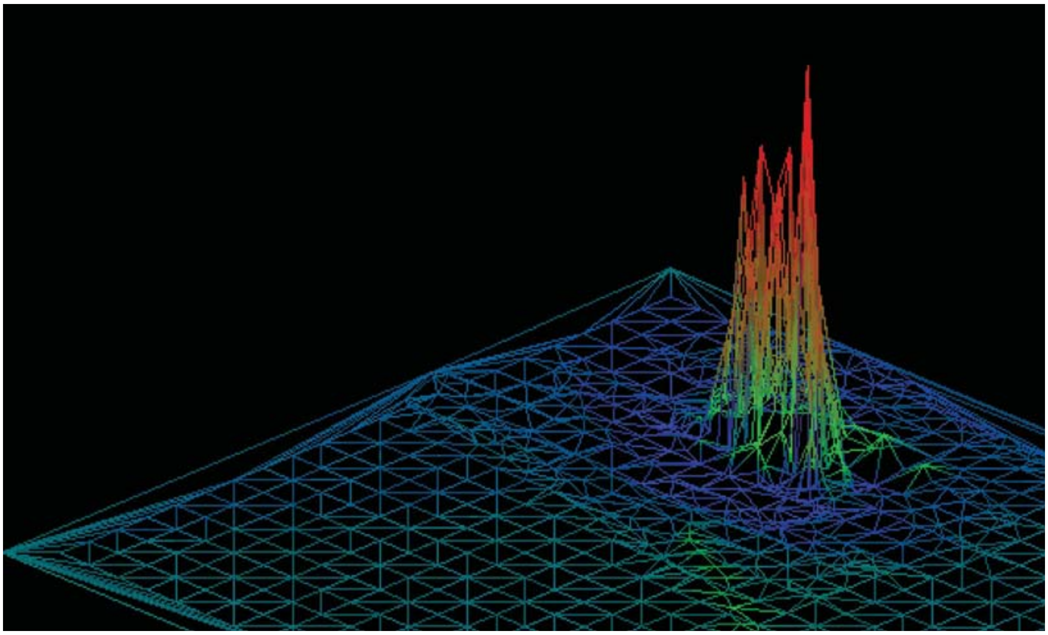
Smart Tip has three search modes of "Positive", "Negative", and "Auto". The search for Positive or Negative objects is fully automatic, for all levels of magnets, and you can start search from anywhere. There is no "Gain" knob to adjust.

In the "Auto" mode, when you don't know the polarity of the object, you must Start/Clear scanning away from magnetic objects. This records the mag free condition of the field. Then again, the search is fully automatic. Variations from the Start condition automatically guide you to any positive or negative polarity object of any magnetic value without needing to play with any gain button or orienting the sensor in any specific direction. You can also view the positive and negative values simultaneously on the same bar which may give an indication of the shape of the object.

You can also alternate between Positive and Negative modes.

Time view of S1 XYZ, XY, and Z components for the last 100 seconds.

3D magnetic view of the scanned field



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

In addition to the two three-dimensional magnetic sensors (**S1 and S2**) in the smart tip, there is also a three-dimensional magnetic sensor inside the TRIUMPH-LS (**INT**).

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

Scan the area until the spread of mag values are higher than **5*** (**Start to Beep**). Audio beep rates of **2, 4, 6, 10 Hz** or **tones** are automatically assigned to magnetic values according to the weights assigned in the **Dynamic Beep** Screen and based on Min and Max mag values.

When you have fixed RTK, hold the monopod vertical (within 5 degrees) to tag mag values with their coordinates. The Smart Tip scans the area 100 times per second and stores the 121 highest mag values and shows them in 11x11 cells of **3*** cm (**Digitizing Size**) wide. In Spatial Views, the **graphs are centered on the cell with the highest mag value**. Only points that fit in the 11x11 grid will be shown. The number of such points is shown above the progress bar. The "Clear" button restarts the process.

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

When there are enough points in the 11x11 grid (a bar shows progress), it stops and you can save the point. You can also **stop** scanning and then click the "**Save**" button to save point name, the peak magnetic value and the Mag Screenshots.

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

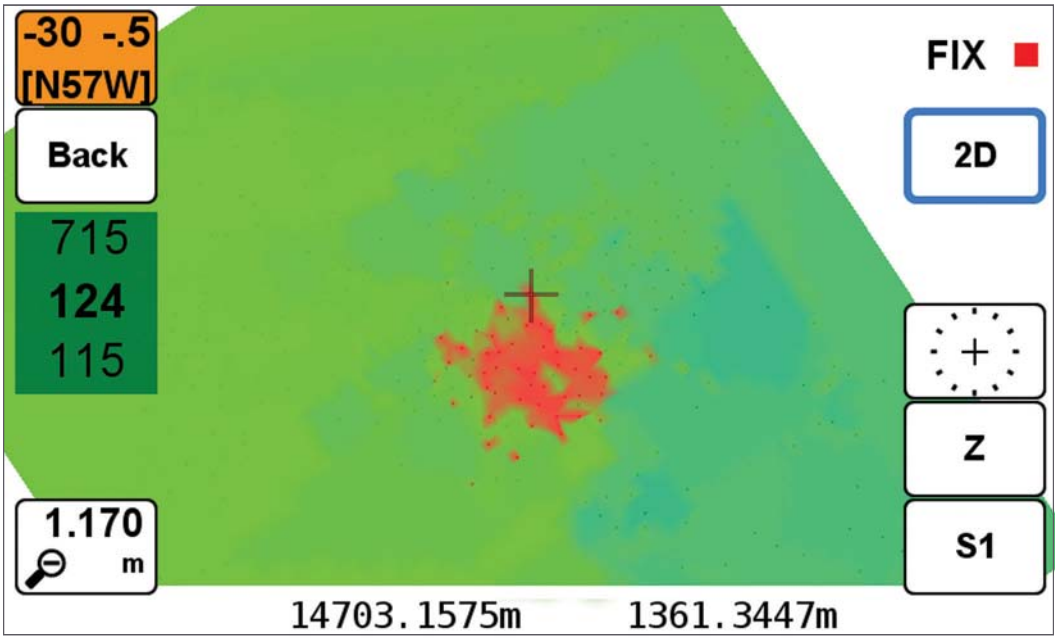
You can view the 2D and 3D graphs by clicking on the top part of the Mag screen. Click the bottom part of the Mag screen to see the Time View.

When pole is tilted less than 5 degrees, solutions will be corrected for pole tilt, otherwise points will be ignored. Time Plots show mag values at all times.

Smart Tip finds the Minimum and the Maximum

***Red numbers** are the default values for their respective items (in **bold**) in Setup screen.

2D magnetic view of the scanned field



automatically. If you disturb the normal field scan by exposing the Smart Tip to an external mag object, click the Clear button.

The hardware Start and Stop buttons start and stop scanning. You can stop scanning, view the results in different screens and settings, and decide the next step.

The known position of the object (entered in the Stakeout screen) is shown on the Mag, 2D and 3D screen if this option is selected.

Time graphs show the magnetic values of the selected sensors in Z, XY and XYZ directions during the past 100 seconds. It also shows the Min and Max values since the Start/Rest.

The Smart Tip is 48 millimeter longer than the metal tip that the monopod is graduated for. Add this to the antenna height offset when in survey mode.

When not “Paired”, the Bluetooth LED of the Smart Tip blinks red. When “Paired” it is red. When Paired and Connected, it is blue. The power LED shows charge level with green, yellow, and red colors. Hold the “On/Off“ button for three seconds to turn off. Click it 3 times to unpair it from the TRIUMPH-LS.

Comparing to conventional locators, Smart Tip has the following advantages:

The Smart Tip does not have “null” points around the peak and will not produce false alarms.

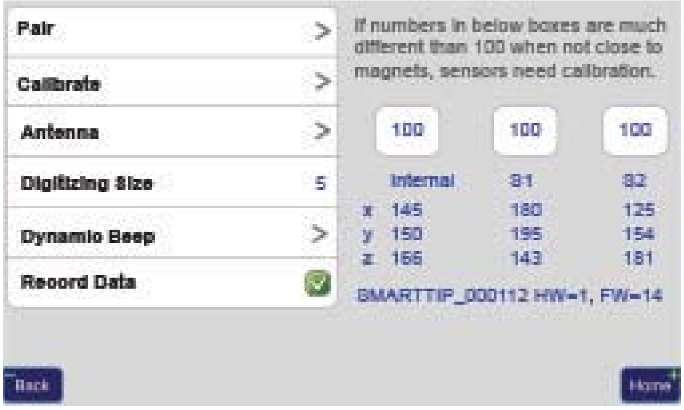
The Smart Tip is fully automatic for all levels of magnets. There is no “Gain” button to adjust.

The Smart Tip senses the mag values in all directions. You don’t need to orient it differently in different searches.

The Smart Tip gives a 2D and 3D view of the field condition when you have RTK and will guide you to the object. You can actually see the shape of buried object.

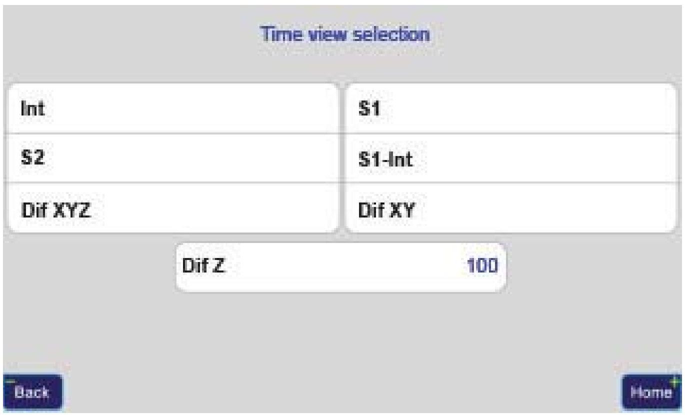
The Smart Tip, In Time View, shows you positive and negative mag values of the last 100 seconds and the Min and the Max since Start/Reset. You can see the search history and decide on the shape and size of the object.

The Smart Tip is integrated with the TRIUMPH-LS. You don’t need to carry another bulky device.



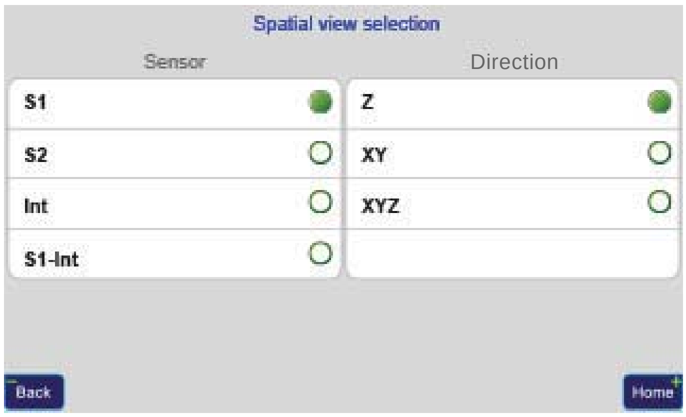
Setup Screen: It is critical to calibrate the Smart Tip and the TRIUMPH-LS sensors. Click Calibrate and keep rotating the Smart Tip around its three axis until the successful calibration message is displayed. You can also record data of a large field for post processing and image processing.

