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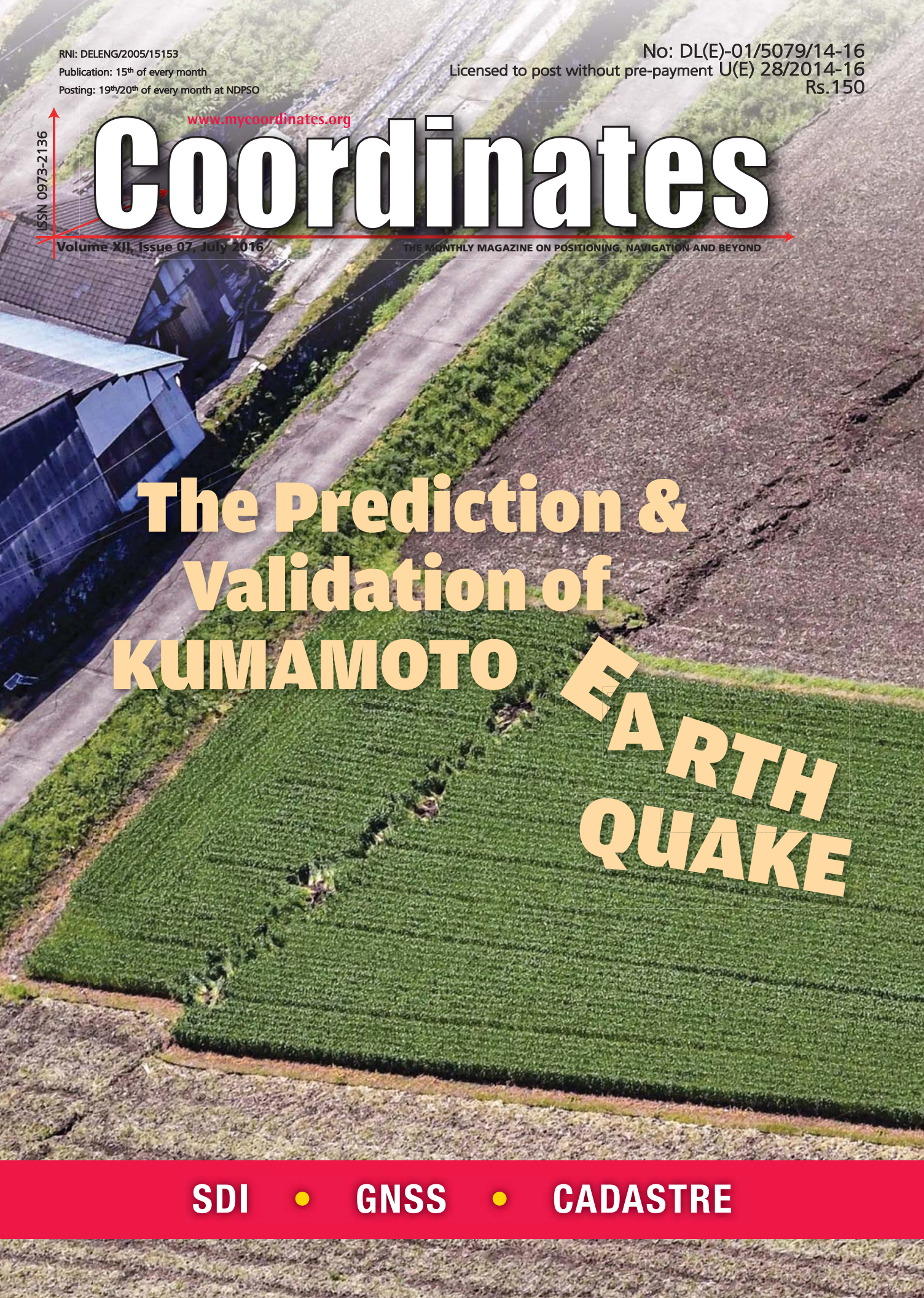

The Prediction & Validation of KUMAMOTO EARTHQUAKE

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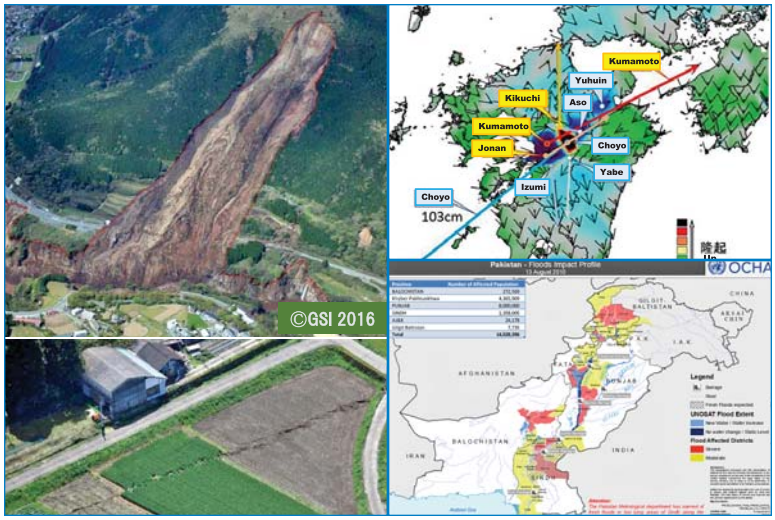

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This issue of Coordinates is of 52 pages, including cover.

FAA rules

The Federal Aviation Administration has announced Small UAS rules.

Drones weighing between 0.55 lbs. and 55 lbs.

Must be registered with FAA,

Pilots must be at least 16 years old,

With Remotes pilot certificates,

And maintain 'visual line of sight',

Flights should be below 400 feet,

And no flights in night.

Endeavour seems to minimize the risks

To other aircrafts, people and property,

And yet extends breathing space to UAS to fly.

Bal Krishna, Editor
bal@mycoordinates.org

The Prediction and Validation of Kumamoto Earthquake

It was very difficult to achieve the prediction of the Kumamoto Earthquake because there were very few short term abnormal changes at multiple GNSS stations which have normally occurred, in our previous experience, for larger earthquakes

Dr Shunji Murai
Professor Emeritus, University of Tokyo and Advisor, Japan Earthquake Science Exploration Agency (JESEA)

Dr Harumi Araki
Director, Environmental Geology Laboratory and Advisor, JESEA

The huge Kumamoto Earthquake 2016 occurred at 1:25am, April 16, 2016 in the vicinity of Kumamoto City, Kyushu Island, Japan (see Figure 1). This destructive earthquake, in addition to very large foreshocks as well as repeated aftershocks, killed 50 persons and injured 1,720, while 86,411 houses were destroyed as of the 14th May 2016, a month after the earthquake.

The authors initiated technical support for an earthquake prediction business in January 2013 using GNSS data provided by Geospatial Information Authority (GSI). Our prediction of the Kumamoto Earthquake was not perfect, but partially succeeded despite its very special characteristics. This article describes how we predicted the earthquake in advance, and the large crustal changes that were revealed after the Kumamoto Earthquake based on the GNSS data analysis.

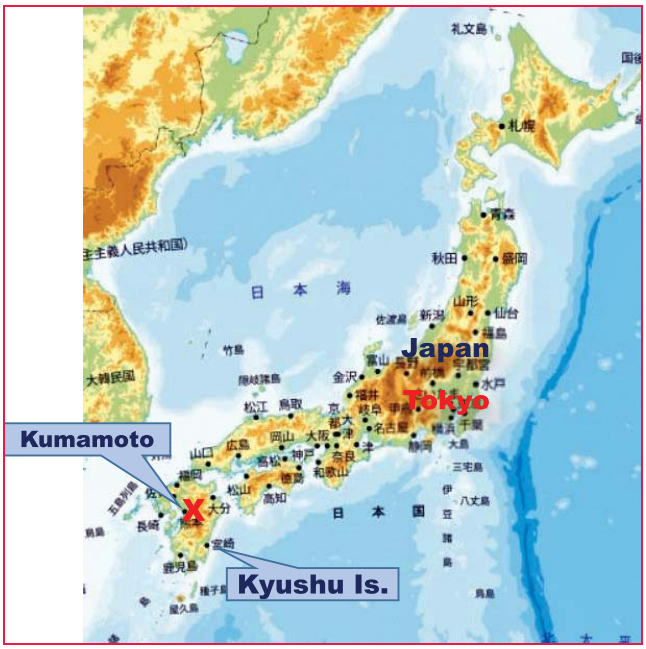

Figure 1: Location of Kumamoto

Introduction

The main Kumamoto Earthquake was M7.3 on the Richter scale, which also registered the highest level of 7 on the Japanese Seismic Intensity Scale (hereinafter called SI). However a foreshock with M6.5 or SI 7 occurred at 21:26, April 14, 2016, 28 hours before the main shock. Because the foreshock was so large, many people imagined that the foreshock was the main earthquake. In addition, the initial damages were not very significant. As most houses and buildings had not collapsed after the foreshock, many people who had been evacuated, went back home for the night. The main shock occurred unexpectedly in the early morning of the 16th April, which resulted in many more houses being destroyed and many more fatalities. The special character of the Kumamoto Earthquake was the extraordinary large number of aftershocks with more than 1,300 occurring in a month, including 11 larger earthquakes of a destructive level higher than SI 5. Such a large number was the maximum ever record in Japanese earthquake history.

From our 14 year experience of earthquake prediction research, there should be extraordinary short term changes in height at multiple GNSS stations in advance of such a large earthquake. However in the case of Kumamoto Earthquake, such short term changes or weekly height changes were not recognized except for a long term significant subsidence in Kyushu Island commencing two years earlier. Based on the abnormal subsidence of Kyushu Island, we issued a warning to our customers that the Kyushu area including Kumamoto (located in the middle of Kyushu) and Kagoshima (in the south of Kyushu) was a risky area on the 'weekly mail magazine: MEGA earthquake prediction'.

The new year 2016 issue of the weekly magazine 'Post' which included our prediction 'be careful in Kumamoto and

Kagoshima until spring' was correct. However the above mentioned weekly mail magazine continued the warning only until the end of March because the warning had been repeated and postponed for these two years. But 14 days after the withdrawal of the warning, the Kumamoto Earthquake occurred. Therefore, the prediction was not correct in this regard.

Special charcteristics of Kumamoto earthquake

The special characteristics of the Kumamoto Earthquake should be noted as follows.

1) The main EQ was quite large (Maximum Magnitude: 7.3 and Maximum SI: 7) and the depth of epicenter was quite shallow at 10 km.
2) There were 5 foreshocks and 11 aftershocks of magnitude greater than SI 5, which are classified at the destructive level as listed in Table 1. This number of large earthquakes caused serious destruction and damages such as house collapses, landslides, mudflows, bridge collapses, road surface cracking, derailments, fires, terminations of supply of water, gas, electric power, sewage and so on.
3) There were about 1,300 aftershocks at higher than the weak level of SI 1 in a month. Normally the number of aftershocks has decreased in a week after an earthquake, but in the case of Kumamoto Earthquake the number did not decrease as usual.
4) Due to continuously occurred aftershocks which accelerated the destruction and fear of people, most could not live at their own houses, which resulted in a large number of 183,000 persons being evacuated.
5) Most of the damage and destruction were concentrated along two faults; namely Futagawa and Hinagu Fault as shown in Figures 2 and 3.

Prediction of Kumamoto earthquake

JESEA commenced its warnings that Kumamoto was a risky area in May 2014 in its published mail magazine, as the Kumamoto vicinity started sinking abnormally. At the end of September 2014, the accumulated deformations were also serious in Kyushu Island shown in Figure 4. Kyushu Island kept sinking until

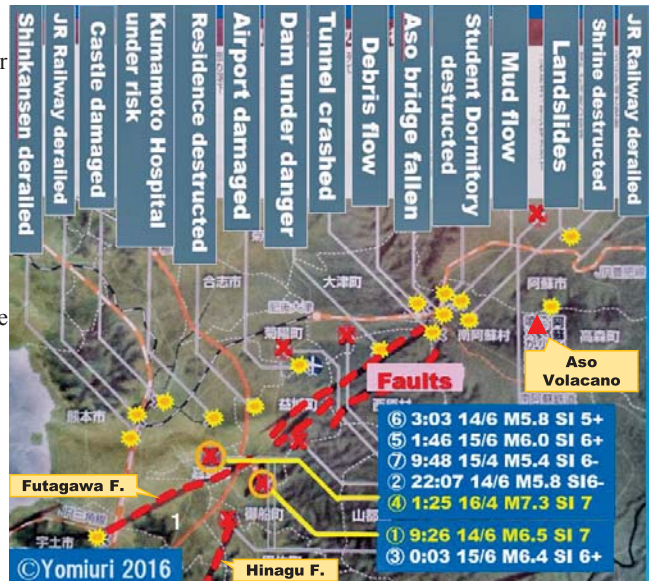

Figure 2: Major damages along Futagawa and Hinagu Faults caused by foreshocks, the main shock and aftershocks

Figure 3: Landslides and land deformation

Table 1: Record of Kumamoto Earthquakes

M/D	Time	M	SI	Type
4/14	21:26	6.5	7	Fore
	22:07	5.7	6+	Fore
	22:38	5.0	5-	Fore
4/15	0:03	6.4	6+	Fore
	1:53	4.8	5-	Fore
4/16	1:25	7.3	7	Main
	1:45	6.0	6-	After
	3:03	5.8	5+	After
	3:55	5.8	6+	After
	7:11	5.3	5-	After
	7:23	4.8	5-	After
	9:48	5.4	6-	After
4/18	16:01	5.3	5-	After
	20:41	5.8	5+	After
4/19	17:52	5.5	5+	After
	20:47	5.0	5-	After
4/29	15:03	4.5	5+	After

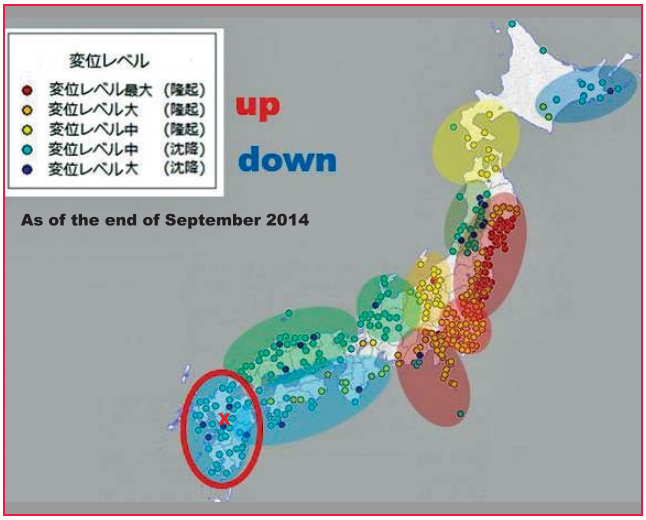

Figure 4: Abnormal accumulate subsidence in Kyushu (shown in circle of red line)

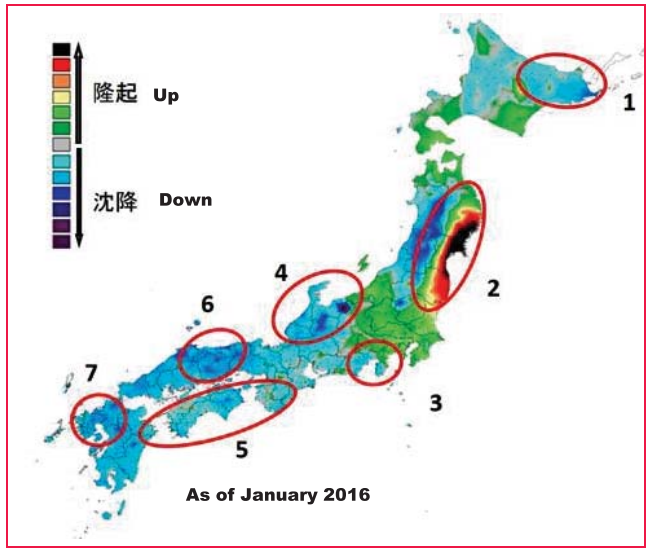

Figure 5: Abnormal Sinking in Kyushu (Shown in circle No. 7 of red line)

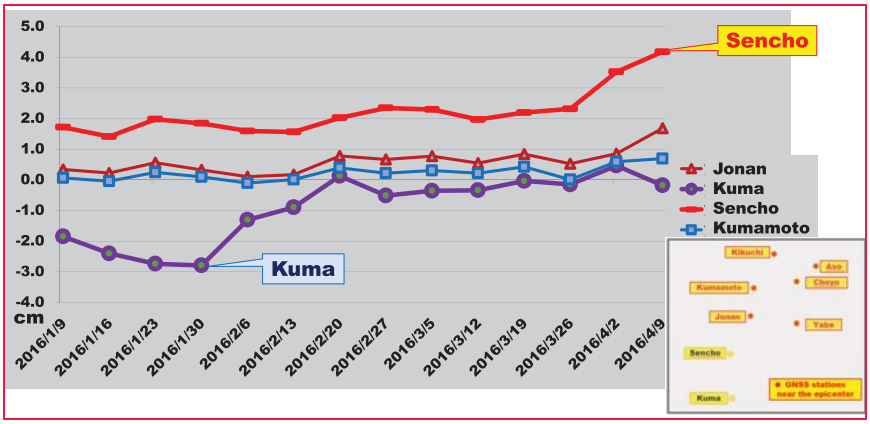

Figure 6: Abnormal sinking of weekly data at Kuma in January 2016 and upheaving at Sancho in April 2016 in advance to Eq.