Dynamic Beep Screen: Tune the system to tones that you like. Assign a higher weight to the "Siren" so a wider range of mag values close to the peak generate a siren. Similarly, for other steps. For each step you can select beep-per-second, or a tone.
You can assign colors to points according to their magnetic values.



The type of mag data to be shown in Time View.

All values are recorded in parallel. You can stop the scan and then click to see different sensors or sensor/direction combinations.



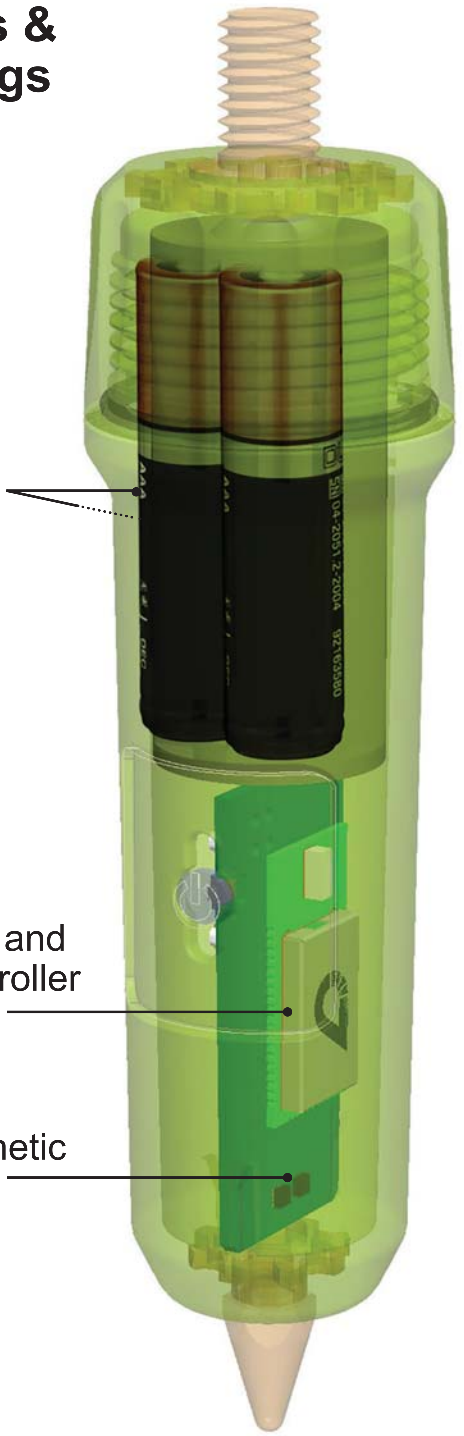
Sensor and Direction selection screen:

You can assign all settings at once to tailor the TRIUMPH-LS to your preference or for special tasks.
Default values work just fine. We show flexibility in examining the internal parameters.

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

It sends 100 Hz magnetic values to the TRIUMPH-LS via its Bluetooth.

Patents & Pendings

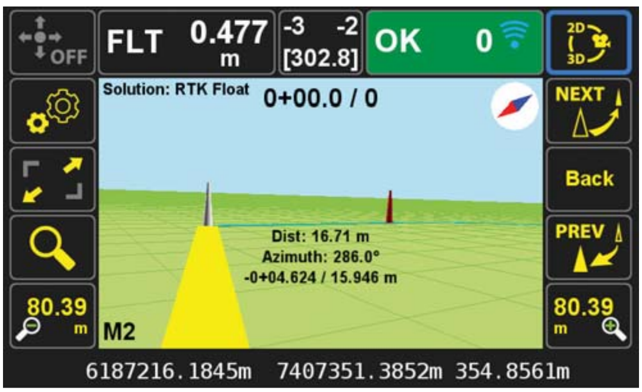


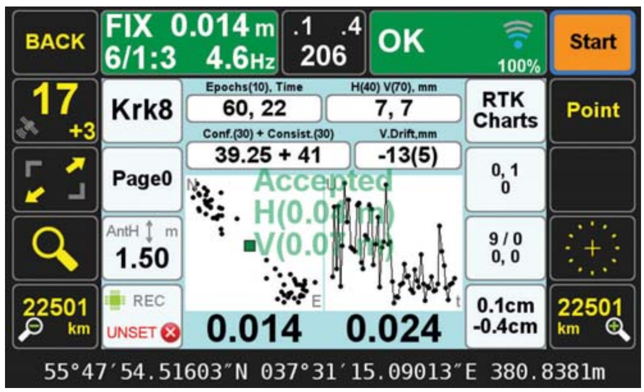
TRIUMPH-LS tags coordinates with magnetic values, It also guides you to top of the item to survey it.

FR

Field view

When you scan a large area, you can save all possible peak points, view them on the map and select the point with the highest peak to dig. When you save a point, you can also save all the raw Mag data of all sensor for future view and research. We also plan to give you the ability to share that data with us by transferring it directly to our server for analysis and improvement.

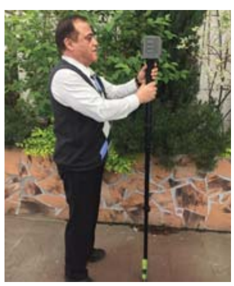




We have not only integrated a sophisticated magnetic locator in the TRIUMPH-LS, but we have also streamlined the whole process. First the “Stakeout” screen will guide you toward the target. Then the “Mag” screen locates your underground target and gives you its estimate of the coordinates of the underground target and a button to save it “as staked”.
And finally in the “Collect” screen you can survey the target point.


Head-on-Shoulder


Witch-on-Broom


Tango


Baby Hold


The Cane

Indoor Maps – the new frontier of mapmaking

This paper examines the evolution of indoor mapping, the current trends in the sector and what the future holds for "the new frontier of mapmaking"

Joseph Leigh
Head of Venue Maps, HERE

Stefan Gimeson
PM Venue Maps Platform, HERE

Less than a decade ago, few could have imagined that it would soon be possible to access detailed maps of indoor spaces on one's desktop computer, let alone on one's mobile phone. Interest and awareness of indoor maps is rapidly gaining pace, as are new technologies to support. In this piece, we'll examine the evolution of indoor mapping, the current trends in the sector and what the future holds for "the new frontier of mapmaking".

The rise of Indoor Maps

The rise of personal computers, and later the internet made it possible for maps to be consumed directly in Geographical Information Systems and within internet web browsers. An abundance of digital map layers and digital gazetteers have become available for use on personal computers. Consequently, digital maps have become a central part of everyday modern living.

These advances had a profound impact on our understanding of the world we live in, but were primarily focused on the "outdoor" world, and largely restricted to desktop-sized hardware.

Since the year 2000, the rise of lightweight pocket-sized personal digital assistants, palm- sized devices, and later smartphones and "wearables" such as smartwatches, made it possible for us to carry around detailed maps everywhere we go. This began to include indoor spaces, where we spend as much as 90% of our time.

This means that, over the past five years, mapmaking has soared beyond the boundaries of walls of buildings, penetrating deep inside complexes with multi-floor, room-level maps becoming available for shopping centers, airports, train stations and even hospitals and office buildings. This has once again raised the bar of digital mapmaking capabilities, and has also triggered a new level of expectations amongst consumers and businesses; expectations of ubiquitous, true-to-life representations of indoor spaces.

Notable trends in Indoor Mapping

Market Valuation

ABI Research recently forecast that Indoor Location will be a $4B global market by 2018. Meanwhile, Opus Research estimated that spending on indoor location hardware, services

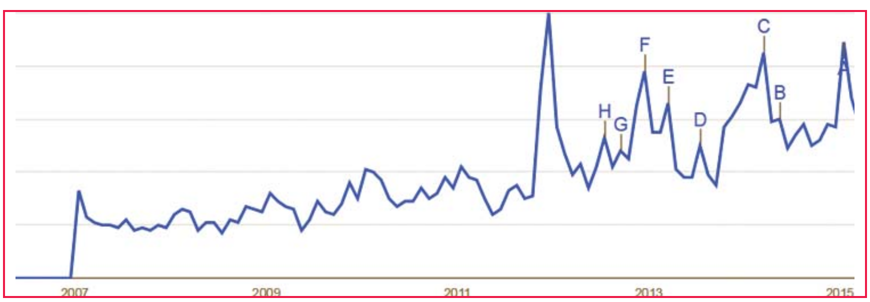


Figure 1: Internet searches for "Indoor Maps" measured by Google Trends

Figure 2: HERE Maps for Samsung's Gear smart watch

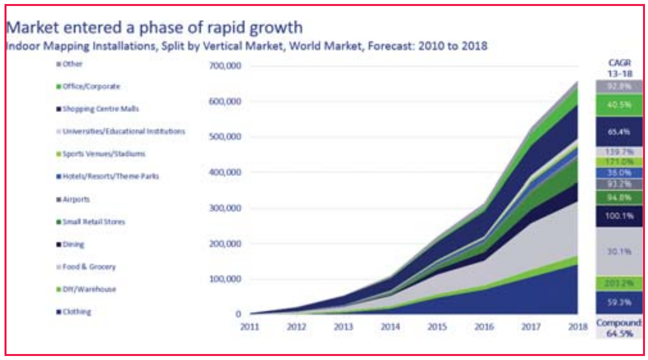


Figure 3: ABI Research, Location Technologies Market Data – 2Q 2015

and license fees will amount to $1.6B in the USA alone by 2018.

In its Q2 2015 report, ABI Research stated that the Indoor Mapping market is entering a phase of rapid growth with indoor map installations poised to more than double from 250,000 locations in 2015, to over 650,000 locations globally, by 2018.

Market Trends and Catalysts

Retail Sector

Mobile applications powered by detailed indoor maps play an ever-increasing role in retail as traditional brick-and-mortar stores experiment with new ways to compete with online retailers such as Amazon.

According to Accenture 83% of shoppers have trouble finding what they're looking for in physical stores, and 73% of shoppers with smartphones prefer to reference their smartphone while in-store rather than ask a sales associate.[1] Smartphones with detailed store maps are starting to appear to help shoppers find their way around stores, and ensure they find all the products they seek.

Retailers are also experimenting with more personal, contextually relevant deals and coupons, based on the shopper's in-store location and behavioral patterns. In-store analytics on consumer behavior are giving retailers an unprecedented insight into dwell time and footfall, based on time of day. These location-based insights are helping retailers detect friction points in the shopping experience, for example when a shopper is hesitating to make a purchase. This allows them to incentivize their shoppers, sending them a deal at the right moment, to maximize chances of a purchase taking place.

Another important trend in the battle with online retailers is centered on offering customers the ability to mix and match purchase channels and delivery options, a trend frequently referred to as "omnichannel retailing". For example, 23% of leading UK retailer John Lewis'customers now research online before making a purchase in one of its local stores.[2]

This online to offline retail trend is gaining pace as stores strive to exploit their widespread physical presence on the high street, with the ability to offer faster, more convenient local fulfillment options; a luxury not available to large online rivals such as Amazon. Once in-store, customers can collect the items they ordered, and are incentivized

Figure 4: Carrefour C-Ou Mobile App (France)

to browse for further items with immediate in-store only deals, often valid only on the day of their visit.

Detailed store maps guide shoppers around the stores, highlighting deals and items that match the user's profile. US retailers Macy's, Target and Meijer are all building location-enabled apps to help further capitalize on this growing trend. Others will follow their lead.

Travel Sector

In the United Kingdom, a CPP research study found that 41% of UK holidaymakers have struggled to find their way around foreign airports. 20% of travelers have had to run to the gate with minutes to spare.[3]

As airports and train stations strive towards ever climbing KPIs on traveler throughput, they are increasingly turning to location-aware solutions to identify bottlenecks and optimize the flow of passengers.

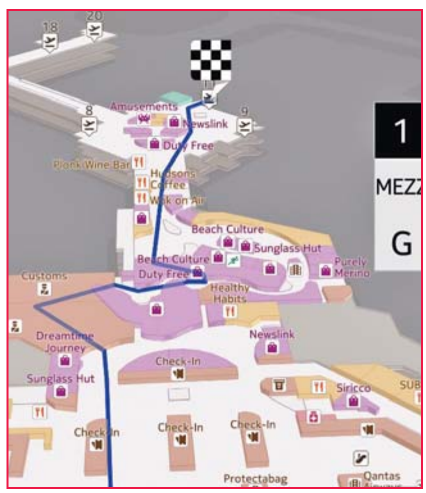


Figure 5: HERE Venue Map of Melbourne Airport

Copenhagen Airport recently partnered with Cisco to offer passengers an indoor positioning-enabled mapping application, with "turn by turn" guidance and detailed maps to help explore the airport and identify facilities, stores and local offers. "We can also monitor and prevent potential choke points. That means passengers spend less time queuing and more time doing the things they want, like dining and shopping." — Jan Zacho, Sector Manager, Infrastructure and Telephony, Copenhagen Airport.

Similar travel solutions are increasingly being developed by leading airports, airlines and rail operators around the world.

Internet of Things (IoT)

Yole Développement predicts the annual value of the overall IoT market in 2024 will be $400 billion with $46 billion coming from hardware, $59 billion from cloud infrastructure and $296 billion from data processing services.[4] Physical objects or "things" are increasingly being embedded with electronics, software, sensors and network connectivity.

When combined with indoor maps and indoor positioning, this opens up a powerful new set of asset tracking and resource optimization opportunities for businesses. For example, it becomes possible to accurately track movable assets such as costly hospital equipment, specialty tools on the factory floor, mobile robots or even livestock.

Manufacturing

Factory floors are often large and widely spread out. When parts or tools go missing or are stored incorrectly, this can lead to major production line disruptions and productivity bottlenecks. Such disruptions are particularly taxing when they relate to costly tools that are in short supply.

To address these challenges, new manufacturing solutions are being developed, that utilize ultra-wideband (UWB) sensors and wireless transmitters to locate people and assets such as tools or parts to within 20 cm. For example Ubisense, a leading provider of Enterprise Location Intelligence solutions, claims to have already installed over 6,000 sensors and 22,000 tags to assist with indoor asset tracking at over 50 manufacturing facilities worldwide. Ubisense customers include Airbus and some of the world's largest automobile manufacturers such as BMW and Volkswagen Group. "Ubisense Smart Factory is specifically engineered to deliver unprecedented visibility of manufacturing processes and provide critical insights by using real-time location data to monitor operations".[5]

Figure 6: DHL warehouse illustration

With around half a million factories in the United States alone, Ubisense and its competitors in this space (including ABB, Bosch, GE, and Rockwell Automation) are only scratching the surface of the overall opportunities for IoT in the manufacturing industry.

Warehousing and Logistics

Large warehouse operations today typically track thousands of goods and moving parts. Any small inaccuracies and loss or spoilage of goods can quickly impact productivity and amount to sizable costs. This makes warehousing an ideal environment for IoT applications.

According to DecaWave, it is now possible to "monitor customers' stock levels, warehousing, distribution and shipping to within 10cm in real time".[6]

In Germany, Aletheia, a leading innovation project funded by the Federal Ministry of Education and Research is testing a real-time positioning system that uses energy-efficient wireless communication to continuously monitor the position, condition and delivery state of goods as they move through the supply chain.

Nonetheless, according to DHL, we are today "just at the tip of the iceberg of fully exploiting IoT potential in the logistics industry".[7]

Healthcare Industry

Today an average-sized hospital carries 8,000 stock keeping units (SKUs) of in-house inventory at any one time, and may "own" as many as 35,000 SKUs end to end. Supply chain costs consume as much as 40% of total operating budget, the second-largest expense for hospitals after labor. [8]

By 2020, supply costs will likely surpass labor costs as the biggest expense for health systems.[9] Consequently, even small efficiency savings in supply-chain performance can have a sizable impact on a hospital's bottom line. For example, it is estimated that on average 30% of nurses report spending at least one hour per shift searching for equipment.[10]

With a combination of detailed indoor maps, indoor positioning, and asset tracking tags, hospitals can achieve sizable efficiency savings and potentially save lives, by tracking costly movable equipment, for instance dialysis machines, infusion pumps, or emergency ventilator machines, and ensuring these can quickly be found when they're needed the most. In 2013 Kingston Hospital NHS Foundation Trust rolled out a Cisco Smart Solution to help manage and protect hospital assets by pinpointing their location to within 3m.[11]

Indoor location technology can also help track hospital staff and patients, to ensure the nearest appropriate staff member is called to an emergency as soon as it arises. Further usages include ensuring each patient is checked on time by the appropriate staff member, and ensuring staff are regularly using hand-washing stations.

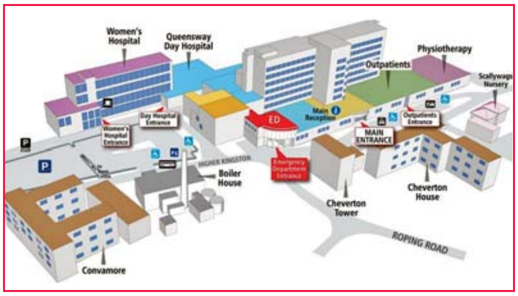


Figure 7: NHS Foundation Trust (Yeovil)

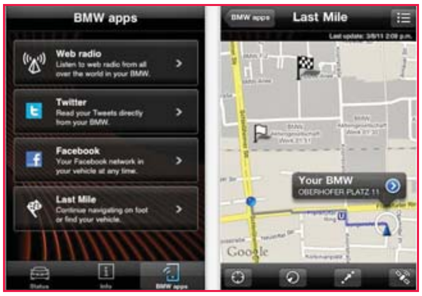


Figure 8: BMW mobile App

Figure 9: Volvo V40 Autonomous Parking concept

In the United Kingdom, 6.9 million outpatient hospital appointments are missed each year amounting to a total cost of around £700m per year.[12] The Guardian newspaper states[13] that a significant proportion of missed appointments are the result of navigation problems, especially at large hospitals. The Wall Street Journal states that "visitors struggle to navigate the maze of the modern medical complex".

Confusing layouts and signage add to patients' anxiety at a time when many are feeling ill and are coming to the hospital to undergo tests and procedures".[14]

In spite of these costly challenges, at the time of writing (August 2016) usage of indoor location technology within the healthcare industry remains in its infancy. This presents a major opportunity to suppliers of indoor mapping, indoor positioning and asset tracking solutions.

Automotive sector

In-dash navigation systems have in the past been limited to largely static map data, with little or no internet connectivity. More recently automobile manufacturers have begun connecting cars, by means of built-in SIM cards, as well as via Bluetooth/Wi-Fi connected smartphones. This has triggered a new trend; the rise of so called "car companion apps". These serve multiple functions including intelligent services such as Telediagnostics, Breakdown Management, Accident Recovery and general car Maintenance Management. They also assist drivers by storing the location where they park, and even permit the exchange of destinations and waypoints directly with their car. These companion applications also now increasingly include functionality to guide drivers to their final destination on foot, after parking their car. This is frequently referred to as "last mile" routing.

While many car manufacturers now offer mobile apps with last-mile guidance, at the time of writing (August 2016), none of these included detailed pedestrian instructions inside of venues such as malls, airports and train stations. Such functionality is however starting to come to fruition on the latest models of Personal Navigation Devices (PNDs) such as the Garmin's latest devices. Drivers will increasingly start to expect car companion apps to offer a similar level of local last mile guidance, to indoor destinations.

Car manufacturers are also starting to experiment with detailed (centimeter-level accuracy) maps of parking garages. Such parking space-level maps will increasingly be required to support advanced use cases such as autonomous valet parking.

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The wider potential market is still waiting for solutions

We face a challenge with the lack of a standard to refer to and of technology understanding from customers

Matteo Faggin
GiPStech Srl

Interest in Indoor Positioning Services has been growing in recent years as the widespread adoption of GPS enabled devices has made outdoor localization ubiquitous to all users. Users in turn are maturing an understanding of how powerful and valuable localization is in many applications, and started pushing to extend the reach of localization to all sorts of applications, most of which are in indoor settings - a normal consequence of the basic fact that we all spend 90% of our time indoor – which are poorly serviced by GPS-based localization.

Many technologies have been developed and indeed successfully used to solve this basic need, most of them though are based on extensive and costly installations of hardware that makes them employable only in the few cases where there is a crystal-clear return on investment.

The wider potential market is still waiting for solutions that are able to cut down the cost/performance tradeoff entailed by solutions already in the market, enabling applications that have clear value propositions but need to work at a lower price point.

At GiPStech we developed a technology that is poised to accommodate the needs of a large portion of this latent market: our core technology leverages both advanced sensor fusion (with a Pedestrian Dead Reckoning deemed state-of-art by technology companies) and geomagnetic fingerprinting. In short, we are able to understand in real time how a user is moving in the space and match it with a free and always on map of signal to reach high precision (1 meter on average), at high level of service, with no infrastructure apart from the cheap sensors already on board on smartphones. To further increase level of service especially on large venues, we also integrated Wi-Fi and BLE signal in our localization platform, therefore not only delivering to market something superior but also matching what most other players are proposing.