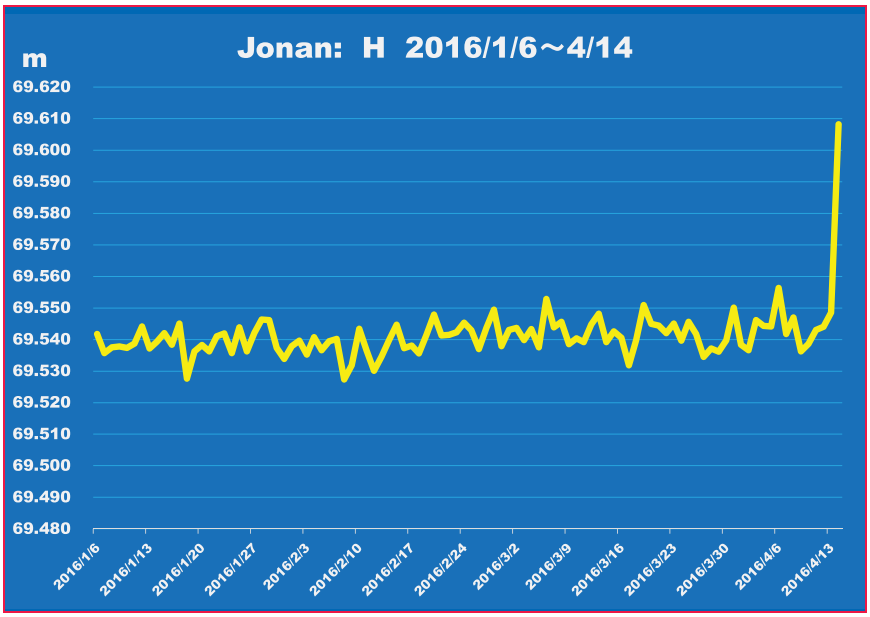

Figure 7: Abnormal increase in height at Jonan just before the Kumamoto Earthquake

January 2016 as shown in Figure 5.

Weekly averaged data at GNSS stations of Kuma and Sencho near Kumamoto showed abnormal behavior in January and April 2016 respectively as shown in Figure 6.

The above abnormalities were reported and warned in our mail magazine to our customers. Because the warnings on Kumamoto had been prolonged until the end of January 2016 and further prolonged until the end of February, JESEA decided to withdraw the warning in the beginning of April 2016. One of the reasons for the withdrawal was because JESEA received criticisms from customers who claimed the warning had been repeated so often. We feel ashamed that JESEA could not maintain its confidence in its predictions until the Kumamoto earthquake occurred only two weeks later.

Daily data at GNSS stations near Kumamoto just before and after the earthquake were checked to determine whether there were any pre-signals in advance to the earthquake. We found that only Jonan just near Kumamoto showed an abnormal increase in height just before the earthquake as shown in Figure 7. This behavior is very rare and strange, since in the previous cases of large earthquakes a large number of GNSS stations revealed abnormal pre-signals in advance. Figure 8 shows the height changes at 4 GNSS stations near the epicenter just before and

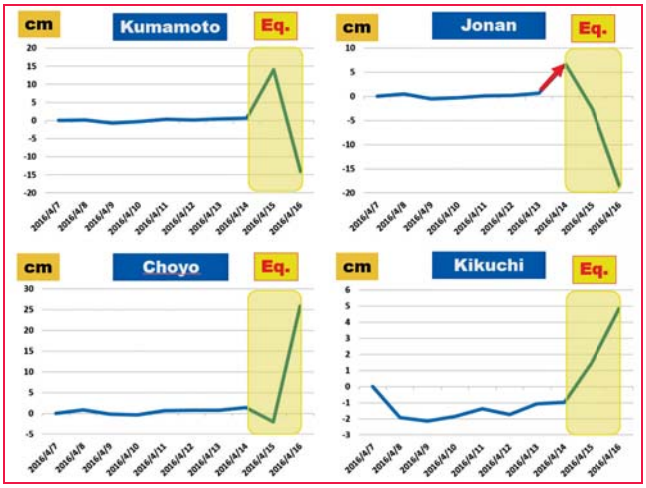

Figure 8: Comparison of height changes between 4 GNSS stations just near the epicentre

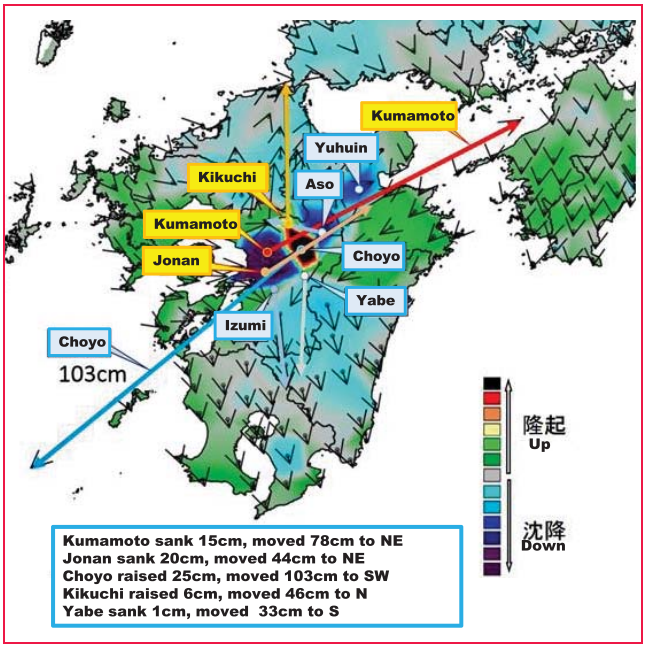

Figure 9: Horizontal and vertical crustal changes during 4 weeks

after the earthquake. Therefore, it must be understood that Jonan was exceptional. It would be difficult to identify just one GNSS station that revealed such abnormality out of the 1300 GNSS stations all over Japan. In addition users of GSI's GNSS data cannot access the data in real time because there is a delay of 2 days in the release of the data. If JESEA could access this data in real time, the prediction would be timelier and more accurately determined. This is why JESEA is now promoting construction of its own GNSS stations in cooperation with NTT Docomo, the largest telecommunication enterprise in Japan.

Analysis of crustal chages after the earthquakes

JESEA has developed GIS applications to visualize image-based crustal changes from pointwise GNSS data with arrows indicating horizontal changes overlaid on color images of vertical changes. The blue color group shows sinking while green, yellow and red color groups show rising.

Figure 9 shows the crustal changes for two weeks before and after the Kumamoto Earthquake. According to the geographical locations in relation to the faults, the crustal changes were completely different in horizontal and vertical directions. For example, Kumamoto sank 15cm

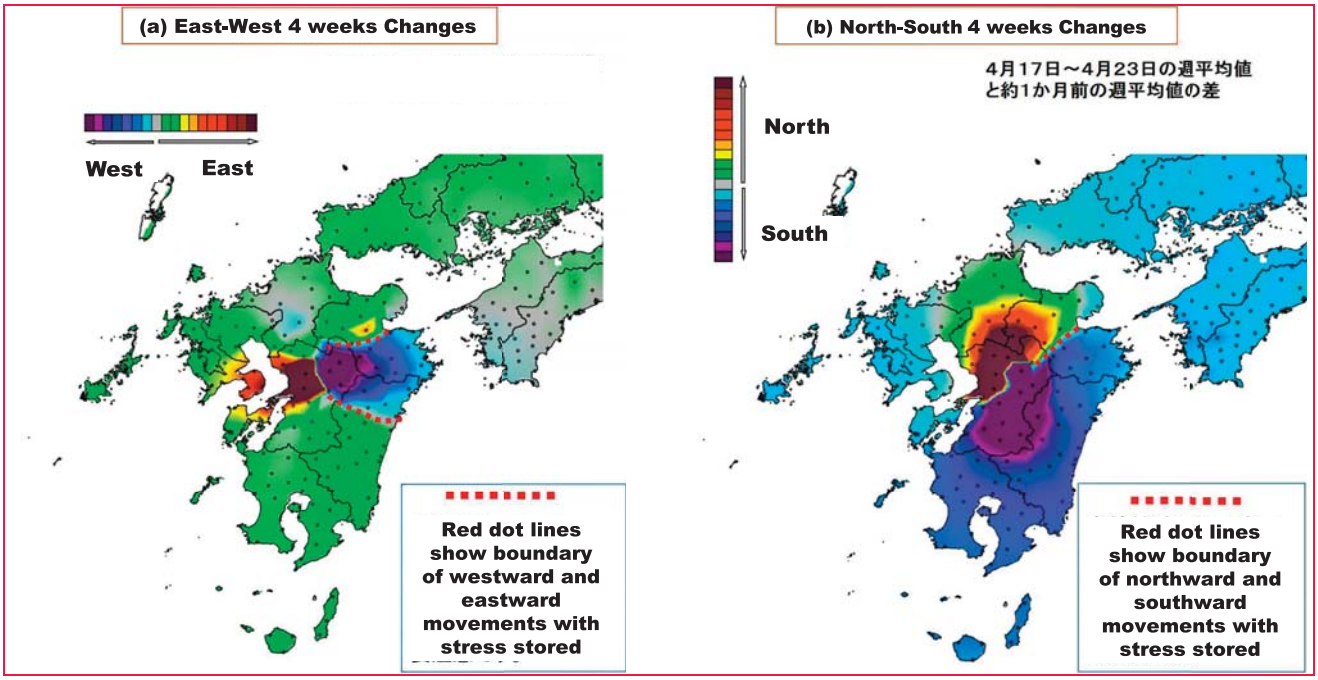

Figure 10: Crustal changes during 4 weeks in east-west (a) and north-south (b)

and moved 78cm to NE, Jonan sank 20cm and moved 44cm to NE, Choyo rose 25cm and moved 103cm to SW, Kikuchi rose 6cm and moved 46cm to N, Yabe sank 1cm and moved 33cm to S.

It is interesting to visualize the east-west components of the changes 2 weeks before against those for 2 weeks after the earthquake as well as the north-south components, instead of using arrows, as shown in Figure 10. In this figure, the boundaries or faults of the crustal changes can be clearly visualized.

Conclusions

It was very difficult to achieve the prediction of the Kumamoto Earthquake because there were very few short term abnormal changes at multiple GNSS stations which have normally occurred, in our previous experience, for larger earthquakes. Only long term changes of trends in subsidence in the Kyushu area, which have been recognized in the previous two years, would have been the scientific evidence for our predictions.

It was human error at JESEA to have withdrawn the warning of potential risk in Kumamoto at the end of March 2016 because of criticisms from the customers over the prolongation of the warning for the long period of two years. Ironically the Kumamoto Earthquake occurred just 2 weeks after the withdrawal of the warning.

In order to improve its predictions, JESEA is promoting a real time observation system at its own GNSS stations which would enable the provision of more timely precise data on an hourly basis instead of daily.

The GIS analysis to enable image-based visualization of the three dimensional crustal changes after the earthquake was very useful in understanding how the land in the vicinity of Kumamoto moved drastically in different directions.

Acknowledgement

The authors would like to express their appreciation to Mr. KITTA Toshihiro, the president of JESEA and Mr. TANIKAWA Toshihiro, Executive of JESEA for their kind support of our research. The authors also thank GSI for providing daily GNSS data of 1,300 stations free of charge. The authors would like to appreciate Prof. John Trinder for editing and correcting English.

References

MURAI, S. and ARAKI, H.: Prediction of earthquakes and volcanic eruptions using GNSS data (Japanese): 2003, Technical report, Journal of Surveying, Japan Association of Surveyors

MURAI, S. and ARAKI, H.: Earthquake Prediction using GPS, GIM International, Volume 17, No. 10, October 2003

MURAI, S. and ARAKI, H.: Prediction of Earthquake and Volcanic Eruption using GPS: Asian Journal of Geoinformatics, Vol. 4, No.3, March 2004

MURAI, S. and ARAKI, H.: Was early warning of Sumatra earthquake possible? Coordinates, Volume 1, Issue 2, 2005.7, p.8-11

MURAI, S. Report on Tohoku Kanto Great Earthquake and Tsunami 311: ISPRS Highlights, April 2011

MURAI, S. and ARAKI, H.: Crustal Movement before and after the Great East Japan Earthquake, Coordinates, May Issue 2012

MURAI, S, ARAKI, H. and YANAGI, H.: Towards the prediction of earthquakes with GNSS data, Volume X, Coordinates, May Issue 2014.

MURAI, S. and ARAKI, H.: Overview for the prediction of larger earthquakes in Japan, Coordinates, July Issue 2015

EGNOS-based Reactive Locator for the European Train Control System

The paper describes a novel train LDS solution based on EGNOS for ETCS

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It is generally believed that exploitation of Global Satellite Navigation Satellite System (GNSS) together with advanced mobile communications for signalling and train control will significantly improve safety and efficiency of railway operations. This is especially true for signalling solutions on low traffic lines and also on some long heavy haul lines where previously planned implementations of the European Train Control System (ETCS) with track balises have appeared as economically unrealistic. Moreover, there are currently visions that ETCS solutions based on GNSS will be installed on main corridor and high-speed lines as well.

The very idea of combining satellite navigation and the ETCS for train localization purposes is not new. A mixed train position determination solution by means of ETCS track balises and virtual GPS ones has been already described in the nineties of the last century [1]. Before that, a series of tests focused on train position determination using GPS and DGPS had been performed mainly in the United States and Europe.