> Users are maturing an understanding of how powerful and valuable localization is in many applications, and started pushing to extend the reach of localization to all sorts of applications

In our approach to the market – now consisting of hundreds of use cases – we noticed of course some naivety, with many potential customers' expectations spoiled by the experience of smartphone GPS-based localization services: free and available at any time and conditions. Indeed, we found this to be the biggest hurdle in implementing indoor positioning: filtering out the naïve requests of well-intentioned prospects and finding those applications where the need is so urgent that the potential customer cannot simply sit and wait for the "magic solution" to happen (provided of course for free by the Google of this world).

We are finding these applications in many specific verticals, broadly divisible in two fields: where the customer needs to provide an outstanding service to the final users of its facilities to distinguish itself from a though competition (as in museums) and where the customer has a clear business case to implement (as in internal logistic optimization, maintenance tracking, at-risk patients monitoring, etc.) to save costs or increment productivity.

Another problem we constantly face has to do with the lack of a standard in the field. Most of IPS provider communication and consequently of prospective customer attention focuses on precision of localization, while this is only one metric (although important) that influences the outcome of a good implementation: stability, responsiveness, lag time and computation power required are some of the other important factors that should be considered in determining what is the best solution to the specific use case. In short, as typical of early stage technologies, we face a challenge with the lack of a standard to refer to and of technology understanding from customers.

We are nonetheless convinced that these obstacles will naturally drop over time, and in particular that will emerge the technical superiority of our solution: a strong platform for IPS that combines multiple approaches – from inertial to geomagnetic to BLE – to provide the best performances in all applications.

End users used to GPS navigation, expect the same service on indoors

Users expect free and effortless service with low latency and low battery and data usage

Dr Thomas Burgess
Chief Research Officer, indoo.rs GmbH

Our end users are used to GPS navigation, and expect the same service on indoors - a blue dot on their own mobile screen accurate to a few meters. Furthermore, they expect free and effortless service with low latency and low battery and data usage. Hence, we support both main mobile OS's and only use data from the standard onboard radio and motion sensors. Latency, traffic and battery drain is reduced by running efficient on-device algorithms (as opposed to in the cloud). Currently a dedicated application or service is required to enable mobile navigation, however if future browsers enable radio api's we could provide navigation directly in the browsers.

The cost of providing this typically is covered by venue owners who wants to improve customer experience, increase engagement with their venues, or increase accessibility. As a side benefit the process produces very useful analytics data of high interest to the venue owners. A general way of lowering the threshold to venue owners to consider indoor navigation would be availability of open standard displayable map and point of interest data.

A known radio infrastructure allows for a fast location fix that can be improved with subsequent observations. Adding motion data can significantly improve the estimated trajectory. Only Bluetooth is available in an open API for both main mobile OS's, but WiFi is usable as an alternative source on Android. However, in our experience obtainable quality is higher with a dedicated infrastructure rather than simple opportunistic use of available WiFi access points. Furthermore, mobile access points and non-standard behaviors such as mac obfuscation and adaptive transmission power further complicate the opportunistic approach. Using cheap off the shelf Bluetooth beacons and mobile phones currently is the most cost efficient way to bring indoor navigation to our customers. Other signals such as light systems, ultra wide band, custom WiFi additions, etc rapidly add to the cost and dramatically reduces the available user base. An additional benefit of beacons is that they can be discovered in the background which gives rough location useful for triggering proximity events and generating complement data for analytics when the user is not navigating.

A known radio infrastructure allows for a fast location fix that can be improved with subsequent observations. Adding motion data can significantly improve the estimated trajectory

Thus, we believe the introduction of standardized beacons has significantly improved reliability in indoor navigation. Still for many reasons, the installation of hardware remains an obstacle for the wide spread use of beacons. This can be due to lack of experience and unawareness of potential benefits, but also fear of technology lock-in, installation cost, and maintenance considerations. Aside from addressing these issues by making documentation, consulting customers, and working with quality beacon providers, we are also we are also working on improved methods to design, deploy and maintain beacon infrastructures. Furthermore, we are following developments made possible in recent Bluetooth 5 and WiFi standards with great interest, and hope to make use of new technology as it appears.

While beacons primarily are intended for proximity events (~10-20m accuracy), radio fingerprinting methods allow for obtaining high accuracy. Fingerprinting methods rely on radio maps with many point measurements of beacons and signal strengths. Traditionally these measurements are made by stopping at each point and collecting radio signals for around one minute. This approach is very slow and only feasible for smaller scale solutions. The radio maps also must be kept up to date with the current environment to give reliable results. For this purpose we developed our SLAM system. We see a lot of potential in using crowd data and are working employing it to replace the initial mapping step.

Geodetic measurements in the area of Kozloduy Nuclear Power Plant

The results of the measurements can be analyzed and interpreted in close cooperation with specialists from different professions and representatives of various fields of science and technology

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Figure 1: Location of the Kozloduy Nuclear Power Plant

For security purposes and safe and flawless operation of the Nuclear Power Plant (NPP) "Kozloduy" at the end of the last century it was given the task to build a monitoring system. As a major component of this system was to be built precise geodynamic (geodetic) network for investigation of deformations, which covers the territory of the plant, double channels and a territory outside the plant. One of the main objectives of the system for geodetic monitoring is monitoring of the spatial displacements and deformations that may occur in the facilities, on the terrain beneath them and in the surrounding areas. This paper presents the results of geodetic measurements of the NPP carried out during time span of 1998-2013 by "Geoprecise Engineering" Ltd Company, mathematical data processing, analysis and interpretation of results.

Introduction

The Kozloduy Nuclear Power Plant (KNPP) is a nuclear power plant in Bulgaria situated 120 kilometres (75 mi) north of Sofia and 5 kilometres (3.1 mi) east of Kozloduy, a town on the Danube river, near the border with Romania (Figure 1). It is the country's only nuclear power plant and the largest in the region.

The construction of the first reactor began on 6 April 1970. Kozloduy NPP currently manages 2 pressurized water reactors with a total output of 2000 MW. Units 5 and 6, constructed in 1987 and 1991 respectively, are VVER-1000 reactors. One of the main objectives of the system for geodetic monitoring is monitoring the spatial displacements and deformations that may occur in the facilities, of the terrain below them and on the surrounding terrain. The results of geodetic monitoring can be used for prediction and prevention of possible accidents.

Geodetic network and measurements

The geodetic measurements in the region of the Kozloduy NPP started in 1998 [Valev et al., 1999].

The entire geodetic network (Figure 2) is generally composed of the following parts which can be considered as separate subsites:

- Control Geodetic Network (CGN) consists of control points (pillars) and benchmarks on the pillars and covers the entire region.
- Secondary geodetic network consists of traverse points and benchmarks within the NPP.
- Geodetic network of points and benchmarks in the area of dual canal.
- Geodetic network of points and benchmarks in the area of the canal for additional technical water supply.
- Geodetic network of points and benchmarks in the area of the Coast Pumping Station (CPS).

The tectonic activity of the area of location of Kozloduy NPP has been studied as part of entire territory of Bulgaria or of Balkan

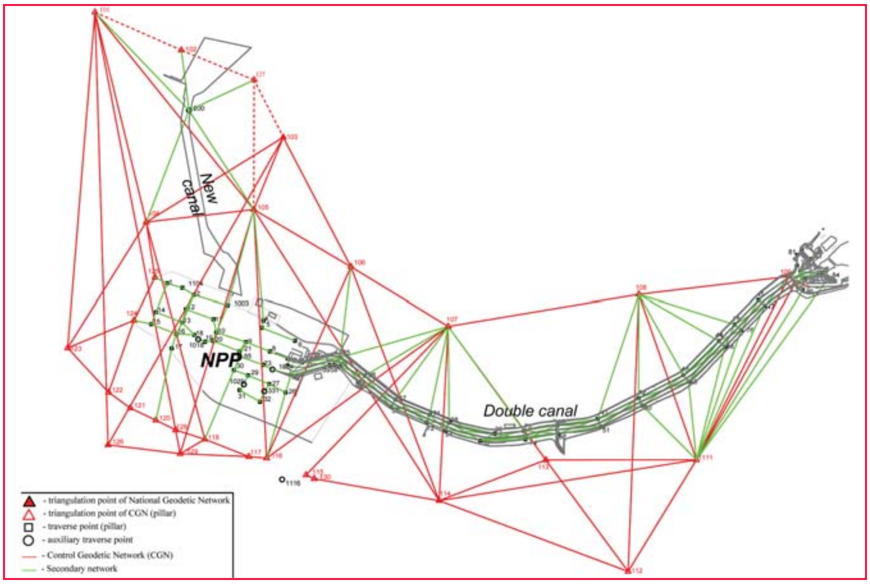

Figure 2: Geodetic network

Peninsula by different researchers [Kotzev et al., 2006; Kotzev et al., 2008; Milev, Dabovski, 2006; Milev et al., 2006].

The structure of entire geodynamic network according to different types of measurements can be regarded as composed of four separate geodetic networks:

- Spatial GPS network;
- Horizontal triangulation network;
- Horizontal trilateration network;
- Height (Levelling) network.

Comprehensive and integrated precise geodetic measurements of all types of networks are carried out in 6 epochs: 1st epoch - summer / autumn 1998; 2nd epoch - winter 2001 and spring 2002; 3rd epoch - autumn 2004; 4th epoch - autumn 2007; 5th epoch - summer 2010; 6th epoch - spring 2013; 7th epoch – carried out this year (summer 2016).

The measurement types carried out are as follows:

- GPS measurements with 5 dual frequency GPS Receivers LEICA Geosystem 1230 and 2 receivers GEONEX;
- Levelling measurements with electronic digital levels and barcodes invar staffs;
- Angular measurements with electronic total station with direct accuracy $\pm 2^{cc}$;
- Distance measurements with laser rangefinder Mecometer ME 5000.

GPS measurements were carried out on the 27th control points of the CGN and on all traverse points located in the area of the plant, near the double canal, the new canal and near the coast pumping station. The total number of all measured GPS points is 279. The precise angular measurements were carried out by the approach of circular rounds and total 402 horizontal directions at 101 stations were measured. Precise distance measurements were carried out with the laser rangefinder Mecometer ME 5000. The precision of laser rangefinder is ±(0,2mm +0.2 mm/km). Weather data were measured (temperature, pressure, humidity), as at the finder, and at the reflector. Number of measured lengths with Mecometer ME 5000 is 448 lengths. The precise levelling measurements were carried out with digital level ZEISS DINI 12, which has a direct accuracy ± 0.4 mm/km. 120 levelling runs are levelled with a total length - 75 km. The levelling includes - deep levelling benchmarks; levelling benchmarks of the existing levelling network; levelling benchmarks to the foundations of the points of the horizontal network; points of all subsites.

Data processing

The results of all types of measurements are processed in compliance with the maximum mathematical rigor, taking into account all the possible harmful external influences and with minimum of hypotheses.

Baselines are calculated first from the GPS measurements [Valev, 1987; Valev, 1995]. Distance measurements are processed after correcting them for weather conditions (temperature, humidity, pressure, curvature of the light path). Levelling measurements are processed for all subsites. The resulting *rms* per kilometer from misclosers in levelling loops is ± 1.3 mm/km. The horizontal network is adjusted as angular-linear network.

For each point are estimated: *rms* of coordinates, *rms* of position and the ellipses of errors. The obtained *rms* of the entire network is $Mp = \pm 5.8$ mm

Secondary network is adjusted separately as definition of datum is from the control network.

The levelling network is adjusted commonly for the control network points and points of the subsites. 8 benchmarks are used for datum definition in the adjustment. The resulting *rms* per unit of weight, which is *rms* per *kilometer,* is: $M_h = \pm 0.9mm$. The obtained elevations of all benchmarks are in Baltic height system. The GPS network is adjusted as free network in two variants:1) using only GPS measurements; 2) using GPS measurements, distances measured by Mecometer and elevations from precise levelling [Valev, Minchev,1995].
The obtained results are adjusted spatial Cartesian coordinates of the points; ellipsoidal geographic coordinates and ellipsoidal heights; plane coordinates in a Lambert map projection. The accuracy of estimated results from two variants of GPS data processing is:

First variant: *rms* in space: $M_{XYZ} = \pm 2.0$mm; *rms* in plane: $M_{XY} = \pm 1.0$mm; *rms* in height: $M_h = \pm 1.7$mm.

Second variant: *rms* in space: $M_{XYZ} = \pm 1.9$mm; *rms* in plane: $M_{XY} = \pm 0.9$mm; *rms* in height: $M_h = \pm 1.6$mm.

On the basis of the obtained results (point coordinates, point heights and distances between points) are studied:

- Height changes of the terrain - the vertical movements of the benchmarks relative to their position in 1998, 2001, 2004, 2007 and 2010.
- Magnitude and direction of horizontal vectors of point movements.
- Surface deformations by applying the finite element method.

The vertical movements of the area of study are shown in figure 3.

Horizontal movements are calculated from the obtained displacements in coordinate axes for the periods between the adjacent epochs (3 years) and between each epoch and the initial epoch of measurements in 1998. Horizontal movements between 5th measured epoch and the initial epoch (in red) and between 5th and 4th measured epochs (in green) are shown in figure 4.

Determination and analysis of deformations

Finite Element Method developed for space [Vassileva, Valev, 2015a; Vassileva, Valev, 2015b] is applied under the assumption that the deformations occurring between epochs are isotropic within a single differential surface element. The same standard surface elements representing non-overlapping triangles are chosen as finite elements. Relative deformations of the sides of each finite element and principle deformations with their direction for each finite element are calculated. The principal axes of deformations between 1st and 5th epochs of measurements are shown in figure 5.

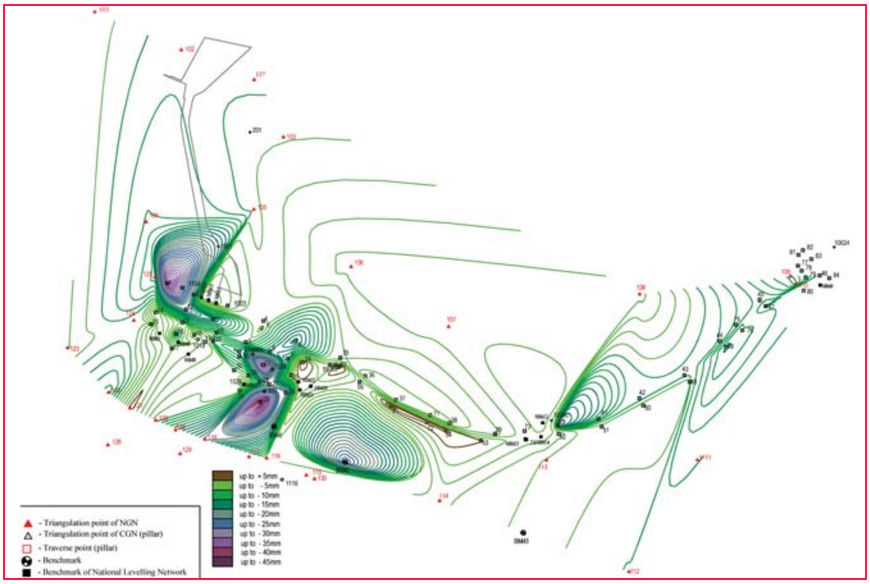

Figure 3: Vertical movements

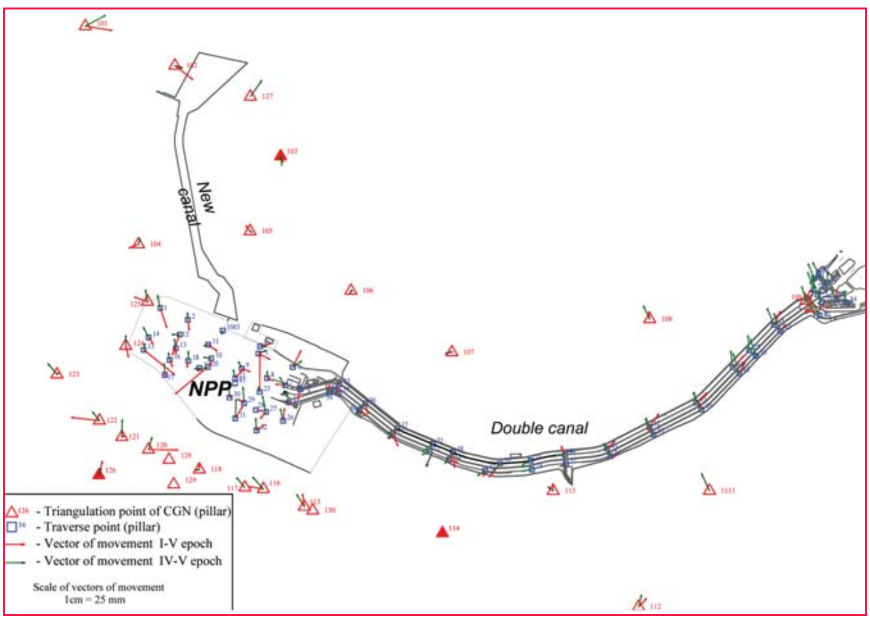

Figure 4: Horizontal movements

The vertical displacements of almost all points of the control network, as well as for the most of the points from the secondary network are obtained. Both uplifts and subsidence are found. Mostly is the sinking. There are also zero displacements. Vertical displacements between 1st and 5th epoch are under 5 cm. It is not found a trend in the vertical movements.

Horizontal movements of the CGN are with various directions and no trend is found. Displacements of half of the points are over 30 mm as maximum displacement is 48 mm.

Horizontal movements of the Secondary network, which covers the area of NPP, are less than 20 mm. The directions of movements are mostly southeast. For the period 1998-2010 the maximum displacement is 30 mm. For all other points displacements are less than 20 mm. Directions of movement are mainly in the south and southeast. From the analysis of the movements it is established that the horizontal displacements are much larger than vertical.

The accumulated isotropic deformations between any two adjacent epochs and between initial and final epoch are analyzed. The maximum deformation of almost all finite elements is below 10^{-4}, but for many, they are even below 10^{-5}. Deformations are diverse in character and direction.

The results from the analysis show that deformations established are of extension and of compression. There are sites where deformations are either just of extension or just of compression. The principle deformations are under critical. Directions of the principal axes of deformation are different. This means a slight change in space and time of the quantitative and qualitative characteristics between the epochs or there exist permanently redistribution of the intensity and nature of deformation processes in the region.

Conclusions

The results of the measurements, data processing and analysis confirm that there is a deformation process in the area of the Kozloduy NPP that is slow and has a variable character. Movements established indicate possible weak geodynamic processes and phenomena. The vertical displacements are not of the same order with the horizontal - vertical are almost an order of magnitude smaller. Deformations established between neighboring epochs are so far below critical values. The situation for now is relatively calm. Our opinion is that there is currently no reason to prescribe any special measures on the safety of the Kozloduy Nuclear Power Plant.

Recommendations

Based on the above analysis the following recommendations can be made.

Geodetic measurements should continue with greater frequency. It is appropriate in the future to carry out measurements at least every two years. The most favorable time for such measurement is late summer and early fall. In addition to regular measurements extra measurements could be possible. The most important circumstances that need to carry out such measurements are: various natural disasters (earthquakes, heavy rains, floods, storms, prolonged drought, etc.); abnormal weather conditions; emergency; after repair of equipment; high water level of the river; increased seismicity; activation of geodynamic phenomena.

The results of the measurements can be analyzed and interpreted in close cooperation with specialists from different professions and representatives of various fields of science and technology. Our information must be correlated with seismic and tectonic one. If more measuring epochs are available a regression analysis and relevant prediction of the displacements and deformations are possible.

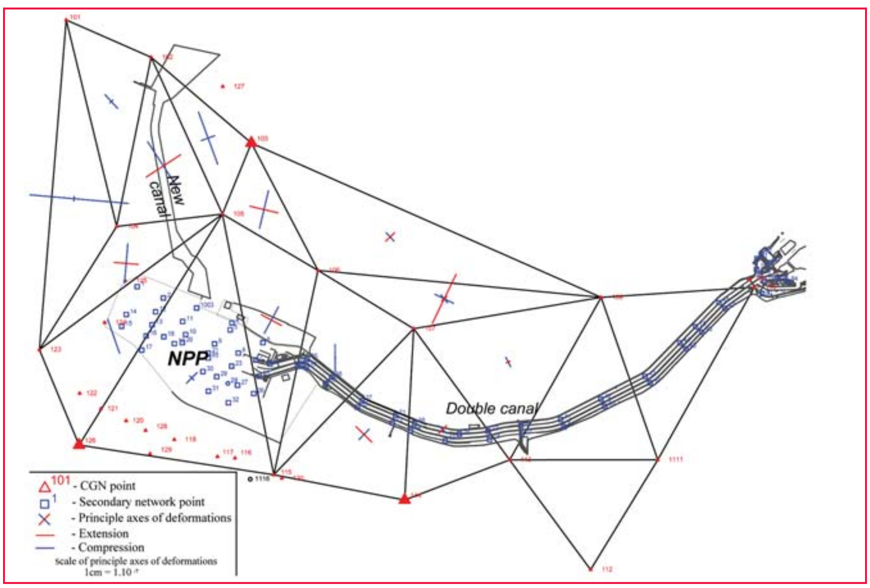

Figure 5: Principle axes of deformations of Control Geodetic Network I-V epochs

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Bentley ContextCapture

Bentley Systems has announced general access to the latest release of ContextCapture and ContextCapture Center. This release enhances the accessibility, scale, and quality of reality models that can be produced for use in BIM and geospatial workflows. The expansion of multi-resolution format support enables ContextCapture to provide improved quality and performance of reality modeling data within geospatial workflows, particularly valuable for the large community of ArcGIS and other geospatial users.