On the 2nd March 2011, the European Geostationary Navigation Overlay Service (EGNOS) with its Safety-of-Life (SoL) Service was officially declared available for safety operations in aviation. EGNOS belongs to the family of wide-area Satellite Based Augmentation Systems (SBAS), similarly as US WAAS [2], Russian SDCM, Indian GAGAN, etc. In spite of fact that SBAS with its SoL service was originally developed and certified for safety operations in aviation, it also represents a strategic infrastructure for safety-related systems in other modes of land transport [3] - [7].

Safe train Location Determination System (LDS) based on GNSS and intended for ETCS belongs among them. It is mainly due to fact that high investment and operational costs of the ETCS track balises used for safe train position determination discourage from further ETCS expanding not only in Europe, but also worldwide. Therefore, at present, the European Commission, institutions and railway industry strongly support replacement of physical balises with virtual ones based on EGNOS and Galileo. This intention is practically realised within several international ESA and H2020 projects (e.g. 3InSat, ERSAT EAV, STARS, RHINOS), and also within numerous national R&D activities in the individual EU member states.

However, only the efficient exploitation of EGNOS for railway signalling according to specific ETCS safety requirements, TSI, railway CENELEC safety standards [8]-[10], etc. can bring applicable solutions. A clear LDS safety concept fully exploiting characteristic GNSS features within the virtual balise (VB) concept, such as provision of abundant train positions in time, is the basis for derivation of realistic ETCS safety requirements for the EGNOS SoL service. It is evident that rapid and independent diagnosis of excessive EGNOS errors significantly contributes to achievement of the required tolerable hazard rate (THR) for the ETCS virtual balises and also for the GNSS LDS.

Basic safety requirements for the train location determination function based on GNSS were specified within the ESA 3InSat project (2012-2015) [11], [13]. It was found that THR for Signal-In-Space (SIS) should meet 1e-8/ 1 hour (SIL 4) and the maximal confidence interval (CI) in the position domain should not exceed

14 m for the most demanding ETCS operational scenarios. In order to meet the safety requirements, the dual-constellation EGNOS-R (R as railway) interface with composite fail-safety for EGNOS V3 has been proposed [12], [13]. However, multi-constellation/ multi-frequency EGNOS V3 is expected to be available as lately as in 2022 and the current pressure for signalling and train control solutions based on GNSS is continually growing. Moreover, there is still a will to utilise existing EGNOS as it is for signalling and that's why new ways enabling it are still investigated.

This paper deals with a novel solution enabling to meet very demanding ETCS safety requirements for virtual balise detection, i.e. THR less than 1e-9 per 1 hour and Safety Integrity Level (SIL) 4, using existing single-constellation EGNOS V2 already certified for safety operations in aviation. The solution consists in LDS with the reactive fail-safety architecture based on EGNOS V2 and supported by a newly introduced travelling virtual balise (TVB) concept. Abundant validated LDS position, velocity and time (PVT) data on track sections between static virtual balises have been proposed for rapid diagnosis of virtual balise detection. The rapid and independent LDS diagnosis is critical for the reactive architecture. The TVB is used for justification of the required safety integrity provided by EGNOS. Since standalone EGNOS V2 based on GPS is not able to meet ETCS reliability requirement for on-board unit (MTBF of 3e5 hours) for hard operational scenarios, then Galileo as a second redundant channel of the 1oo2 (one-out-of-two) LDS architecture within EGNOS V3 was proposed to meet this hard operational target.

Way to efficient EGNOS V2/ V3 exploitation in ETCS

The classical ETCS track balise group, also called information point (IP), which shall be compliant with SIL 4 (λ_{IP} of 1e-9/1 hour) [6], determines together with the ETCS on-board balise reader, a so-called balise transmission module (BTM), the absolute position of train.

The ETCS odometry (SIL 4) provides the instant speed of train and the relative distance from the last relevant balise group (LRBG) including its CI. The train position, velocity and other data are reported via radio (GSM-R) to the track-side radio block centre (RBC). One of the important odometry functions is called linking of balises via the relative distance measurement. It is in fact the independent diagnosis of balises and on-board unit (ONB) because it enables detection of a deleted (missing) balise, incorrectly inserted balise or an ONB fault.

In case of the virtual balise concept the absolute position of train is determined using the LDS based on GNSS. The instant position of the train is compared with the position of virtual balises whose coordinates are stored in the on-board European vital computer (EVC) and in RBC. If the actual GNSS train position together with the relevant CI match with a virtual balise stored in the database, then the VB is considered as the last relevant virtual balise (LRVB). The odometry together with the track database perform two following functions: 1) diagnosis of the consecutive virtual balises using linking with its direct positive impact on the desirable reduction of the safety integrity requirement for the GNSS LDS – i.e. GNSS THR increasing, and also 2) provision of the relative train position from LRVB if GNSS SIS is temporally unavailable due to SIS service outages or SIS shadowing in a harsh railway environment.

And now it should be answered the question how ETCS can profit from GNSS – where is the main gain. As it is evident from Figure 1(a), the ETCS ONB is able to perform fault diagnosis of physical balise groups (BGs) and also its own diagnosis only in locations of the BGs. It is possible thanks to BG linking because position of next BG with respect to the LRBG position is known to the ONB and the correct BG detection can be validated using a so-called expectation window (ExW). The ExW includes all potential uncertainties due to odometry and BG position errors. However, GNSS LDS is naturally able to perform its fault diagnosis also in the vicinity of virtual balises or on the whole track section between virtual balises, depending on SIS visibility – see Figure 1 (b). It can be utilised for a fully automatic LDS initialization, which is in case of the baseline ETCS with track BG performed in Staff Responsible (SR) mode and the unreliable human factor must be involved in this safety function.

Note: parallel track discrimination in this LDS development phase can be solved by classical means (track circuits, axle counters, balises) or later by GNSS – e.g. two tier augmentation [5] or using future EGNOS with decimetre accuracy.

The abundant GNSS train positions outside of the VB vicinity are not in fact needed under normal operation (after LDS initialization) for train position reporting to RBC because it is provided by means of the relative distance measurement from the LRVB – see Figure 1(b). However it is evident that these abundant GNSS positions together with the odometry data and other techniques can be effectively used for the

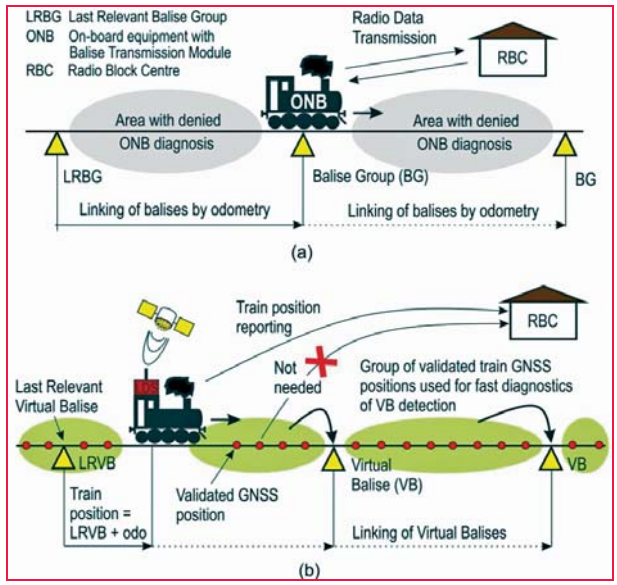

Figure 1: Diagnosis of ETCS: (a) Balise Group and ONB, and (b) Virtual Balise.

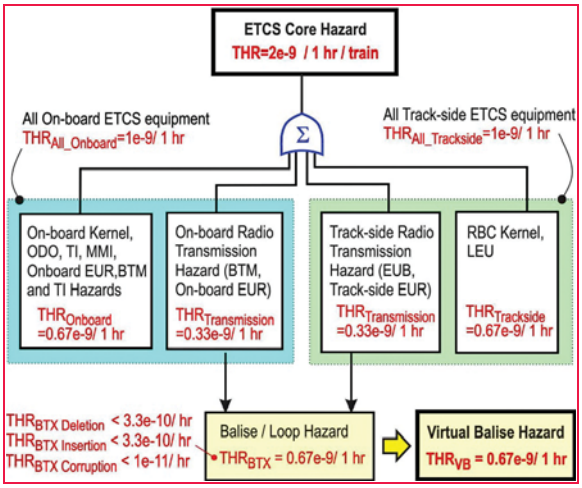

Figure 2: ETCS Core THR allocation to Virtual Balise.

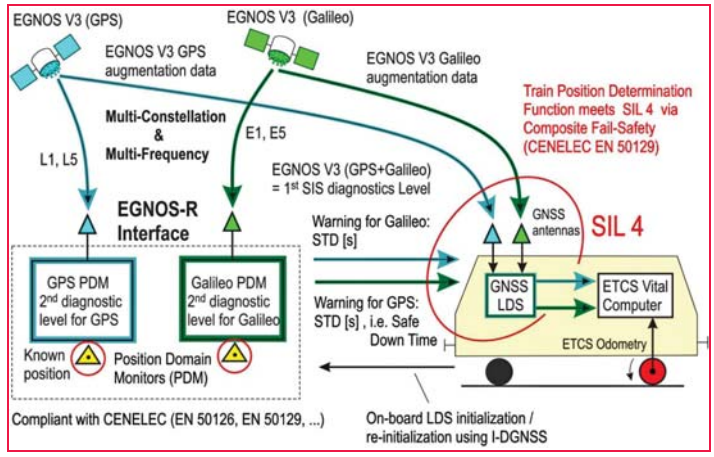

Figure 3: Principle of LDS based on dual-constellation EGNOS and composite fail-safety.

rapid GNSS diagnosis and it can in final effect lead to significant reduction of safety requirements for the GNSS-based LDS. It opens the door for railway exploitation of current EGNOS V2 in terms of the required LDS safety integrity and also enables to prepare a roadmap for efficient, i.e. safe and reliable EGNOS V3 exploitation in ETCS. It is the major benefit of the above rapid validation of VB for ETCS LDS.

Two following VB failure modes can be specified:

- *Virtual Balise Deletion* - means an event, when the VB (i.e. virtual IP) was not determined by means of on-board GNSS LDS. It can happen due to: 1) excessive latent LDS error (wrong position), or 2) absence of train position in the GNSS LDS output. In both cases no VB is detected within the ExW provided by the odometry;
- *Virtual Balise Insertion* - means an event when a wrong virtual balise is determined due to wrong GNSS LDS position.

Since both VB failure modes are caused by a wrong GNSS LDS position (i.e. incorrect or no position), and diagnosis for both failure modes is provided by rapid and independent diagnosis in GNSS service volume, then the total THR_{BTX} of 0.67e-9/ 1 hour was taken as THR for virtual balise, i.e. THR_{VB} = 0.67e-9/ 1 hour – see Figure 2. THR_{VB} will be further used for derivation of the ETCS THR requirement for GNSS, i.e. THR_{GNSS} (THR_{SBAS}). The derivation and justification of THR_{GNSS} for the virtual balise insertion/ deletion is described in the next section.

Novel LDS solution based on EGNOS V2/V3

The SIS Integrity Risk (IR) of 2e-7/150 s is guaranteed by EGNOS V2 for APV-I / LPV-200 service level [15]. Let's assume that IR corresponds to hazard rate of 4.8e-6/ 1 hour. There are two following possibilities how to meet the THR for virtual balise detection, i.e. THR_{VB} of 0.67e-9/ 1 hour, by means of LDS based on EGNOS V2. First, EGNOS integrity has to be improved by a suitable technique. Or requirement for EGNOS integrity has to be somehow reduced assuming that the target THR requirement for VB and also for LDS has to be met.

Railway safety-related systems to be compliant with SIL 3 or SIL 4 must ensure that they will remain safe in the event of any kind of single random HW fault. This principle is known as fail-safety and can be achieved by means of the following techniques [10]:

- Inherent fail-safety;
- Composite fail-safety; and
- Reactive fail-safety.

Implementation of these techniques not only determines which level of LDS safety will be achieved, but also how efficiently GNSS will be used within the LDS.

Inherent fail-safety allows a safety-related function to be performed by a single channel, provided that all the credible failure modes of the channel are not hazardous. It would be very difficult or impossible to make such evidence in case of complex EGNOS and therefore inherent fail-safety is not further considered for the EGNOS-based LDS.

Composite fail-safety allows a safety-related function to be performed by at least two independent channels. Hazardous fault in one channel shall be detected and negated in sufficient time to meet the required THR. The fault is detected by the comparison of the output values of these two or more channels, or also by means of an additional independent diagnosis. This technique has been already employed in case of a dual-constellation EGNOS-R interface [12], [13] - see Figure 3. The EGNOS-R (R as railway) was mainly proposed with the intention to improve EGNOS safety integrity and meet the THR requirement for VB detection.

Finally, reactive fail-safety allows a safety-related function to be performed by a single channel, provided its safe operation is assured by fast detection and negation of any dangerous fault. The single channel in itself doesn't have to meet the required safety integrity. And it is the case of EGNOS within LDS. New reactive LDS solution for VB detection intended for reduction of the safety integrity requirement for EGNOS SoL service is proposed in Figure 4.

It is evident that mere EGNOS employment for LDS within the virtual balise concept is not sufficient since the required VB safety integrity cannot be demonstrated. It is because an average balise group spacing of 400 m in the baseline ETCS is not able to assure sufficient short time to fault detection

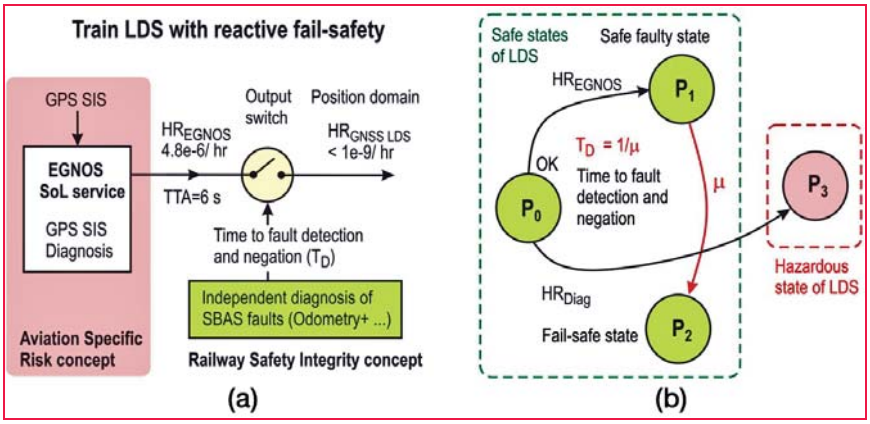

Figure 4: LDS based on single-constellation EGNOS V2 with reactive fail-safety: (a) High-level architecture, (b) Markov model.

and negation T_D to meet the required safety target (THR_{VB} = 0.67e-9/ 1 hour). Even if the spacing between two consecutive static virtual balises would have been shortened, then it would not have been still possible to distinguish between two adjacent VBs, because they could fall into one ETCS ExW. To solve this problem a non-static VB, a so-called travelling virtual balise (TVB), was newly introduced into LDS concept based on EGNOS V2. It is demonstrated below that the TVB concept together with the reactive LDS 1oo1 architecture (one-out-of-one with diagnostics) is able to meet the THR requirement for VB.

LDS with reactive fail-safety based on EGNOS

The existing single-constellation EGNOS in itself can be considered as a system with reactive fail-safety, because the safety function is performed by the GPS and its correctness is checked by the EGNOS infrastructure.