SuperGIS Mobile Series

Two core products of SuperGIS Mobile Series: SuperSurv for Android and SuperPad are all capable of receiving the signal from external GNSS devices. After connecting and matching the smart devices and external GNSS receivers, users can acquire high accuracy data with ease. SuperPad and SuperSurv for Android can fully support and display the location and other detailed information collected by mainstream external GNSS devices, which can meet demands of most fieldworkers. *www.supergeotek.com*

14 'core' INSPIRE themes for global sustainable development goals

The scope of geospatial data extends far beyond environmental, social and economic analysis, a study by UN-GIMM: Europe has found. Research by the regional committee of experts shows that information about location also plays a key role in implementing policy to help address a wide range of concerns at regional, national and global level.

The report, which is the first deliverable of the Working Group on core data, has identified 14 INSPIRE themes which can support the UN's sustainable development goals (SDGs) and meet user needs for authoritative, harmonized and homogeneous framework core data.

"We know that many of the SDGs require dependable geographic information to measure, monitor and manage sustainable development," says Chair of the UN-GGIM: Europe Executive Committee, Bengt Kjellson from Sweden.

"Core data may be used as a framework on which other richer, more detailed, thematic geospatial and statistical data rely. UN-GGIM: Europe believes that it should be produced once for national and regional uses with maximum resolution, and then provided to international users if necessary through generalising and aggregating processes."

The INSPIRE themes identified as 'core' for the SDGs are:

- Administrative themes that provide a hook for integration with other data; namely administrative units, statistical units, geographical names, addresses, cadastral parcels, area management/ restriction/regulation and reporting units, and governmental services.
- Themes that provide a topographic description of a territory: elevation, land cover, land use, orthoimagery, buildings, transport networks and hydrography. *www.un-ggim-europe.org*

Galileo update

Galileo and Japan's QZSS constellation to be integrated

Talks are starting on integrating the GPS satellite constellations of the EU and Japan. It is hoped that an integrated constellation will help the development of autonomous vehicles, farm machinery and construction equipment by allowing those made in Japan and the EU to use GPS signals from either constellation.

Japan's Quasi-Zenith Satellite System (QZSS) and the EU's Galileo constellation could be linked in two to three years if all goes to plan. Mitsubishi Electric, Hitachi Zosen and NTT Data and Thales are involved in the talks. The objective is to have an integration plan in place by the end of this year.

Galileo is intended to be a 20 satellite constellation. So far it has launched 14 satellites. Japan's QZSS constellation is a three satellite constellation which is planned to be increased to four by 2018. It is geosynchronous rather the geostationary so that one of the satellites is always over Japan. *www.electronicsweekly.com*

Jackson Labs delivers Galileo-Enabled GNSDO™

Jackson Labs Technologies, Inc (JLT) has announced several new products with full support for Galileo, as well as a free software retrofit to existing products adding Galileo functionality.

JLT has upgraded the popular Mini-JLT GPSDO with an 8th generation GNSS NEO-M8T Timing receiver from u-blox that allows receiving Galileo signals as well as concurrent GPS, Glonass, BeiDou, and QZSS signals. Users can choose to operate a single GNSS system, or multiple concurrent GNSS systems for redundancy.

The Galileo GNSS promises significant improvements in timing and frequency performance due to improved on-board Hydrogen Maser Atomic references (Cesium and Rubidium references are used in GPS and Glonass satellites) and other system improvements. In stationary timing mode, the new Galileo-capable GNSDO products will operate with as little as one single satellite in-view, and can use additional satellites to improve timing stability and accuracy via an over-determined timing solution for oscillator disciplining. Indoor tracking is possible with an unmatched GNSS performance of down to -167dBm. *www.jackson-labs.com*

BQ Aquaris X5 Plus Flagship Smartphone launched Galileo

BQ, a Spanish Smartphone manufacturer has launched a new Flagship smartphone – the Aquaris X5 Plus. It is the first handset to come with the satellite navigation system Galileo. It will be available in Two RAM and Storage options - 2GB of RAM and 16GB of internal storage and 3GB of RAM and 32GB of Internal Storage. It also sports host of other smart phone features. Coming to the connectivity options, the Smartphone offers 4G LTE with VoLTE, 2G/3G, Bluetooth 4.1, Wi-Fi 802.11 a/b/g/n/ac (2.4 / 5GHz), GPS + GLONASS, 3.5mm audio jack and Micro-USB port. *http://fitnhit.com/*

At a Glance

- Handheld Launches the NAUTIZ X2 All-in-One Rugged Android Device
- Bluesky Geospatial Joins Ireland's Growing Geographic Information Industry
- Topcon GPS L1 L2 Glonass Hiper Lite with RTK Set NEW 900 mhz GNSS
- FAA regulations creating opportunities for Louisiana-based SJB Group
- Vricon launches 0.5m resolution Digital Terrain Model (DTM)
- Uber partners with a DigitalGlobe to boost mapping capabilities
- LVM chooses Sokkia GNSS receivers for forest data collection
- Lockheed prepares WorldView-4 satellite for Sept 15 launch
- MDA signs €31 million contract with EMSA to provide RADARSAT-2 information
- TomTom introduces TomTom TRUCKER 6000 Lifetime Edition
- Esri releases new version of ArcGIS Full Motion Video
- eMaint introduces interactive image mapping feature
- Iceland to provide geospatial data to European Location Framework
- Kerala, Indian state's transport department to bring private bus under GPS reach

Australian maps and GPS will align by 2020

The country's maps are currently based on a standard called the Geocentric Datum of Australia 1994 (GAD94), which is more than 20 years old and ties map references to locations fixed on the Australian continent.

Since GDA94 was created, however, the country has moved about 1.5 metres, because its fast-moving tectonic plate moves 7 cm a year (we're colliding with the Pacific Plate, which is heading west 11 cm a year).

As the Australian Broadcasting Corporation reports, the country's geodata agency Geosciences Australia (GA) plans to start using a new datum, GDA2020, from 2017.

GA has based GDA2020 on where it expects Australia to be in 2020, so in 2017, the datum will have a 20 cm error that will converge on the "correct" position over time.

That phase of GDA2020 will, however, still be fixed to the continent, so GA is planning a second phase: the Australian Terrestrial Reference Frame (ATRF), which will be rolled out out between 2020 and 2023. The ATRF is designed to stay in synch with global navigation satellite systems (GNSS), making local spatial information directly interoperable with sat-nav. *www.theregister.co.uk*

CSMART officially opens

Carnival Corporation's Center for Simulator and Maritime Training (CSMART) was officially opened in Almere, Netherlands. The CSMART is the largest facility in terms of training capacity and utilises the most innovative technology solutions from Transas. The Transas Integrated Full Mission Simulation Academy Solution implemented at the CSMART is a significant innovation that moves the capability of the most complex challenge to maritime safety forward.

The CSMART facility houses navigational and engine room simulators in various configurations from classroom stations up to part-task and full mission solutions, interlinked to provide training and assessment for the entire crew. *www.transas.com*

China's satnav industry grows 29 pct in 2015

The output value of China's satellite navigation and LBS industry grew 29.2 percent year on year in 2015, with the country's self-developed BeiDou Navigation Satellite System making a big contribution, according to a white paper.

The output value reached 173.5 billion yuan (26 billion U.S. dollars), nearly 20 percent of it from the BeiDou application, showed the white paper released by the GNSS & LBS Association of China.

Though China's satellite navigation and location-based service industry is still at an early stage of development, its output value will continue growing at an annual rate of 20-30 percent in the coming years, the white paper predicted. *http://news.xinhuanet.com*

Air Force declares Nunn-McCurdy breach on GPS ground system

The U.S. Air Force would notify Congress that a next-generation ground system to control GPS satellites would exceed baseline cost estimates by at least 25 percent, triggering a series of regimented cost control measures and raising more questions about the future of the program. The mandatory notification, part of what is known as a Nunn-McCurdy breach, sets the stage for the cancellation of the Air Force's Operational Control Segment, or OCX, program unless the Secretary of Defense determines the program is vital to national security, no reasonable alternatives exist, and that the Air Force has a solid plan to put the project back on track. OCX was expected to offer improved information assurance and unprecedented cyber protection while automating various GPS 3 satellite operating functions. But the program has faced continuing technical difficulties and the delays have been a sore point for Air Force leaders, who say that because of the lag they will be unable to immediately leverage the full capabilities of the GPS 3 satellites, which include better accuracy and higher-power signals. *http://spacenews.com*

SatNav expert Terry Moore decorated by RIN

Terry Moore, satellite navigation professor at The University of Nottingham, has been honored with the J E D Williams Medal for his contributions to the Royal Institute of Navigation (RIN). Moore is a longstanding Fellow of the RIN, and currently its vice president.

India, Nepal agree to use GNSS for border pillars

More than 8,000 pillars along the India-Nepal border will be linked to a global navigation satellite system, allowing authorities for the first time to effectively manage the over 1,700-km-long porous boundary. Nepal's ministry of foreign affairs said the Nepal-India Boundary Global Navigation Satellite System (NIB GNSS) will be used for the boundary pillars. The decision in this regard was made at the third meeting of Nepal-India Boundary Working Group (BWG) which concluded in Kathmandu recently. *www.hindustantimes.com*

Roscosmos eyes joint projects with India, China

Russian State Corporation Roscosmos is considering joint space projects with India and China, including on manned programs, according to Roscosmos head Mr. Igor Komarov. "We maintain constant contact with Indian partners. Now we are agreeing to deploy GLONASS adjusting stations in India. Besides, they had requests connected with the possibility of participation in our moon programs," Komarov said. With China, he said, the issue of exchanging data from remote Earth sensing satellites to address emergency situations is being discussed. *https://rbth.com/*

Russia issues stamp to honor GLONASS

A Russian stamp honoring GLONASS was issued on July 5. A new Russian Federation postage stamp features the GLONASS-K satellite and graphic icons representing the main application areas of the satellite navigation system's services.

DLT in Thailand installs GPS system

DLT Director General Sanit Phromwong disclosed that since January, over 66,000 public transportation vehicles have been equipped with the GPS system, in an attempt to raise the safety standards of public transportation. The DLT has designated that newly registered vehicles must be equipped with the GPS system to link the data with the DLT within 2016. All public transports are required to be equipped with the GPS system by 2017 as well as the all trucks in 2019 under the supervision by the DLT's GPS System Management Center. *http://news.thaivisa.com*

Location Matters in Manchester CityVerve Project

July saw the official launch of CityVerve, the UK's demonstrator project in Manchester for large scale deployment of Internet of Things (IoT) technology. Ordnance Survey (OS) are part of a consortium of over 20 public and private sector organisations, ranging from SMEs to large global corporates, who over the next two years will design and deliver a series of citizen-focused solutions around the themes of Transport, Energy, Health and Culture, using IoT sensor and collaborative platform technology.

The first three months of the project will focus on the more detailed requirements of the use cases in each theme. This will help understand the type of existing content each use case needs access to, and the gaps need to be filled. For example, it is likely that it will be needed to provide accurate location and attribution data for street-side furniture, such as streetlamps and bus stops; and infrastructure to support use cases around way-finding and cycling/road safety. This could require ground-based capture, extraction of features from vehicle-based surveying, using remote-sensed aerial imagery to identify features, or collaborating with third party data suppliers and owners to validate and integrate that content with OS data. There will also need to be internal and consortium conversations about how that content will be delivered – the project will use the IoT protocol HyperCat as a data brokerage service – so more traditional data delivery methods will be a thing of the past. HyperCat acts as a data hub that organises data in a simple way that applications can search autonomously without human intervention. *www.os.uk*

BMW has 2 new partners for driverless cars

BMW is set to announce an alliance to develop self-driving cars with collision detection specialist Mobileye and computer chipmaker Intel. The tie-up is likely to focus on technology being developed by Mobileye to give computer-driven vehicles better reflexes without driver input, ushering in an era of self-driving cars early in the next decade, analysts said. *http://fortune.com*

Drones to chart a way through Gurgaon's land record maze

At the Gurgaon Secretariat, in Haryana, India, one often sees ageing village patwaris sitting along with young computer operators trying to reproduce maps, often in tattered shape, on computer screens.

These are no ordinary maps. Many of them are drawn on a piece of cloth, with notations in Urdu. Some of these maps have been passed through generations after Raja Todar Mal, finance minister in the Cabinet of Mughal emperor Akbar who first invented a land revenue system and started creating maps of North India somewhere in the 16th century. In India, land records were last compiled in 1957 and have not been updated since then the Gurgaon administration is trying to solve this discrepancy by using a modern solution: drones. In a first, Gurgaon will deploy drones to take high-resolution imagery of one of the largest tech hubs in the country to carry out land-record regularisation after similar proof of concepts have been carried out in satellite towns of Sohna and Manesar. The images taken by drones are then tallied by the maps which have been digitised from the 1957 physical records to arrive at a final and a foolproof version.

Drones are already being used in Gurgaon for mapping a 16 sq km area for the power smart grid project in Gurgaon. Under the project Udaan, the authorities are using two drones. A similar project is underway in Manesar, another satellite town of Gurgaon and also an auto industry hub. *http://economictimes.indiatimes.com*

Drones could be the answer to early disease detection in banana crops

A researcher is looking into the possibility of using remote sensing to detect diseases in banana crops. University of New England PhD candidate Aaron Aeberli said different sensor systems could be attached to satellites or drones.

Mr Aeberli said the technology was already being used in other crops such as sugar cane, wheat, cotton and peanuts. Diseases could be detected early through the application of thermal imaging.

"There is potential to notice changes in the leaf temperature if the plant is no longer able to function normally. Some of the bigger crops like wheat, they use it a fair amount and it does save them time. It can help with production and management systems."

Mr Aeberli is hoping to develop the technology further for the banana industry.

He is collaborating with the Queensland Department of Agriculture and Fisheries and Horticulture Innovation Australia on upcoming trials in far north Queensland.

"We're looking to take some satellite imagery and we'll go into the field and try and evaluate this satellite imagery, so that the field conditions reflect what we've been taking from the satellites," he said. "We're also looking at the use of UAVs (unmanned aerial vehicles) for a similar system."

There could be potential for banana growers to one day monitor the health of their own crops by drones. "I wouldn't necessarily go out and tell everyone to buy a drone at this point in time, but once a valid system that works has been set up, there's potential for that." *www.abc.net.au*

Delivery that comes to you with one click

Delivering packages wherever you want it, through the air, via drone in just 30 minutes - that's Amazon's vision. On the heels of getting FAA permission for experimental test flights in the United States in March, the U.S. Patent and Trademark office has published Amazon's patent application for its drone delivery system.

Amazon is thinking beyond home delivery. They're thinking delivery to wherever you are at the moment. The patent application describes a customer option called "Bring It To Me." With this option, using GPS data from the consumer's mobile device, the drone locates and delivers the item to that location. Once the customer places the order he or she does not have to remain in one place. *http://edition.cnn.com*

Drones will monitor crop and soil health in India soon

The Indian Council of Agricultural Research (ICAR) through the Indian Agricultural Research Institute (IARI) under a collaborative research project is developing indigenous prototype for drone based crop and soil health monitoring system using Hyperspectral Remote Sensing (HRS) sensors. This technology could also be integrated with satellite-based technologies for large scale applications. *http://indiatoday.intoday.in*

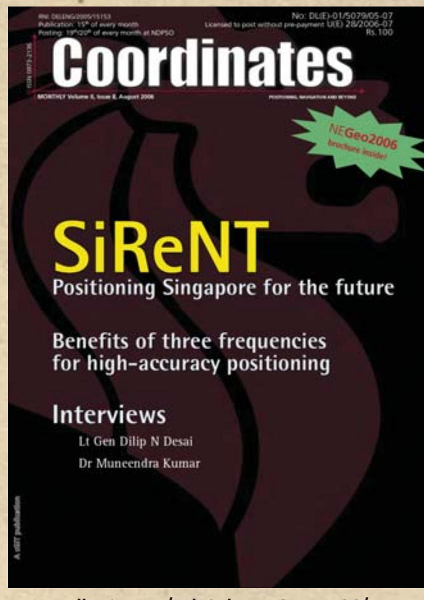
Advance Queensland funding to advance RPAS tech in Queensland

One hundred new aerospace industry jobs will be created in Queensland, Australia as a result of the Palaszczuk Government's $1m investment in drone technology. Premier Annastacia Palaszczuk has announced the State Government was providing $1 million in Advance Queensland funding in a first-of-its kind partnership with global aerospace giant The Boeing Company, in conjunction with Boeing subsidiary Insitu Pacific, Shell's QGC project, Telstra and locally based small to medium-sized enterprises providing industry and technical expertise. The funding will develop and test cutting-edge Remotely Piloted Aircraft Systems (RPAS) technologies for adoption by critical industries including LNG, agriculture, mining, energy, telecommunications, search and rescue and environmental management.

The $10 million Advance Queensland Platform Technology Program is part of the Queensland Government's $405 million Advance Queensland initiative, which aims to transform Queensland into a knowledge-based economy and help create the jobs of the future. *http://statements.qld.gov.au*

In Coordinates

10 years before...



mycoordinates.org/vol-2-issue-6-aug-06/

SURVEYING

SiReNT - Positioning Singapore for the future

An initiative by the Singapore Land Authority, SiReNT infrastructure is based on the Global Positioning System that provides data and services for various surveying and positioning applications

Soh Kheng Peng, Victor Khoo Hock Soon, Loh Sook Yee

Benefits of SiReNT

SiReNT is a nation-wide GPS reference station network infrastructure. It provides high precision, real-time DGPS (Differential GPS) data and services. The system supports all types of GPS positioning modes and formats. It is flexible and easy for integration with minimum configuration.

With SiReNT:

- Individually owned reference stations are no longer required for GPS surveyors;
- Many types of positioning applications that requires sub-metre accuracy are made possible;
- Real-time high precision and high reliability surveying, mapping, navigation, tracking, applications are supported.

HIS COORDINATES

"We are pursuing the development of an indigenous GIS solution"

says Lt Gen Dilip N Desai, Director General Information Systems, Indian Army while discussing the role, activities of his department

Moreover, maps of numerous types are required for development purposes. Nonetheless, those agencies which are mandated to look into the security implications relating to mapping are only fulfilling their responsibilities when they express concerns and reservations when commenting upon a more open regime.

GNSS

The benefits of three frequencies for high accuracy positioning

The availability of the third civil frequency has obvious advantages to instantaneous carrier phase accuracy and ambiguity resolution for cm level measurements in the short base-line

Nobuaki Kubo, Akio Yasuda, Isao Kawano Takeshi Ono, Chie Uratani

Conclusion

This paper introduced the effectiveness of new L5 frequency for precise positioning based on the experiment using three frequency GPS simulator and three frequency QZSS/GPS proto-type receiver. Data analysis result shows that the new L5 signal contributes to the improvement of positioning accuracy for DGPS and RTK under the severe multi-path environment. It is also verified that the ambiguity fix rate of RTK is significantly improved.

Indian govt's plan to legalise drone use stuck in regulatory maze

The government's plan to legalise the use of drones has hit a hurdle, with uncertainty over who will regulate these unmanned aerial vehicles that promise big commercial potential but are also seen as a threat to security and privacy by many.

The home ministry has asked the Directorate General of Civil Aviation (DGCA) to regulate the use of drones, but the civil aviation regulator said it will be difficult with its current resources, and unless states and police pitch in with help.

DGCA had circulated among ministries a draft policy on commercial operations of drones and the home ministry's suggestion. All other ministries have supported the plan — while the defence ministry has given a go ahead, the IT ministry is pushing hard to legalise the use of drones. *http://tech.economictimes.indiatimes.com*

MIRSAC erects stone at Tropic of Cancer

Mizoram Remote Sensing Application Centre (MIRSAC), India has erected a stone at a place where the Tropic of Cancer runs through Mizoram. The stone was set up and a hoarding put up at Maubuang Lungsai hamlet in Aizawl district on the World Bank-funded road linking Aizawl and south Mizoram's Lunglei town.

Mr. R K Lallianthanga, Chief Scientific Officer of the Directorate of Science and Technology, said that the Tropic of Cancer runs through 23.5 degree Latitude and the imaginary line was identified with the data of the Survey of India's topographical map and with the help of the GPS. *http://economictimes.indiatimes.com*

SIIS started KOMPSAT-3A commercial services

SI Imaging Services (SIIS) started commercial services of KOMPSAT-3A imagery with the world's second highest resolution satellite from July, 5th. KOMPSAT-3A is part of the Korean Multipurpose Satellite Program developed and operated by the Korea Aerospace Research Institute (KARI) for earth observation purpose.

The earth observation satellite offers clear imagery with a resolution less than 0.5 meter. KOMPSAT-3A, also known as Arirang-3A, was launched into orbit in March last year.

After more than a year of successful test operation, SIIS began the commercial services on 5th of July. It would make South Korea the world's second country to enter the less-than-0.5-meter-resolution satellite imagery market after the USA.