Nevertheless, the standalone EGNOS is not yet able to meet the ETCS SIL 4 requirement for train position determination. Excepting this the position determination function must also meet the required SIL/THR in case of local effects, such as multipath, EMI, spoofing, etc. against which EGNOS does not protect. That's why the EGNOS fault diagnosis must be completed with an additional independent fault diagnosis realised e.g. using safe ETCS odometry (SIL 4), 3-dimensional track database (SIL 4) and other relevant fault detection techniques.

The high-level architecture of the reactive LDS is depicted in Figure 4 (a) and the corresponding Markov model of the LDS in Figure 4 (b), where HR_{EGNOS} – hazard rate of EGNOS per 1 hour, HR_{Diag} - hazard rate of EGNOS independent diagnosis, μ - rate of diagnosis and fault negation. The following four system states are defined for the model:

- P_0 – Fully functional LDS state: both EGNOS and independent EGNOS diagnosis work well according to the specifications;
- P_1 – Safe faulty LDS state: EGNOS is faulty and rapid diagnosis is functional;
- P_2 – Fail-safe state of the LDS: EGNOS fault was detected and negated;
- P_3 – Hazardous LDS state: Independent diagnosis of EGNOS is faulty. Note: Although EGNOS is functioning properly according to the specifications, the LDS is in a dangerous state.

The time (t) dependent probabilities corresponding to the above states are obtained from the Markov model solution [19]. From viewpoint of LDS safety design, the most important is $P_1(t)$, which is the safe faulty state probability in case of GNSS/EGNOS fault. The corresponding hazard rate per 1 hour long mission can be expressed as [19]

$$HR_1 = HR_{GNSS} \times T_D \times 1h^{-1} \quad (1)$$

where T_D (i.e. 1/ μ) is time to fault detection and negation, which is also sometimes called safe down time (SDT) [10]. Equation (1) is used for justification of the EGNOS integrity performance for ETCS LDS in the next section.

Travelling Virtual Balise

The classical ETCS requires both track balises and on-board equipment (ONB) for safe train position determination. On the other hand GNSS estimates the position on board of train. Let us assume that λ_{ONB} is the rate of occurrence of ONB being unable to detect a correctly working ETCS information point (IP). If linking of IPs is active, then the duration of ONB failure corresponds to the time interval T_L between two successive IPs marked as linked. Further if the average speed of train is v and the linking distance D_L, then the probability of ONB failure causing the IP deletion is

$$P_{f,ONB} = \lambda_{ONB} \times T_L = \lambda_{ONB} \frac{D_L}{v} \quad (2)$$

There is no safety requirement in respect of not being able to detect an information point when IP linking is active [6]. As lately as two expected consecutive IPs announced by linking are not detected by on-board in the ExW, measured from the Last Relevant Balise Group (LRBG), the on-board vital computer shall consider the linking command of the second IP as a command to apply the service brake. Then the hazardous failure rate of ONB corresponding to the deletion of any IP met during 1 hour long mission is

$$HR_{ONB} = \lambda_{ONB} \times (2 \times T_L) \times 1\ h^{-1} \quad (3)$$

In order to check the ONB functionality even before the detection of a regular and properly working BG by the ONB, an additional hypothetical "testing" BG can be placed on the track ahead of the regular BG in the direction of movement from the LRBG – see Figure 5. A much shorter ONB failure duration T_D is achieved in this case. Then (2) can be then modified as

$$P_{f,ONB} = \lambda_{ONB} \times T_D \quad (4)$$

and the corresponding ONB hazardous failure rate per mission (1 hour) is

$$HR_{ONB} = \lambda_{ONB} \times T_D \times 1\ h^{-1} \quad (5)$$

The hazardous ONB failure rate (5) due to IP deletion can be thus reduced with respect to (3) significantly. It is evident that installation of the additional

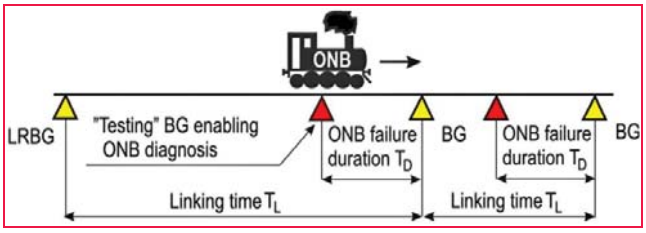

Figure 5: Diagnosis of ETCS on-board unit using "testing" BGs.

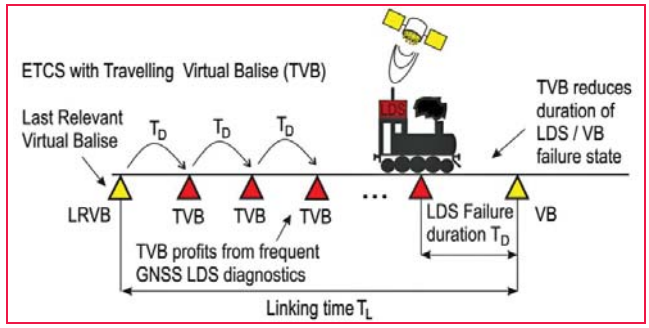

Figure 6: ETCS LDS concept with reactive-fail safety and justified using Travelling Virtual Balise.

"testing" BGs on a track would be very inefficient. Nevertheless, the reactive fail-safety principle can be easily implemented in case of the GNSS LDS. The "testing" BG is simply replaced by a so-called travelling virtual balise (TVB), as it is depicted in Figure 6.

The TVB is equivalent to LRVB from viewpoint of safety integrity because it is a validated GNSS train position by the independent diagnosis. The TVB arises from the LRVB as a subsequent validated train GNSS position generated just after LRVB is detected and further *travels* to the next virtual balise location in a given direction of movement. The TVB can also originate on a track section between VBs during LDS initialization.

The detection function of the presence of an information point (IP) by ETCS on-board unit (ONB) is a critical function and this function is the most critical when IPs are employed in scenarios where linking is not used. It is e.g. during ONB initialization in SR mode or during entry into an ETCS area from unfitted area when wrong IP can be inserted or IP can be deleted. The ETCS THR requirement for GNSS must be derived using these scenarios considering that VB insertion can cause a more dangerous situation than VB deletion.

It is evident that the TVB can be utilized for the LDS diagnosis of the next VB from viewpoint of VB deletion or insertion failure modes in the same manner as the hypothetical static "testing" BG is used in Figure 5. The ETCS THR requirement for GNSS (i.e. THR_{GNSS}) can be determined for the LDS start-up from the THR requirement for VB deletion or insertion per mission, i.e. THR_{VB} of 0.67e-9 hour^{-1}, as

$$0.67 \times 10^{-9}\, h^{-1} = THR_{GNSS} \times T_D \times 1h^{-1} \quad (6)$$

where T_D is the duration of GNSS hazardous failure defined as the time interval between the two consecutive linked TVBs or linked TVB and next VB.

The SIS IR of 2e-7/150 s for Precision Approach (PA) including LPV-200 operations is required in the vertical direction. Excepting this the SIS IR of 1e-9/150 s in the horizontal/ lateral (one dimensional) direction shall be also met for the aviation PA operations. It seems that the integrity (i.e. guarantee) of accuracy in the horizontal plane or in the track direction would be sufficient for signalling in case of the reactive LDS architecture. Nevertheless, three dimensional (3D) track map appears as an effective means for the independent diagnosis of EGNOS, and therefore the IR of 2e-7/150 was conservatively selected for signalling. The corresponding EGNOS SIS hazard rate is approximately 4.8e-6/ 1 hour. Then the allowed duration of GNSS/EGNOS failure can be estimated as

$$T_D = \frac{0.67\times10^{-9}}{4.8\times10^{-6}} hour = 0.50\ s \quad (7)$$

The horizontal alert limit (HAL) of 40 m and VAL (vertical AL) of 35 m is required for LPV-200 operations, where the pilot's decision height is 200 feet (60 m) above the runway. The actual WAAS/ EGNOS accuracies (95%) in horizontal/ lateral and vertical directions are typically better than 1.1 m and 1.5 m, respectively. If SBAS receiver with an output rate of 10 Hz will be used, then all the above calculated value of T_D is realistic.

EGNOS V3 for LDS reliability improvement

LDS based on EGNOS shall meet excepting the required safety integrity also a high reliability for ETCS on-board unit, which is specified as mean time between service hardware failures MTBF-S_{ONB} of 3e5 hours [16]. Reliability of the proposed LDS solution can be evaluated using continuity attribute of the applied EGNOS service level.

Continuity, or reliability, is the *ability* of a system to function within specified performance limits without interruption during a specified period, i.e. the continuity time interval t, which represents the most critical phase of operation or whole operation in aviation. The duration of the most critical phase is 15 s for APV-I/ LPV-200 operations [15]. Assuming the service is functioning at the beginning of the operation, then the probability that it is still functioning is [17]:

$$C = e^{-\frac{t}{MTBF}} \quad (8)$$

This is the standard expression for reliability and excludes scheduled outages (i.e. uses MTBF) assuming that planned outages will be notified and the operation will not take place. If MTBF is much greater than t, then (8) can be approximated to

$$C = 1 - \frac{t}{MTBF} \quad (9)$$

Continuity risk (CR) is defined as one complement of C, i.e.

$$CR = 1 - C = \frac{t}{MTBF} \quad (10)$$

Equation (10) can be utilised for calculation of MTBF for specific EGNOS SoL service level.

The ICAO requirement for SIS CR for APV I approach is 8e-6/ 15 seconds. It

corresponds according to (10) to MTBF of 520.8 hours. It is much less than e.g. the required ETCS mean time between service hardware failures MTBF-S_{ONB} of 3e5 hours, which is specified for onboard equipment. It is evident that the aviation CR requirement for single constellation EGNOS V2 is unable to meet the ETCS reliability requirement using the LDS 1oo1 architecture.

Let's consider now a dual-constellation LDS (GPS and Galileo) based on EGNOS V3 as a dual-channel redundant system with 1oo2 architecture. Then MTBF of the 1oo2 LDS architecture can be expressed as [19]

$$MTBF_{1oo2} = \frac{MTBF^2}{t} \quad (11)$$

If MTBF of 520.8 hours for both GPS and Galileo channels within EGNOS V3 is assumed, then for t=1 hour eqn (11) yields $MTBF_{1oo2}$ of 2.7e5 hours. It means that the LDS based on dual-constellation EGNOS V3 with the reactive fail-safety architecture and TVB is able to practically meet the required MTBF-S_{ONB} for the ETCS on-board equipment.

Conclusion

This paper describes a novel train LDS solution based on EGNOS for ETCS. The solution consists in LDS with reactive fail-safety based on EGNOS V2 or EGNOS V3, which is further combined with a newly introduced travelling virtual balise (TVB) concept.

It has been demonstrated that the required THR for virtual balise of 0.67e-9/ 1 hour can be met using the reactive LDS structure with single-constellation EGNOS V2. The TVB has been employed within the ETCS virtual balise concept to justify use of EGNOS from viewpoint of the required LDS safety integrity. The LDS solution contributes to the harmonization of the aviation and railway safety concepts based on EGNOS, because the required safety integrity targets in both transport modes can be met by single-constellation EGNOS V2. Galileo as a second constellation within EGNOS V3 can be then used for reliability and availability of integrity improvement via the redundant 1oo2 LDS architecture.

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References

[1] B. J. Sterner, "On the Method of combining GPS and ETCS for Localization Purposes", The European Railway Research Institute (ERRI), Draft of the 8th May 1998, 6 pages.

[2] RTCA DO-229D – "Minimum operational performance standards for GPS WAAS Airborne Equipment", RTCA Inc., Washington, D.C., 2006.

[3] S. Pullen, T. Walter, and P. Enge, "Integrity for Non-Aviation Users. GPS World," July, 2011, pp. 28–36.

[4] A. Neri, S. Sabina, F. Rispoli, and U. Mascia, "GNSS and odometry Fusion for High Integrity and High Availability Train Control Systems," ION GNSS+ 2015, Tampa, September 14-18, 2015, 11 pages.

[5] Neri, A., Vegni, M. and Rispoli, F.: A PVT Estimation for the ERTMS Train Control Systems in presence of Multiple Tracks. Proc. of ION GNSS 2013, September 16-20, 2013, Nashville, TN, USA.

[6] "ETCS/ERTMS – Class 1, ETCS Application Levels 1 & 2 - Safety Analysis, Part 3 – THR Apportionment," SUBSET-088 Part 3, ISSUE: 2.3.0, DATE: 02-04-2008, 91 pages.

[7] "ETCS/ERTMS Safety Requirements for the Technical Interoperability of ETCS in Levels 1 & 2", SUBSET-091, ISSUE: 3.3.0, DATE: 2014-05-08, 51 pages.

[8] "EN 50126 Railway Applications: The Specification and Demonstration of Dependability Reliability, Availability, Maintainability and Safety (RAMS)," CENELEC European standard, 2002.

[9] "EN 50128 Railway Applications: Communications, signalling and processing systems – Software for railway control and protection systems", CENELEC European standard, 2003.

[10] "EN 50129 Railway Applications: Safety-related electronic systems for signalling," CENELEC European standard, 2003.

[11] A. Filip and F. Rispoli, "Safety concept of GNSS based train location determination system SIL 4 compliant for ERTMS/ETCS," Proceedings of ENC GNSS 2014, Rotterdam, April 2014, 15 pages.

[12] A. Filip and F. Rispoli, "SIL 4 Compliant Train Location Determination System Based on Dual-Constellation EGNOS-R for ERTMS/ETCS," Proc. of the International Symposium on Certification of GNSS System (CERGAL 2014), Dresden, Germany, July 8 - 9, 2014, pp. 109-114.

[13] A. Filip, "Multi-Constellation Railway SBAS Interface: A Common Platform For Advanced Signalling Compliant With SIL 4 World-Wide," Proceedings of the International Heavy Haul Association 2015 conference (IHHA), Perth, Australia, June 21-24, 2015, 10 pages.

[14] T. Lovric, J. Gülker, "Singe Channel ATP Architectures, a new Trend in Europe?," WCRR 2001, Köln, November 25-29, 2001, 9 pages. http://www.uic.org/cdrom/2001/wcrr2001/pdf/sessions/3_5/040.pdf

[15] EGNOS Safety of Life (SoL) Service Definition Document, GSA, 2015, ISBN: 978-92-9206-025-1, 64 page.

[16] ERTMS/ETCS RAMS Requirements Specification Chapter 2 – RAM, Version-6, Reference EEIG : 96S126, UIC, 30/09/98, 83 pages.

[17] e-NAV2 / 07 / 02 Continuity requirements. Document available at: https://imo.amsa.gov.au/iala-aism/e-nav/e-nav2/eNAV2-07-02ContinuityRequirements.pdf

[18] GNSS Rail Advisory Forum: REQUIREMENTS OF RAIL APPLICATIONS, UIC, May 2000, 29 pages.

[19] Filip, A., "Efficient use of multi-constellation EGNOS for the European Train Control System," Proceedings of the 2016 European Navigation Conference (ENC GNSS 2016), Helsinki, May 30 – June 2, 2016, 9 pages.

Mainstreaming Spatial Data Sharing approach in Sri Lanka

This paper describes the Spatial Data Infrastructure approach being adopted by the Sri Lankan Government to mainstream data sharing

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A recent study of data sharing in Sri Lanka has revealed that using a SDI approach has potential to deliver economic, social and environmental benefits to the wider community and financial benefits to government

Accessing integrated spatial information for land development and economic initiatives is often ridiculously difficult. Much of a country's spatial data is managed in closed systems of government. How do business leaders, not-for-profit project teams and policy makers know what information there is, in what format and where to find it?