With KOMPSAT-3A imagery available today with 0.5 meter resolution imagery of KOMPSAT-3 at customer's service, decision makers have new and more options to consider for their needs. *www.spacedaily.com*

Eos announces sub-meter and RTK Solutions

Eos Positioning Systems (Eos) announces Arrow GNSS receiver series compatibility with Esri's Collector for ArcGIS running on iPads and iPhones. The receivers have been tested and certified as high-accuracy GNSS receivers compatible with Collector 10.4.0 for iOS.

The full range of Arrow GNSS receivers from sub-meter to decimeter to centimeter RTK accuracy all work flawlessly with Collector for ArcGIS running on all iPhones and iPads running iOS 8.x or later. GNSS metadata such as estimated accuracy, correction status, correction age, # of satellites used is displayed in real-time in Collector so the user can monitor data quality in the field.

As a companion software to Collector, Eos offers a free iOS app called Eos Tools Pro that allows the user to connect to an RTK Network and to set alarms for estimated accuracy, HDOP, correction age, and others. If a threshold is exceeded (eg. estimated accuracy greater than 10cm), an alarm sounds on the iPhone/iPad to alert the user. *www.eos-gnss.com*

Sokkia GNSS Receivers for Latvian Forest Management

Sokkia has announced the largest forest management company in Latvia - Latvia's State Forests (LVM) -has chosen its latest compact GNSS receivers for forest data collection. The company will use 140 Sokkia GCX2 receivers to gather GIS data for assistance in forest management employing more than 6000 people. It will also be used to assist in environmental projects such as specially protected black stork nests.

New Positioning and Connectivity Modules by u-blox

u-blox has announced the expansion of its product offering with automotive qualified product variants added to their range of positioning and cellular wireless connectivity modules. The additions comprise the NEO-M8Q-01A and NEO-M8L-01A, and respectively the SARA-G350-02A and LISA-U201-03A. Manufactured according to the ISO/TS 16949 automotive supply chain quality management standard, the modules are thoroughly tested with an extended qualification process aimed at achieving the lowest level of failure rates. *www.u-blox.com*

ComNav releases new-generation OEM Boards

ComNav Technology has released its advanced K700 and K708 GNSS OEM boards to the international market. With the advanced ComNav application-specific integrated circuit (ASIC) chip, K7-series OEM boards have higher observation data quality and lower power consumption compared to previous K5-series OEM boards. The data output rate also increases substantially by working with a new Atmel processor.

As a cost-effective GNSS OEM board, K700 is scalable for sub-meter to centimeter-level positioning applications such as GIS, precision agriculture, marine and automotive systems. It can track GPS L1, BeiDou B1, GLONASS L1 and SBAS, and also supports PPS, Event Marker and short baseline RTK. For the K708 OEM board, the inside GNSS tracking engine with 388 channels is capable of tracking all current and future constellations. It is designed with strong compatibility and built-in functions, including high-accurate PVT output, long baseline RTK and reserved webserver service.

OriginGPS and TDK collaboration

TDK, one of the largest manufacturers of electronic components in the world and OriginGPS, a leading manufacturer of miniature GNSS modules, have announced a new collaboration. As part of this collaboration, customers utilizing OriginGPS Spider modules will receive increased support to integrate TDK antennas into their designs. Existing reference designs coupled with TDK's extensive Electromagnetic (EM) simulation capabilities will allow customers to maximize GNSS performance. This collaboration pairs OriginGPS' smallest GNSS receiver modules, including the recently unveiled Multi Micro Spider, with the smallest chip antennas by TDK to deliver a "mini + mighty" solution for wearables that represents the best of both worlds: combining TDK's specialized RF simulation capabilities with OriginGPS' GNSS expertise and support. *www.origingps.com*

GPSengine partners with Sinocastel

GPSengine a leading hosted platform service provider in GNSS, Telematics, IoT and Tracking, has announced a new partnership with Sinocastel, adding support for Sinocastel's range to GPSengine's Platform Connect service. Based in Shenzhen, China, Sinocastel has over 15 years experience in GPS R&D and manufacturing, with experience in North America, Europe and Asian markets. *www.gpsengine.net*

Oregon® 700 series of handheld GPS units

Garmin International Inc. has announced the Oregon 700, 750 and 750t, an update to its popular series of touchscreen outdoor handhelds. Featuring high-sensitivity GPS and GLONASS support, the new Oregon 700 series has a redesigned GPS antenna for better reception and performance. All models feature a worldwide basemap with shaded relief, while the 750t adds preloaded TOPO U.S. 100K maps. *www.garmin.com/outdoors*

Spirent's new GSS7000 system offers flexible multi-GNSS testing

Spirent Communications has released a new series of multi-frequency, multi-GNSS RF constellation simulators. The GSS7000 series provides an entry to multi-frequency testing, with a modular approach to enable this new precision GNSS simulation system to expand with users' needs.

The GSS7000 system will suit receiver, system and application developers who want to take advantage of new satellite navigation systems and the better accuracy offered by civilian, multi-frequency GNSS. It offers faithful emulation of

Trimble News

R2 GNSS receiver

Esri has announced the availability of the Trimble R2 GNSS receiver for collecting professional-grade GPS data with Collector for ArcGIS. It is a rugged certified MIL-STD-810G, IP65 rated, compact and streamlined to enable a quick setup. The receiver is capable of delivering between submeter and centimeter positioning accuracy in real-time to Android or iOS mobile devices via a wireless Bluetooth connection or USB cable to support GIS or survey-grade workflows.

Trimble R2 GNSS receiver provides total flexibility to choose a solution based on the accuracy and GNSS performance level that suits their application. Now the locational precision of mobile devices can be enhanced via the Trimble R2 GNSS receiver. It is capable of supporting multiple GNSS- including GPS, GLONASS, Galileo, and BeiDou, and delivers GNSS positions in real time without the need for postprocessing.

TDC100 Handheld GNSS Data Collector

Trimble has introduced its Trimble® TDC100 handheld data collector. An entry-level GNSS device for a variety of GIS applications, it combines both smartphone and ruggedized data collection capabilities in a single, mobile device. The Android-based TDC100 is flexible and can run commercially available or in-house developed applications on a professional, IP-67 ruggedized platform with a sunlight readable display and user replaceable batteries. The built-in GNSS receiver also provides real-time accuracy. The Trimble TDC100 is available in two models. Both models are available with an Android operating system and Wi-Fi, with an optional 4G LTE cellular version. *www.trimble.com*

all civil GNSS systems and regional augmentation systems, and allows devices to be tested under a multitude of operating environments and error conditions. It has the flexibility to reconfigure satellite constellations, channels and frequencies between test runs or test cases.

Pix4D Elevates Agriculture Software to Desktop & Cloud Solution

Pix4D announces its first hybrid processing solution, users of Sequoia with a license of Pix4Dmapper Ag will be able to process both locally in Pix4Dmapper Ag and on the Pix4Dcloud. Together with this announcement, Pix4D also introduces very flexible monthly (149 USD) and yearly (1490 USD) plans for its Pix4Dmapper Ag solutions.

This new strategy comes from seeing the need in the agriculture industry for more flexible processing options to facilitate competitive operations. With the hybrid approach, users are able to choose where to process: whether they prefer to process data right after landing and are in an area with bad connectivity, or want to upload to the cloud and not involve processing hardware.

"We were camera agnostic, now we are both camera and platform agnostic," says Pix4D founder and CEO Christoph Strecha. "In the end, we care more about the quality and the ease-of-use than whether mappers are processing on desktop or the cloud."

Esri and ICMA Partner to Educate Smart Communities

Esri and the International City/County Management Association (ICMA) have taken steps to strengthen their strategic relationship to bring forward the best practices in building smart communities. The smart communities movement advocates that municipalities and counties rethink the way local governments deliver services and address the issues of our times. At the heart of these efforts is the call to use technology and data to create stronger, more resilient, and more business-savvy cities and counties. ICMA, which serves local government management professionals worldwide and identifies leading practices in the field, and Esri, a global leader in GIS technology, have partnered to produce a series of case studiesthat highlight leading practices of a well-run government.

Rockwell Collins reaches key milestone

Rockwell Collins, in collaboration with The University of Iowa's Operator Performance Lab (OPL), successfully controlled an unmanned aircraft system (UAS) using its end-to-end UAS integrated avionics solution. The test flight was a key milestone toward the successful operation of UAS beyond an operator's visual line of sight in the National Airspace System (NAS).

Key elements of Rockwell Collins' UAS integrated avionics solution, which is optimized for safe and secure integration of UAS into civil airspace, include:

A Ground Control Station based on Rockwell Collins' Pro Line Fusion®—a Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) certified integrated avionics solution. *www.rockwellcollins.com*

Route Monkey & Sygic partnering

The GPS navigation firm Sygic and the route optimization firm Route Monkey have entered into a new partnership that will see the joint development of a fully integrated optimization and navigation platform for electric vehicles. *http://cleantechnica.com*

Skycap and Skeye join forces

Skycap and Skeye announced the merger of their two companies, continuing under the name 'Skeye'. The merger results in the creation of the European leader in aerial topographic surveys, using unmanned aircraft. In addition, Skeye will instantly enter the European market as a top 3 provider of unmanned aerial inspections and extend its services portfolio with specialised aerial imagery. *www.skeyebv.com*

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September 2016

The Commercial UAV Show Asia
1-2 September
Singapore
www.terrapinn.com/exhibition/commercial-uav-asia/index.stm

Lebanon Internation Surveyors Congress
6 - 8 September
Jiyyeh, Lebanon
http://www.ogtl.org/

Interdrone 2016
7-9 September
Las Vegas, USA
www.interdrone.com

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

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

October 2016

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

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

3D Athens Conference
18-21 October
Athens, Greece
http://3dathens2016.gr/site/

3rd Commercial UAV Show
19-20 October
ExCel, London, UK
http://www.terrapinn.com/exhibition/the-commercial-uav-show/

Commercial UAV Expo 2016
31 October - 2 November
Las Vegas, USA
www.expouav.com

November 2016

ICG-11: International Committee on GNSS
6 - 11 November
Sochi, Russia
http://www.unoosa.org/oosa/en/ourwork/icg/icg.html

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

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

36th INCA International Congress
9 -11 November
Santiniketan, West Bengal, India
http://incaindia.org

FROM IMAGERY TO MAP: Digital Photogrammetric Technologies
13 - 17 of November
Agra, India
http://conf.racurs.ru/conf2016/eng/

13th International Conference on Location Based Services
14-16 November
Vienna, Austria
http://lbs2016.org

International technical symposium on navigation and timing
15-16 Nov
Toulouse, France
http://itsnt.recherche.enac.fr/index.php

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

December 2016

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

United Nations/Nepal Workshop on the Applications of GNSS
5 - 9 December
Kathmandu, Nepal
http://www.unoosa.org/pdf/icg/2016/nepal-workshop/InfoNote.pdf

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

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

March 2017

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

April 2017

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