This paper describes the Spatial Data Infrastructure approach being adopted by the Sri Lankan Government to mainstream data sharing. The approach is multifaceted and challenges decision makers to move beyond policy settings to create a blueprint for sustainable data sharing.

The Underlying Problem

Countries worldwide have significant spatial information holdings collected by various government agencies, but access to data is a common obstacle. The inability to share information across whole-of-government systems is a massive and costly ongoing problem for governments and the international community.

Older technologies are often not interoperable making data integration a problem. The effort to manually integrate updates from one agency to another is labor intensive and time consuming. Data inconsistencies arise and information is liable to become out of date quickly, and the wider community cannot get access.

One of many challenges for policy makers is existing cross-agency data sharing policies that often require paper agreements and contracts. These have evolved over many years and are just not relevant to modern open data initiatives and online cross-government alliances that can be achieved with today's technology.

A recent study of data sharing in Sri Lanka has revealed that using a Spatial Data Infrastructure (SDI) approach has potential to deliver economic, social and environmental benefits to the wider community and financial benefits to government.

The data sharing problem is not unique to Sri Lanka. Many countries face problems associated with accessing and using their spatial information assets. The mechanisms by which agencies typically share information is via customized exchanges of bulk data. The approach is cumbersome, resource intensive and data is prone to becoming out-of-date because information is replicated and updates are not sustainable.

A common problem is the lack of clear oversight of national/internationally funded projects that acquire spatial information. This leads to operational inefficiencies, as limited awareness of newly acquired project datasets results in organisations recollecting the same information at a later date. A more practical solution is required.

The Game Changer

Having an operational SDI in place is a game changer. It means that business leaders, not-for-profit project teams and policy makers will have the ability to work at scale using the best available data that is easily accessed.

It also means that valuable project data can be seamlessly scaled up in the national interest by incorporating it within a country's SDI. In this way, project-level flood models can be incorporated into nationwide models and reused by the insurance sector to make decisions about levels of risk. Similarly, imagery of the built environment can be reused by the real-estate sector and developers to attract international investment.

A disaster management project in Sri Lanka recognized early that information from a variety of sources was required, but access was problematic. Instead of recreating new datasets and systems, which would have added to supply chain complexity and duplication, the project sought to resolve the underlying data sharing problem as a way to move forward for the project, government and for society as a whole.

Data reuse is a central SDI principal. All spatial data investments are done in a way that accrues benefits nationally and globally - well beyond a project's lifetime. This includes scaling-up project-level spatial data acquisitions to ensure that valuable project data is transitioned to a country's SDI for reuse.

Policy support, leadership, established partnerships and financial considerations all relate to the feasibility of going to scale. Without these broader inputs, projects will assuredly result in isolated spatial investments that have one-off usage with benefits only accruing to project participants in the short term.

Rationale for Change

The data sharing problem requires urgent attention. While spatial data has significant value as a single information product; it is the integration of spatial data with other information that increases its value exponentially to government and businesses.

Continuing with the traditional approach is not an option. Government agencies will struggle to deliver services that meet consumer and industry expectations in the future. The new norm is to find contemporary ways to increase the effectiveness and efficiency of government services, increase productivity and contribute to innovation excellence across the public and private sectors, and broader community.

There are considerable economic, social and environmental benefits that can be achieved from investments in spatially referenced information (ACIL Tasman, 2008, LGA, 2010; MNR, 2015; EC, 2006). In Sri Lanka, the population is expected to grow at an annual rate of around 0.86%, from its current population of 21 million. Industrial activities have been increasing, and many agricultural workers are expected to seek higher-paid employment in industry and the services over the coming years. Many of these jobs will be in urban areas and this suggests an accelerating rural–urban transition. Achieving employment growth, while ameliorating potential adverse social and environmental impacts from urbanization will be a key development challenge for Sri Lanka (MENR, 2014), and continued growth will increase demand for spatial information for both planning and operational decision-making.

Governments are continually looking for ways to reduce future capital expenditure and Sri Lanka is no different (ICTA, 2014). A shared approach to the delivery and management of spatially-related information is one way to achieve this. When agencies implement their own spatial infrastructures, to give access to their spatial data holdings, the total cost to government is much higher than if a shared infrastructure approach is adopted. With a National approach, there is an opportunity for the smaller agencies to leverage off the investments by larger agencies for minimal incremental cost, with economies of scale yielding further reduction in per-unit costs.

The Sri Lankan Approach

The multifaceted SDI approach conjures up a highly complex system for the storage and use of data that can be daunting – especially for developing countries. This is not the case. The Sri Lanka experience shows that a SDI can be implemented in manageable stages and piloted for specific applications. There are six components planned for the Sri Lanka Spatial Data Infrastructure:

- A **Governance Model** that brings agencies together to share spatial information, reform cross-agency business processes, acquire data strategically and adopt modern information technology standards.
- A **Legal and Policy Framework** that provides clear direction and unified approach to data sharing including guidelines for custodianship, data acquisition, spatial data management and access, privacy, security of sensitive data and intellectual property management.
- A **Map Portal** to deliver spatial information centrally in an online and mobile environment.
- A **Data Framework** that provides for the orderly management of data and metadata.
- **Spatial Data Supply Chains,** which minimize manual data handling, and provide for authoritative data sources as well as local community knowledge through crowdsourcing initiatives.
- A **Modularized System** designed to grow capability over time.

When implemented together, these components effectively institutionalize cross-government data exchange, operational transparency, digital service delivery and importantly, the ability to mainstream spatial data sharing.

The Strategic Enabler

The Sri Lankan Government has recognized for some time that current data sharing processes could be more efficient (UN-SPIDER, 2011), and the rationale for change is encapsulated in the consultation draft of the government's SDI strategy; *Powering Decision Making and Innovation Using Spatial Information Technologies* (Sri Lankan Government, 2014). This strategy seeks

to address environmental and social imperatives and stimulate the economy.

The Sri Lankan SDI will be a strategic enabler for the many government initiatives aimed at planning for economic growth, delivery of better services, poverty alleviation, socially inclusive development, tourism growth, protection of the environment, disaster management, regional cooperation and, importantly, transparency in governance (Sri Lankan Government, 2014).

A government program to improve the supply of clean water and sanitation in rural areas requires integrated spatial techniques from which planning and development decisions can be made. Currently, information is fragmented across a number of departments. With improved access to information, agencies can focus on their core tasks rather than diverting resources into searching for, and retrieving, data from other agencies.

Spatial information can be applied to improve agricultural productivity. In Sri Lanka, small-scale farms have declined over the past decades due to irregular rainfall, recurrent drought and poor irrigation. Food security (in terms of availability, accessibility and affordability) is uncertain, notably in the rural regions (MENR, 2014). Integrated spatial information can assist small-scale farm holders to achieve higher productivity through yield monitoring, crop stress mapping and soil condition monitoring.

Promoting Sustainable SDI Governance

Without an SDI in place, governments typically lack the inter-organizational communication necessary to coordinate and provide integrated access to their spatial data holdings. This is also the case in Sri Lanka. Cross-agency interaction and collaboration is often based on official channels of information flows (UN-SPIDER, 2011). This approach it subject to a high degree of bureaucracy for data requests, the preparation and signing of data sharing agreements, and manual data transfer methods. Delays are frequent and the process is costly. While fast-tracking is possible in the event of emergencies, the process is often reliant on personal relationships, which can collapse when changes in staffing occur.

A new approach to spatial data governance is required: one that will ensure data is readily accessible so that it can be leveraged in the national interest. The governance model considered for Sri Lanka embraces this approach. The principles are:

- an approach that focuses on strategic national imperatives, as well as, institutional requirements;
- a governance model that is easily accessible and credible to participating institutions;
- a model that is driven from the top, so that participating institutions are well supported and guided in their daily tasks and decisions where the SDI mandate is concerned;
- an alertness to inter-agency cost-shifting where SDI programs and projects complement changing cross-government strategies; and
- regular cross-sector and cross-committee SDI reporting and monitoring, complemented by re-evaluation of performance expectations and adjustments where necessary.

A key characteristic of a sustainable SDI Governance Model is the central governing body often referred to as the *National SDI Office* (NSDI) (Figure 1). This office coordinates cross-sector SDI activities, formulates strategies and produces general standards, policies and guidelines for data management and access. Its core mission is to provide stewardship and build networks of people to continually improve the sharing of spatial information and promote its broader use. For this reason, the NSDI office is usually an independent body representing whole-of-government needs and not just the needs of a single Ministry or Department.

SDI Governance Models need to make provision for project data and its ongoing maintenance and reuse. All projects that acquire spatial information should make their planned acquisitions known to the NSDI Office for oversight and so that project leaders can be directed to appropriate data custodians for responsibility of its residual value. Without a SDI Governance Model in place, there is often no provision for the ongoing storage and management of project data and these assets quickly depreciate in value.

Globally, there is a shift to more inclusive models for SDI governance. In Sri Lanka, the considerable breadth of stakeholder groups calls for an enduring underpinning structure that takes into account the balance between public and private sectors, and data providers and users. Notably, the private sector and academia will have a significant role to play. User demands will often trigger partnerships and alliances to produce and share information.

Cooperation is assisted through a *Steering Committee* (appropriately mandated) that

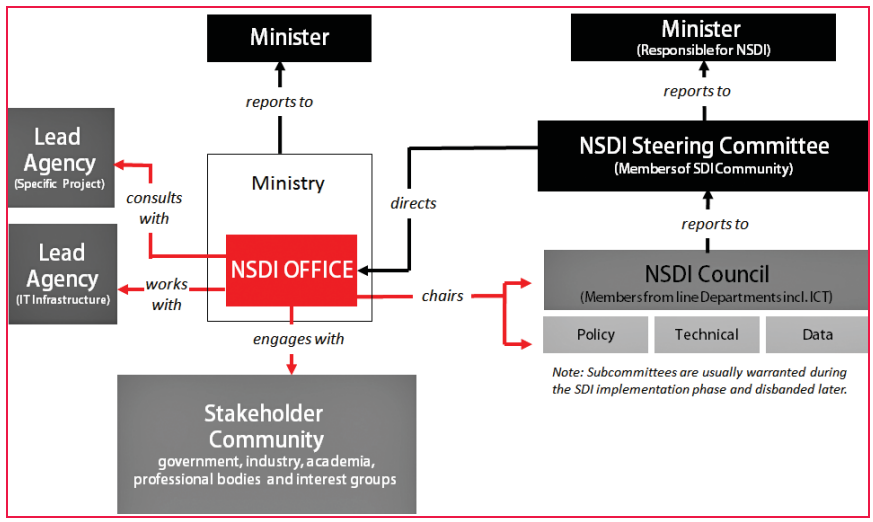

Figure 1: Example of a Sustainable SDI Governance Model

sets policy and binds institutions to work towards achieving common interests. Operational SDI matters are best dealt with by a body of experts (or NSDI Council) drawn from the line Departments.

The Policy Framework

An all too familiar difficulty for governments is that legislation and policy solutions frequently fail in their first evolution due to lack of support. The lesson learned is to deliver policy reform incrementally, where each stage is geared towards inspiring cooperation and collaboration for data sharing. Involvement of a broad range of stakeholder groups early and at every stage promotes support for open data initiatives.

The six stages are (Figure 2):

1. *A strategy* that encapsulates the vision and goals of the broader stakeholder group for the use of spatial technologies in delivering on the important social, economic and environmental objectives of government. This builds support for open data initiatives across the broader stakeholder group.
2. *A Road Map* that identifies the critical steps towards achieving the short and long-term SDI outcomes including anticipated milestones to manage stakeholder expectations.
3. An *Intergovernmental Charter for Spatial Data Management* that articulates the main principles and some specific undertakings required by data custodians. The charter is generally a 1-2 page Memorandum of Understanding (MOU) enacted at the Steering Committee and NSDI Council levels. Its purpose is to instigate and build cooperation between agencies to develop and implement data sharing policies in the national interest.
4. A *Policy Framework* that describes the overall strategic approach and desired future. The objective is to set out what needs to be achieved in order to bring about change. It is often an 'umbrella' strategy to which a number of policies relate.
5. The actual *policy*/s drafted in consultation with stakeholders. The policy/s identifies how to achieve a particular strategic outcome. It clarifies what needs to be done and by whom. It is likely to include a policy position followed by a set of practice standards or detailed procedures supported by guidelines or toolkit. Seven *policies* that collectively contribute to effective and efficient management of spatial data throughout its lifecycle are: custodianship, data acquisition, spatial data management, information privacy, sensitive information, data access and pricing, and intellectual property management.
6. *Legislation* is the final step in policy reform and may not be required if the policy/s is proving an adequate instrument for opening up access to data. Also, countries often have existing legislation for intellectual property rights management, information privacy, copyright and data security, which already provide an adequate basis for spatial data access and management.

Guidelines for Scaling-up Project-level Spatial Data Acquisitions

Having a SDI Policy Framework in place means that all new projects have the necessary information to plan, record and capture spatial information in a way it can be reused. This includes the Spatial Data Acquisition Policy that has the following principles for working at scale:

- **Avoid Duplication:** All projects and activities that give rise to substantial datasets will establish at the outset whether suitable data already exist in a potentially usable form, or whether new data needs to be acquired.
- **Assign Custodianship:** Prior to approval of new data collection activities, establish how the acquired data will be exploited for maximum benefit, identify who will be responsible for full exploitation of the data, and how the benefits will be shared.
- **Plan Ahead:** Data handling and storage needs are planned in order to manage and maintain databases in a way that maximises data investments and benefits, and meets business priorities.
- **Consult:** Consultation is carried out with relevant authorities to determine the correct protocols, methodologies and classification procedures to use for newly acquired data.
- **Determine Point of Truth:** When sourcing data, work with relevant agencies to determine the authoritative 'point-of-truth' dataset.
- **Compliance:** Custodians to provide external contractors (project teams) with compliance standards for the acquisition of data including, but not limited to, procedural guidelines, data standards and metadata standards to facilitate data reuse.
- **Assess Fit for Purpose:** All new datasets are assessed for their appropriateness against specified criteria including, scale, resolution, accuracy, reliability, classification and integrity.

Working at Scale Using the Map Portal

The Map Portal is one of the key enablers to working at scale. Projects have ready access to datasets via a data catalogue. Access to data stores can be achieved via a decentralised or centralized warehouse.

When compared to the governance model and data sharing polices, the technology installation side of the SDI can often be achieved far more smoothly because:

- there are a number of systems available in the market that are readily deployable; and
- resistance to collaboration is lessened as the actual data remains within the control of custodial agencies. This alleviates concerns with information security, as security can be managed within the control of each organisation even though access to data is opened up.

Figure 2: Spatial Data Sharing Policy Reform Stages – An Incremental Approach

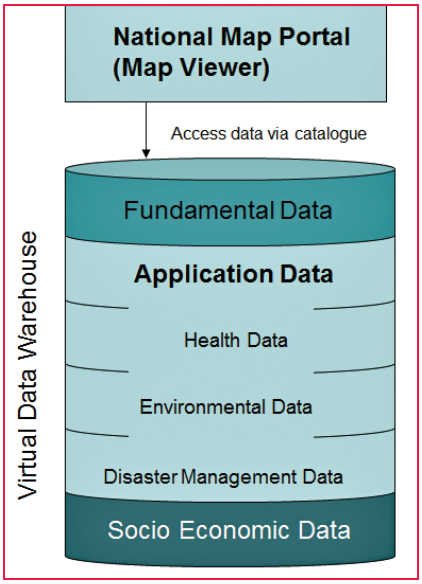

Figure 3: Data Framework

Getting Organized with the Data Framework

Major technical obstacles for governments are often the lack of standards for spatial data, incompatible classification schemes, and no common vocabulary and/or data dictionary.

A three tier Data Framework is being considered for Sri Lanka (Figure 3). This model supports projects working at scale, as well as the ability to scale up project data acquisitions. The tiers include:

- **Fundamental data themes** for which users (including projects) have a recurring need i.e. administrative boundaries, reserves, place names, transportation, buildings, hydrography, utilities, elevation, land use, cadastre, address and imagery.
- **Application data themes** that often include project data, such as flora and fauna for ecological and biodiversity studies, hazard risk maps for disaster preparedness and disease outbreaks for public health programs.
- **Socio-economic data themes** such as census statistics or household surveys conducted through projects.

For Sri Lanka, as with other countries embarking on their SDI journey, organizing the catalogue requires a data inventory to understand the breadth of data assets and where they are held. During the inventory process the level of data access is determined. Categories of access levels include public access, government-only access and restricted content.

Mainstreaming Spatial Data Supply Chains

A challenge for project teams is often how to move project-level data acquisitions, including community provided information, into mainstream spatial data supply chains. Because different data vocabularies, standards and schemas can occur, exchanging and reusing project-level data is not necessarily straightforward and project data may enter the supply chain a various locations (Figure 4).

Given technology interoperability today, this situation is hard to comprehend. The problem is historical. Since the 1980s-90s, when digital mapping systems first came into effect, organisations in many countries typically handled everything from data collection, presentation, marketing and distribution and often adopted their own information technology and data standards. Many of these datasets are still managed and maintained separately today; creating ambiguity for end users and an unnecessary financial overhead for governments.

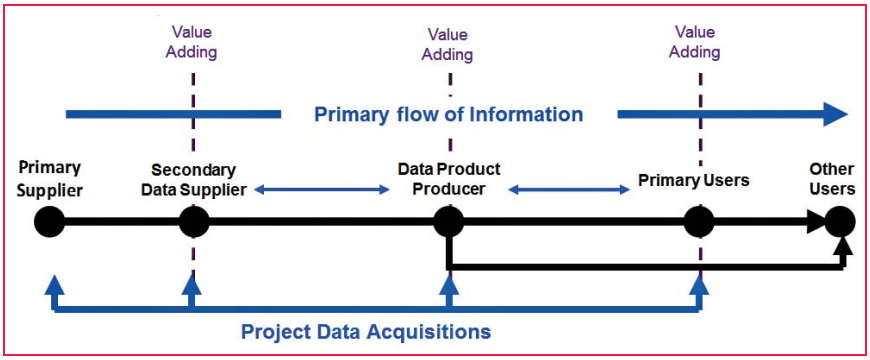

Figure 4: Project-level data acquisitions may enter the supply chains at various locations.

While this is the case for cross-government supply chains in Sri Lanka, the vertical government supply chains are streamlined with consistent data models and standards particular to each institution. This puts Sri Lanka in an extremely advantageous position, as vertical supply chains (i.e. between the various levels of government) are typically far more difficult to control with reliability, particularly in countries where provinces/states have a long history of autonomy, as is the case in Australia, United States of America and Vietnam.

With a plethora of data models and standards in place, provincial/state systems cannot be easily joined with consistency. On-the-fly processes to federate province/state datasets to create a seamless nationwide view are currently being investigated (CRCSI, 2013). In the interim data harmonization is the customary approach.

The implementation of a SDI is an opportune time for governments to evaluate their spatial data holdings and supply chain strategies and bring clarity to data custodianship and responsibility for specific upstream and downstream activities. It is also time for project sponsors to consider operating within a more sustainable supply chain framework rather than within an isolated project scope. Methods available to project teams include:

- *Incremental Updating*, where project data updates are forwarded to the data custodian for the inclusion/integration into the authoritative database.
- *Database Versioning*, where updates are performed by the project team on a copy of the custodian's database, which is then integrated into the authoritative source by the custodian.
- *Direct Editing*, where updates are performed directly to a custodian's authoritative database.

Research is currently examining more automated methods to conflate

project-level data with authoritative sources (Yu *et al,* 2016).

Preparing for the Future with a Modularized System

SDIs characteristically incorporate design flexibility and therefore, any number of applications/modules can be built from accessible data stores. This is an important capability given the changing SDI landscape.

Digital economies are expanding worldwide and 40 percent of the world's populations have access to the internet, and the number keeps growing (Internet Live Stats, 2016). With internet users spending more than 108 minutes per day on mobile internet services (Statistica, 2015), spatial information has the potential to become further embeddedspent an average of 74.4 minutes on mobile internet services per day. As of the second quarter 2014, this time had increased to 108.6 minutes per day. 74.4 minutes on mobile internet services per day. 74.4 minutes on mobile internet services per day. 74.4 minutes on mobile internet services per day.spatils in digital economies.

The enabler for this change will stem from the Internet of Things (IoT), with city-wide sensors connecting people with locations and services, becoming part of information systems and end-user applications. For government this means an unprecedented opportunity to streamline city operations, improve logistical management, reduce service costs and advance overall economic sustainability.

This is where the full value of the SDI comes into being. Technologies for climate sensors, animal tracking, silo stock calibrations, flood gauges, pest monitoring and dust cloud detection systems all have spatial location as a crucial component and can be incorporated into the SDI as accessible datasets from where they can be reused again and again for *Smarter City* services.

Conclusion

While SDI solutions come with some significant challenges, getting the policy and governance components in place early will allow governments to achieve major incremental steps towards achieving a robust data sharing solution; one in which business leaders, not-for-profit project teams and policy makers can work at scale using the best available data, and where project-level data can be scaled up and reused in the national interest well beyond a project's lifetime. This is the plan for the Sri Lanka SDI.

Acknowledgements

This paper would not have been possible without the support of the National Spatial Data Infrastructure Committee, Government of Sri Lanka and Dr I.H.K Mahanama, Secretary Ministry of Lands.

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References

ACIL Tasman (2008) *The Value of Spatial Information: The impact of modern spatial information technologies on the Australian economy*, [Online] Available at http://www.crcsi.com.au/Resources/general-interest, accessed Oct 2013.

Cooperative Research Centre for Spatial Information (CRCSI) (2013) *Spatial Infrastructures Research Strategy*, [Online] Available at http://www.crcsi.com.au/library/resource/spatial-infrastructures-research-strategy, accessed June 2015.

ICTA (2014) *Transforming a Nation through Information Technology*, [Online] Available at http://www.icta.lk/en/e-sri-lanka.html, accessed June 2014.

Internet Live Stats (2016) *Internet Users in the World*, [Online] Available at http://www.internetlivestats.com/internet-users/, access December 2015.

Local Government Association (LGA) (2010) *The Value of Geospatial Information to Local Public Service Delivery in England and Wales,* Final Report, [Online] Accessible at http://www.acilallen.com.au/cms_files/ACIL_Geospatial_UK.pdf

Ministry of Environment (2009) *National Action Plan for Harita Lanka Programme* [Online] Available at http://www.environmentmin.gov.lk/web/pdf/Harita_Lanka_Book_small.pdf, accessed June 2014

Ministry of Environment and Natural Resources (MENR) (2014) *National Sustainable Development Strategy*, under development, [Online] Available at http://www.un.org/esa/agenda21/natlinfo/countr/slanka/nsds.pdf, draft accessed June 2014.

Ministry of Natural Resources Canada (MNR) (2015) *Canadian Geomatics Environmental Scan and Value Study*, [Online] Available at http://ftp2.cits.rncan.gc.ca/pub/geott/ess_pubs/296/296426/cgdi_ip_41e.pdf, accessed December 2015.

Sri Lankan Government (2014) *Powering Decision Making and Innovation Using Spatial Information technologies*, Consultation Draft [Online], Available at http://www.landmin.gov.lk/web/upload/downloads/SLSDI%20Strategy.pdf, pp35, accessed Nov 2015

Statistica (2015) *Mobile Phone Internet User Penetration Worldwide from 2014 to 2019*, [Online] Available at http://www.statista.com/statistics/284202/mobile-phone-internet-user-penetration-worldwide/, accessed December 2015.

UN-SPIDER (2011) *Technical Advisory Mission*, unpublished works, 17-21 October.

Yu. F, West. G, Arnold. L, McMeekin, D. Moncrieff, S (2016) *Automatic Geospatial Data Conflation Using Semantic Web Technologies*, in proceeding of 39th Australasian Computer Science Conference, 2016.

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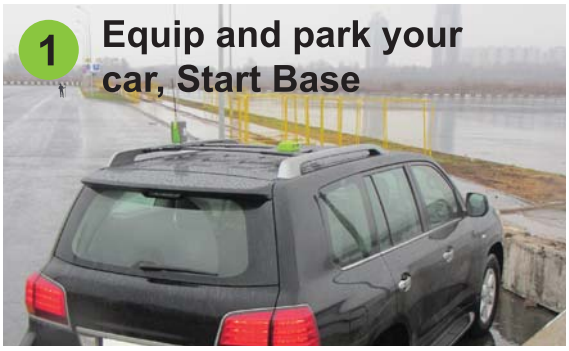
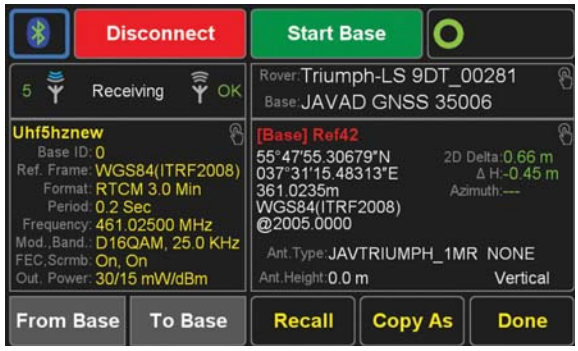
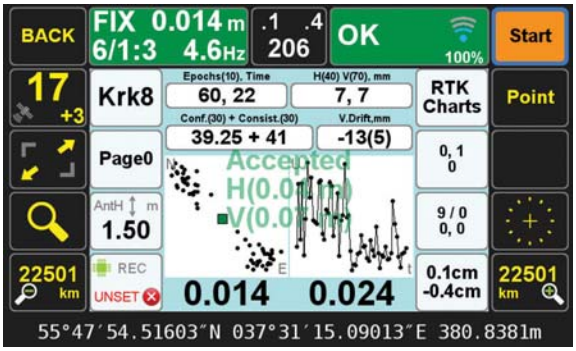


2
Start Base





3
RTK Survey

4
Sip your favorite drink while DPOS does the rest.

With six RTK engines, auto verify, Confidence and Consistency counters, and validation features of our RTK you are already confident that you have reliable and accurate RTK results. You may have base/rover communication outages in some points and you may want to make sure your base location was correct. You may want to use Autonomous solutions for your base and then find the accurate position. DPOS complements your filed work.

With DPOS we check the accuracy of you Base in two ways. One is to post process the Base raw GNSS data with CORS stations and second is to use the known points during your survey and inverse to base. We record the history in three buckets of the “Base” screen. 1) Original base, 2) CORS processed, and 3) m-Local reverse calculations.

In m-Local reverse calculation of the Base, you can pair as many known points with the points that you have surveyed.

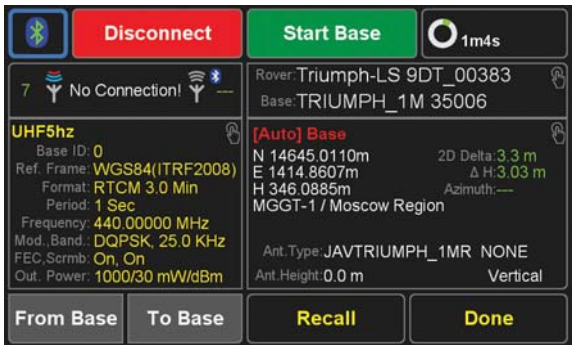
We also check the accuracy of the RTK solutions in two ways: 1) we post process your base and rover data and 2) we process your rover data directly with CORS stations, provided that there is enough data for long baseline processing.

We record all histories in the following ways:

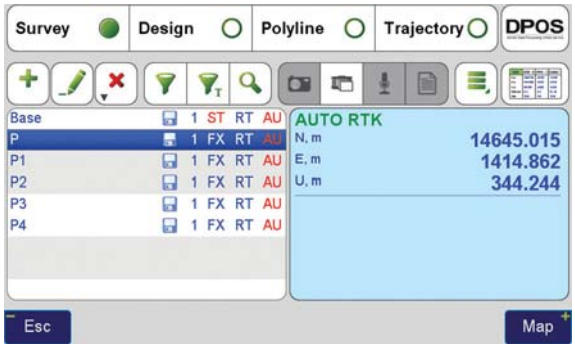
In Base screens there are three buckets for the Original Base, CORS processed Base, and m-Local processed Based. We don’t show the coordinates of the CORS stations. They can be viewed in reports.

And this is how it works.

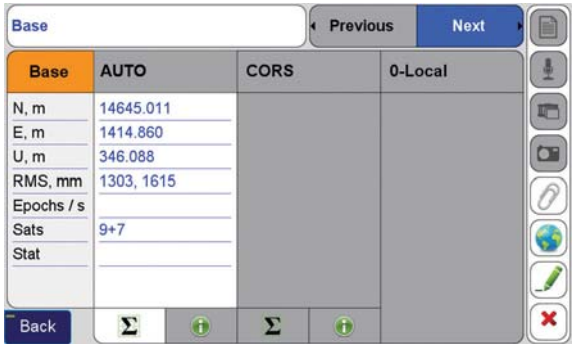
Here we explain the process and details of the six solution buckets (in Auto/ Known and Absolute screens) and three buckets of base in Base screen.



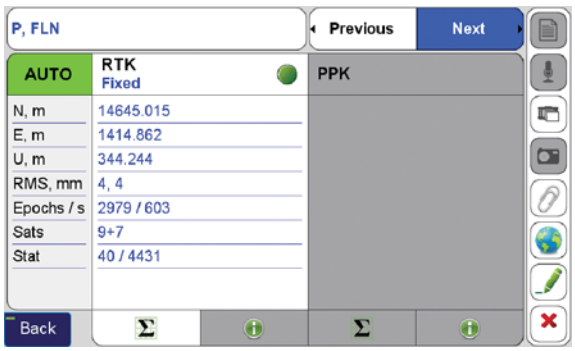
When survey is done, in Base/Rover Setup screen, download the base data in rover and enter a name for Base.



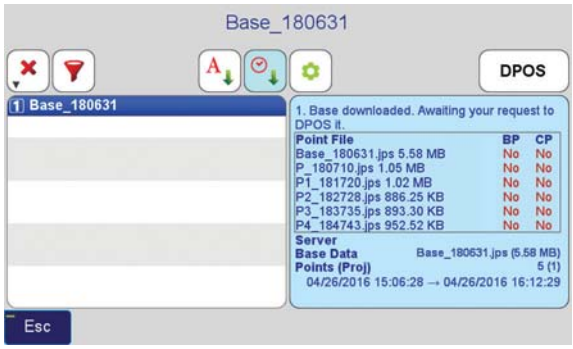
Click “Points” to see the list of points that you have surveyed. The first in the list is your base, followed with all the points that you surveyed relative to that base. Click  to see details of base and rover points details.



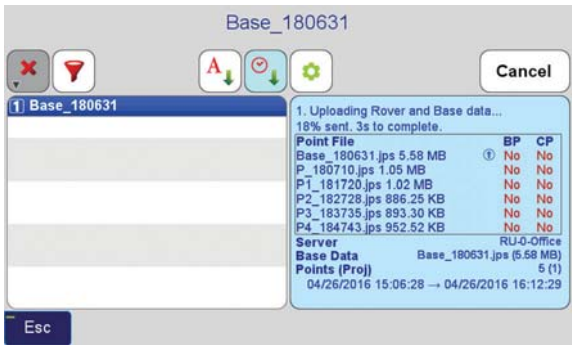
The original Base coordinate is saved in “Auto/Known” bucket of the “Base” screen.



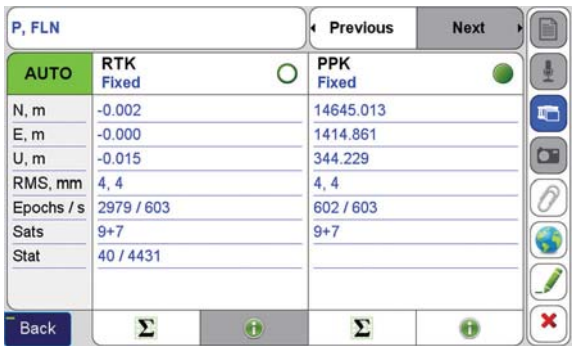
The RTK solution of each point is saved in the “RTK” bucket of that point in the “Auto” screen.
You can long click on the Point name box and select which of point code and description also to be shown in that box.



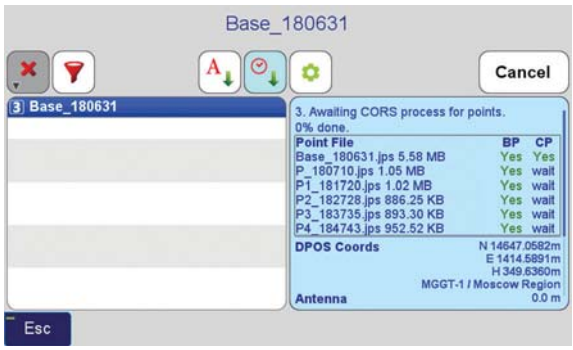
If you want to verify and improve your original solutions click DPOS to send your data to DPOS server and do the following tasks automatically and fill the other 5 buckets.



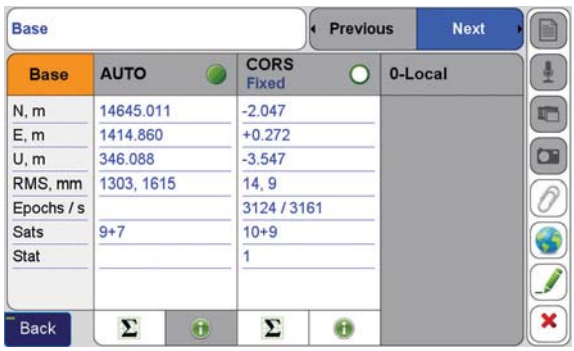
Base and rover data is sent to DPOS.



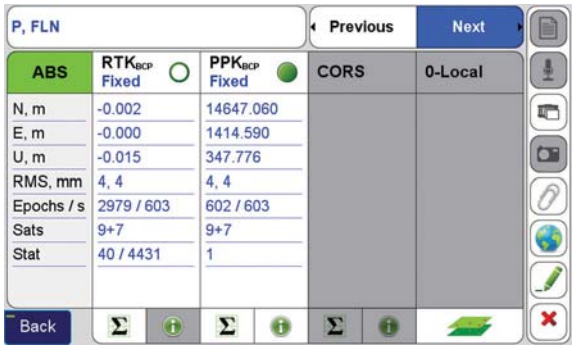
First DPOS will post process the rover data at each point with the Base data and verify that RTK results were correct. The new results are saved in PPK (Post Processed RTK) bucket of each rover point in the “Auto” screen. This will cover any failure at RTK due to communication loss or else.



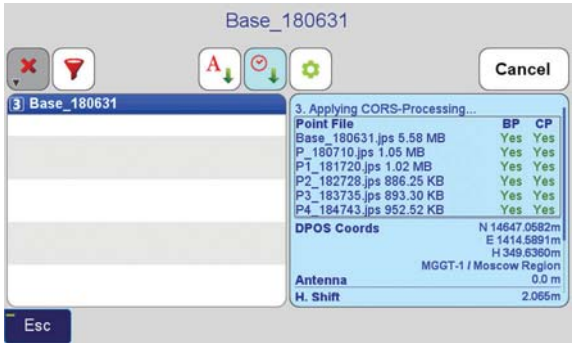
The status and progress of DPOS process is shown in the DPOS screen.



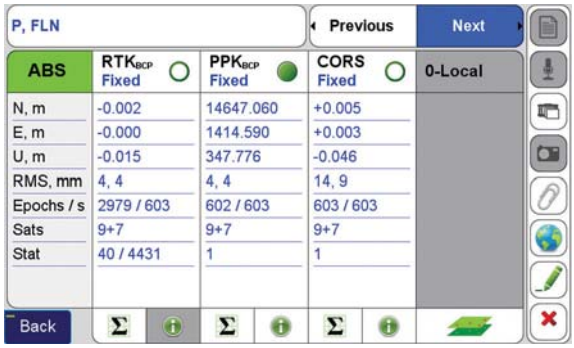
Then DPOS will process the base data with CORS stations and record accurately calculated coordinate of the base in the CORS bucket of the “Base” screen. You could have installed the Base in any location, use Autonomous solution for base and later find its accurate position in DPOS.



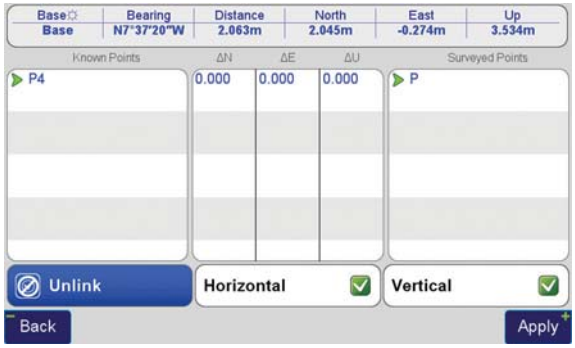
The accurate position of the base calculated with CORS stations is used to adjust the rover RTK solutions and record them in the PPK bucket of each point in the “ABS” (Absolute) screen. As said, you don’t need to know the accurate position of your base. You can toggle the top left button.



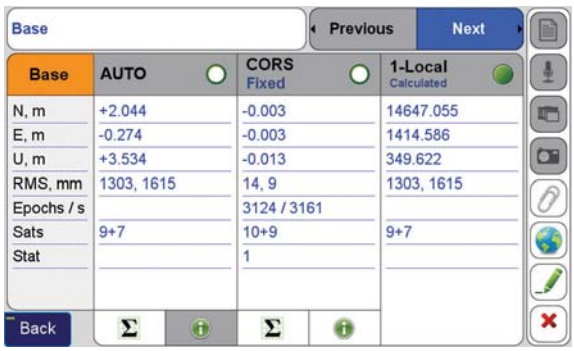
DPOS also processes all rover data directly with CORS stations (if sufficient data) without need for your own Base station. This is another way to check the accuracy of your RTK.



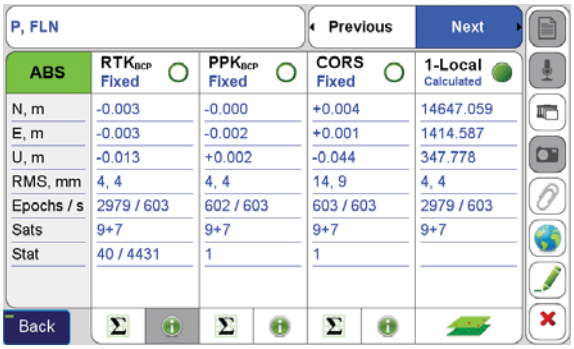
The CORS processed rover points are saved in the CORS bucket of the points in the “ABS” screen.



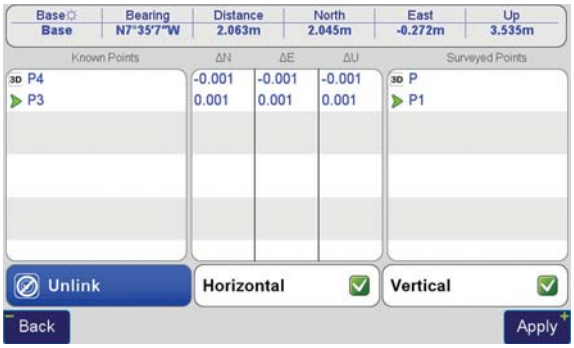
If you know the accurate location of some of the points that you have surveyed, you can use the “m-Local” process to pair them, “reverse calculate” the position of the base. You can do this in the field in real time too.



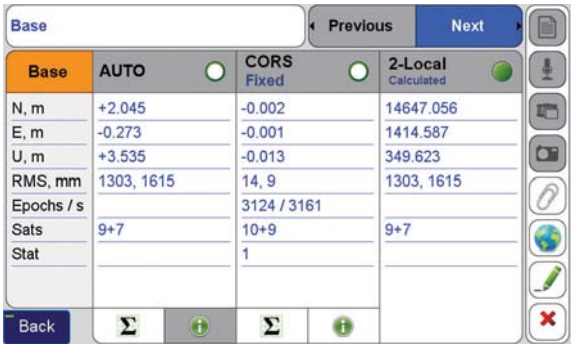
The inversed location of the base is saved in the “m-Local” bucket of the base screen.



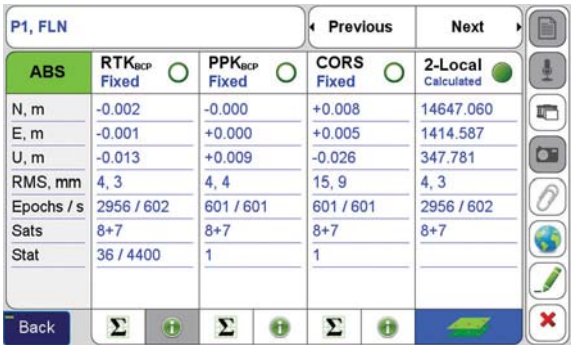
The adjusted points according the “inverse calculate” base are saved in the m-Local buckets of the points in the ABS screen. With this process you don’t need to know the accurate location of your base or use this to verify your works.



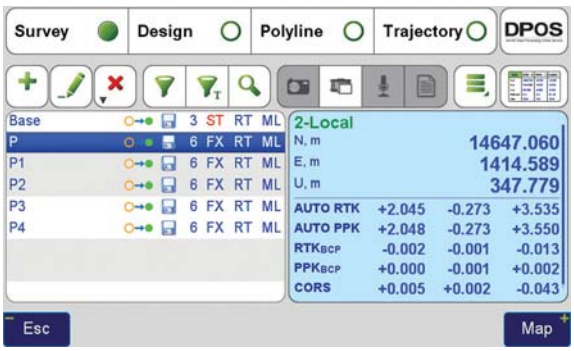
You can continue the “m-Local” process with more than one pair and enhance your base and results.



The result of newly reverse calculated base is recorded in the m-Local bucket of the Base screen.

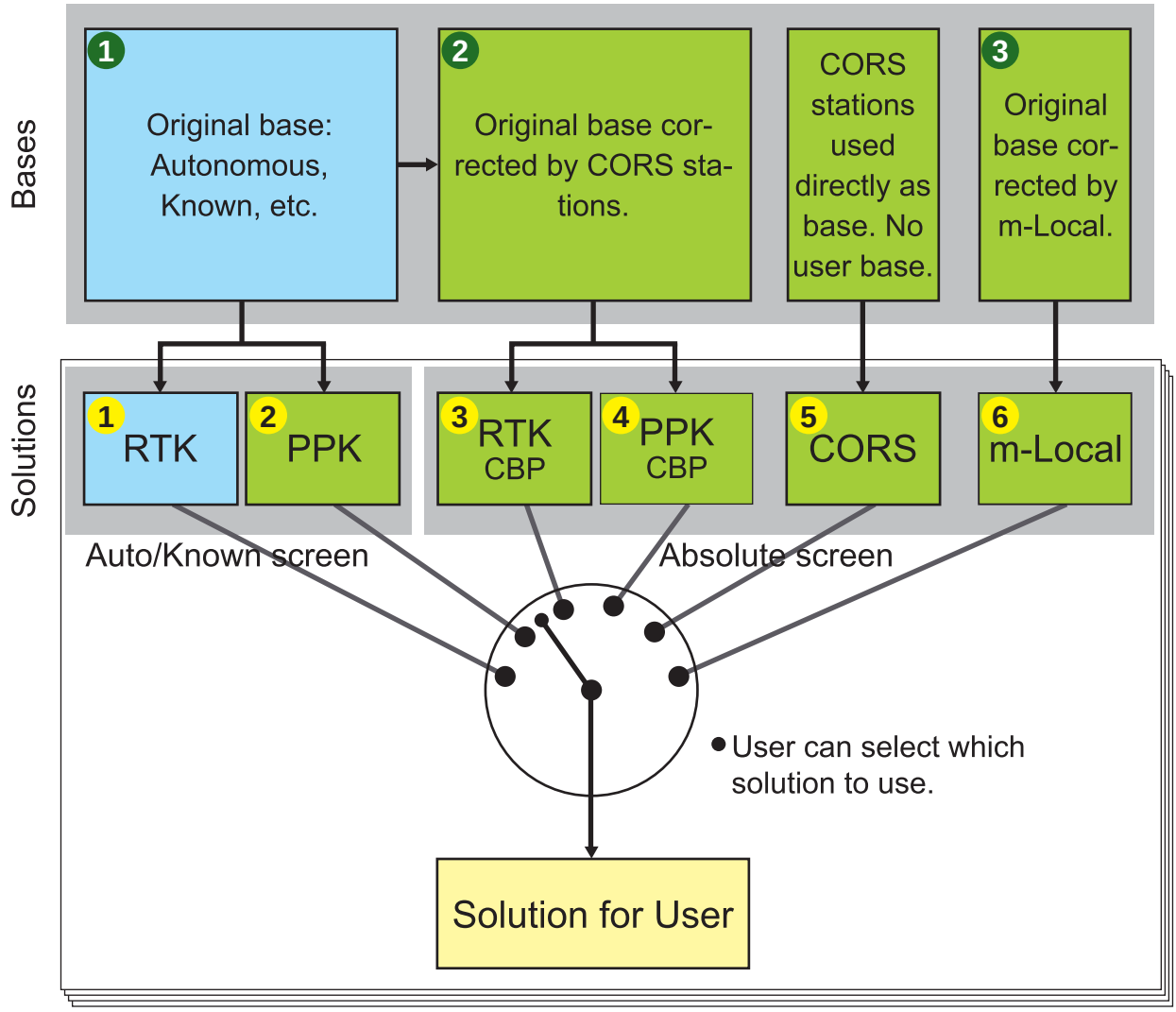


The impact on points are recorded in m-Local bucket in the ABS screen of each point.



The summary of the six buckets and the one that is selected is shown in the points list screen. You can change the selection in the detail point screen. Shift and GNSS raw data symbols, number of solutions, solution type, Process type, and Base type are shown in columns.

... while we fill the other 5 buckets.



For the Original Base there are two buckets in “Auto/Known” screen: one for the RTK solutions in the field and second for the PPK (Post-Processed Kinematic) based on the Original base.

For the CORS processed base, there are two buckets in “Absolute” screen: One for the corrected RTK solutions and one for the PPK based on the corrected base with CORS.

For the rover data processed directly with CORS, there is one bucket in the “Absolute” screen.

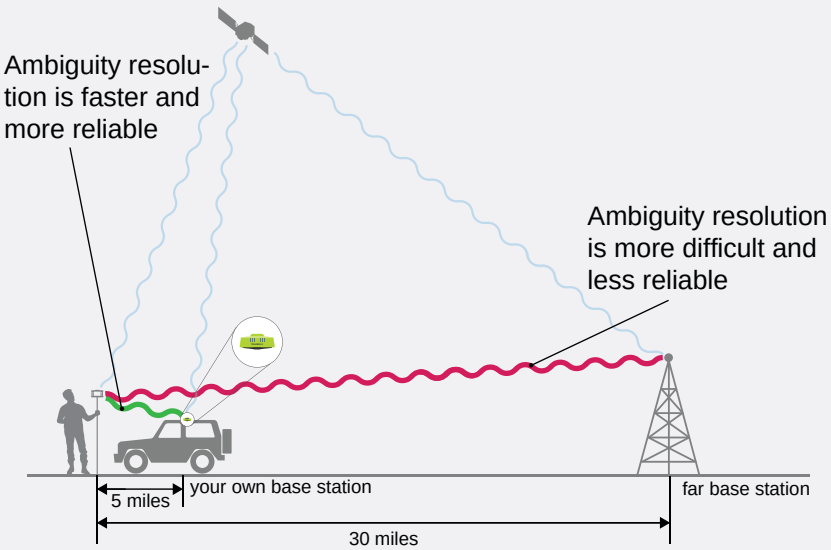
Rover solutions that are corrected with “m-Local” are also shown in the m-Local bucket of the “Absolute” screen.

So, the six rover solutions are shown in two screens: two in the “Auto/Known” screen and four in the “Absolute” screen. You can view them by clicking the boxes in the upper left of the “Point Detail” screen.

We will show one solution as default, but you can change to what you want by clicking the radio button of that point bucket. Buckets in the Base screen are only for information.

In the Base screen, the selected coordinate for the base is recorded as the effective position of that base for future use.

Advantages of your own base station and short baselines



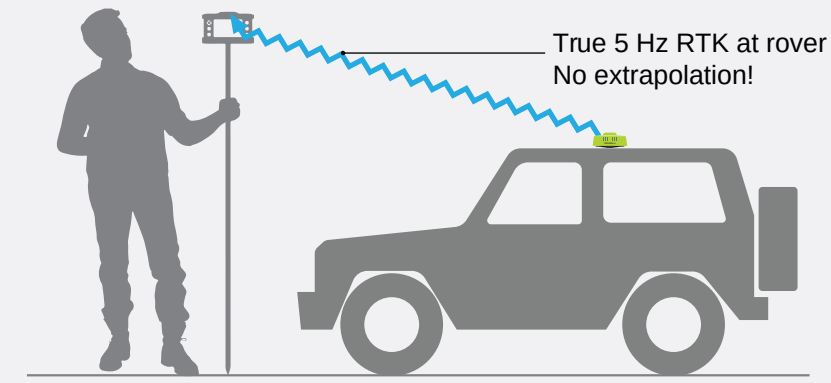
1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.

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

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

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

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



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

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Systematic Cadastre Surveying and Inventory of Real Estate Objects in Azerbaijan

This paper describes the methods used for the implementation of land administration in development cooperation projects, especially in Azerbaijan

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In all development cooperation projects in the field of land administration, initially, the particular national and regional characteristics must be considered, especially regarding institutional, legal and technical conditions. Additionally the Know how level in the partner organizations and in the private sector must be considered adequately. Finally, the expectations of the target group must be respected. These expectations should be harmonized with the project goals.

GCI – Dr. Schindler Geo Consult International GmbH & Co. KG (GCI) has been active for more than 20 years in more than 25 countries in international projects in the field of land administration and land management. The project countries are located in East and South East Europe, Africa, Central and South East Asia and Latin America. Many projects were executed in cooperation with GFA - Consulting Group GmbH, based in Hamburg, Germany.

This paper, prepared for the Journal "Coordinates", describes the methods used for the implementation of land administration in development cooperation projects, especially in Azerbaijan, and the experiences made by the consortium GFA/GCI.

Selected aspects of surveying and data collection in land administration projects

Expectations and adapted methods in development cooperation projects

It is generally acknowledged that in a couple of West European countries, also in Germany, the land administration (real estate registry and land register) is realized at a very high level. In the context of development aid this can redound to disadvantages in the international competition. It's presumed, whether consciously or not, that the experts in developed countries are to accurate and therefore to expensive. But if a government has decided to establish a nationwide land administration the government is often influenced by what is presented at international conferences and exhibitions (e. g. INTERGEO©). The decision-makers don't realize that the high quality level in Western European countries and other developed countries is not arose in two or three years.

Therefore it's not easy for consulting companies to fulfill high quality standards while being simultaneously measured on a value of money which make it difficult to deliver results that meet the demands of quality. Therefore it is important, to use adequate methods and technologies which meet the requirements of development cooperation projects, e.g..:

- Involving local experts for the creation of local resources at acceptable costs,
- preferably digital techniques for reducing errors,
- use of modern and high effective methods to accelerate surveying and data collection,
- complementary consultancy services to improve the legal framework,
- involving owners and local administrations to improve legal certainty of border determination and data collection,
- continuous training and systematic controls as indispensable quality management components.

As a consequence the used methods have to offer a high output at minimal costs per parcel and legal entity.

In many projects, especially in technical development projects GCI could contribute components for the systematic implementation of a land administration system. In two financial cooperation projects all different aspects of the systematic cadastral surveying for the preparation of owner registration were deployed.

In a KfW (German Bank for Development) financed project in Georgia from 01/2000 to 02/2008 a systematic surveying for a new cadastral surveying was conducted. In this surveying 1.4 million parcels and ca. 1.0 million additional legal entities (apartments, buildings) were recorded and prepared for a first registration. Additional surveying results and attributes were adopted from cooperation projects of other donor organizations and were integrated into a consistent geodatabase for the national cadastral and registration agency NAPR.

At the end of the project ca. 3.5 million parcels and ca. 1.0 million additional legal entities were saved in the geodatabase. The „National Agency of Public Registry" (NAPR) already took responsibility for the data and data updates in the final stage of the project. NAPR improved consequently the usability, extended the possibilities of using the data and took care of the procedures for the ongoing updates of the cadastral and register data. These actions led to the result that Georgia, in the last years, rank first several times in the World Bank Ranking „Doing Business".

Since the beginning of 2011 GCI operates with the consortium partner GFA Consulting Group in Azerbaijan. In a concept phase from 01/2011 to 10/2011, in close cooperation with the State Committee for Property Issues (SCPI), it was proved whether the required conditions existed to implement a systematic cadastre and register system. The following aspects were proved:

- Existing legal framework,
- political willingness and governmental mandate of the responsible agency SCPI,
- availability of local experts from the public and private sector,
- quality of the required technical infrastructure (internet, GNSS reference service),
- the owners willingness and interest to cooperate,
- efficiency of the planned surveying and collection methods,
- financial requirement for future project areas.

The concept phase succeeded. In the frame of intergovernmental negotiations Azerbaijan and Germany agreed to continue with the planned implementation phase. In 10/2013 this phase started with the goal to survey systematically and completely the districts Ganja and Sheki, located in the west and northwest of Azerbaijan. Additionally all relevant attribute data should be collected in digital form. The data for ownership registration is recorded through surveying and data collection. But the registration itself is only fulfilled on request of the owners. Therefore the Azerbaijanian partners name the project "systematic cadastre inventory".

For the implementation of this project the consortium GFA/GCI can use the rich experience and expertise of the Georgia project 2000-2008. The proven surveying and collection methods are used again. Nevertheless there are significant technical improvements in the current project, e.g.:

- Utilization of CORS (permanent stations for GNSS reference service),
- collection of attribute data in digital form using tablets,
- utilization of open source software for data examination and data storage in a temporary database

As part of the general government task about 170,000 parcels are measured in the Ganja and Sheki regions.

When the pilot project finished in 10/2011 the estimation was 100.000 parcels to be surveyed in both districts altogether. But the real estate market evolved in an accelerated way during the past five years. As well as in the second biggest city of Azerbaijan Ganja as in the more rural district Sheki private construction works increased enormously. That's why the real number of parcels doubled in some regions compared to initial estimations. This is a clear sign for the necessity of the executed inventory of all real estate objects. At the same time it is obvious, that communal and state institutions don't have reliable information on existing real estate so that they are able to fulfill their administrative tasks only in a severely limited way. It gets very clear, that the newly collected cadastre data are needed not only for assuring ownership but also for many additional administrative tasks. The meaning of multi-purpose cadastre becomes very clear here.

Below some essential aspects of the methodical approach of the surveying and data collection are highlighted.

Systematic local surveying versus digitalization of orthophotos

At international conferences, especially in the context of developing cooperation, the digitalization using orthophotos is publicized. In this matter cost benefits and the good readability of images are playing an important role. But this method is not suitable neither for Georgia nor in Azerbaijan as the dominant method because:

- Dense vegetation in settlements impede the identification of borders. In many cases the lines of the borders at the site are not marked. Sometimes they are marked just with simple means (wire, laths, decayed fences). They are not visible on orthophotos.
- In cities usually there aren't demarcations between private, municipal and governmental areas. In many cases these demarcations must be determined by a concerted site inspection. Only afterwards a surveying of the areas is possible.
- The use of orthophotos to determine the demarcations of arable land, meadows and orchards as well is problematic because many times the areas are leased by several owners but are cultivated corporately. Therefore the cultivation borders are not the same like the property borders.

The problems described here are illustrated in figures 1 und 2.

In Azerbaijan, as well in Georgia, the principle is used: „A cadastre must be realized by foot."

After the agreement of the local demarcation the border is determined by terrestrial surveying. Therefore a Digital Plan Table (DPT) is used. DPT consists of a GNSS-Rover, a field computer with the mobile GIS PENMAP and an inclinometer enabled laser distance meter. All single components are connected via Bluetooth.

Using this equipment most of the points can be surveyed directly. In case of shadowing or in roofed courtyards auxiliary methods may be applied. Therefore auxiliary points are determined using the RTK mode of GNSS. With these points the relevant border and building points are determined using special geodetic methods like bilateration, embedding in a straight line or extension. The coordinates from the GNSS-Rover and the distances measured with the laser distance meter are transferred to the mobile computer via Bluetooth. Subsequently the leader of the surveying team can analyze the data on-site using PENMAP and he can create the preliminary cadastral map.

In Azerbaijan for the field work a total of 25 DPTs are used. Each system consists of a Trimble R 10 or R 6 receiver in combination with the PENMAP software. Trimble RTX technology inside of R10 allows the use of GNSS in remote regions without CORS accessibility.

Figure 1: Orthophoto of a steadily growing settlement without borders

Figure 2: Orthophoto with locally determined borders

In the surveying team two qualified local persons are working. With this method 20 to 25 parcels within settlements and 30 to 50 parcels outside settlements are measured during an 8-hour day. The applied surveying method is extraordinary effective and is one of the main reasons that the costs per parcel in Azerbaijan currently only amounts to ca. 20 $ US. These are not only the mere surveying costs of the local surveying companies but the total costs. These costs comprise as well the costs for the following components and services: Acquisition of the surveying systems and computers, data collection in the field, training of local staff, consulting services by international and local experts, quality management by the consulting company.

At the end of the working day all data is transferred into a temporary database that was developed by the consultant especially for the project. The database uses several test methods (topology, plausibility, completeness) to check the required data quality. Simultaneously all data is saved and stored until completion and delivery of a complete lot.

Utilization of orthophotos and CORS

In spite of the facts mentioned above orthophotos (if available) are used additionally to terrestrial surveying, especially for information with little precision requirements, e. g.:

- Forest and municipal meadows,
- water,
- mountains,
- road axes,
- (partly) municipal boundaries.

The orthophotos of a particular surveying area are stored as tiled images on the field computer. Thus the team leader has the possibility to compare the surveying results with the orthophoto to check plausibility errors. Unacceptable deviations are examined directly on-site.

During the project in Georgia 2000 – 2008 Continuously Operating Reference Stations (CORS) were in development stages, even in developed western countries. In Georgia they even did not exist. Therefore DPTs with two GNSS receivers together with base and rover were used. Beforehand densification points were determined with reference to the national control network. From the densification points temporary auxiliary points were determined using RTK (long exertion, dual measurements) directly on-site. On these points the base station were mounted which provided the necessary correction data to the mobile rover. That way a positional accuracy of 10 cm was achieved throughout Georgia.

In this regard the conditions in the current project in Azerbaijan are much better. The implementation of CORS already started in 2010. Unfortunately it wasn't yet ready for operation during the concept phase in 2011. However, since the beginning of the implementation phase in October 2013 the reference service AZPOS is available and usually works reliably. Sometimes limitations occur due to shortened internet access which make it impossible to receive correction data. The same problems occur in some remote mountainous regions and mountain villages. In such circumstances base and rover are used. Overall, it has to be noted that the availability of the CORS network facilitates the work process and increases the efficiency of the surveying teams.

Determination of borders in cooperation with the owners

The on-site determination of the borders in cooperation with the owners is an important element for accepting the first cadastral surveying by the people and the administration.

The cooperation is prepared by informing the people. Before the start of the surveying the population in the affected areas is informed by local television, radio and press. The advantages of a systematic cadastre inventory is explained and the owners are requested to submit an application for property registration to the registry agency. Additionally, the responsible surveying companies inform every owner via a flyer ca. 3-5 days before the surveying date about the upcoming surveying. This guarantees that in most cases, at the first attempt, the access to the properties is granted. In this regard it is advantageous, that in many houses still three generations are living together. Furthermore, by far

there is no full employment, especially in rural areas. This procedure achieves an intense inclusion of the owners in the surveying process and leading to a high acceptance of the results by the population.

Collection of property data

In the frames of systematic re-measurement of all properties not only the boundaries, buildings and land use will be measured, but also numerous property data about the owners, real estate (buildings, apartments, commercial units) and rights to the property (e. g. servitudes) will be collected. This makes absolute sense in the context of an initial systematic inventory of all properties. As in Azerbaijan the registration of rights to property takes place only on request, it is expected that many months or even years pass till the full legal registration of all property takes place. Since the property data can be used in addition to the registration of property in the sense of multipurpose cadastre for various administrative tasks, their collection is convenient, even if some of the information, in particular in terms of ownership, until the legal binding registration have only a formal character.

To collect the property data, a special software has been prepared by the consultant based on the open-source application 'Open Data Kit' (ODK). ODK is used by an employee of one of the surveying teams on a Tablet PC to capture property data digitally parallel to the surveying works. In addition, all relevant documents are photographed with the tablet PC and linked to the right object with an ID. The following documents are included, if exist:

- Personal document of the holder / owner,
- possession of evidence, such as building permits, house books, etc.,
- documents from the land reform.

If the property has already been registered, it is only checked, if the registration number detected by the surveying team is identical with the number in the document. Only if there are differences, as a precaution, all property data is collected again. In such cases the registration authority is responsible for elucidation of the contradictions.

In addition to the various documents one or two meaningful photos related to the property are made and stored for all buildings. These images can be used in conjunction of the property data with the buildings, e. g. for approximate valuation, for urban planning as well as for building regulation duties.

Use of existing data from existing archives

In the frame of the systematic inventory of all property data from reliable already existing data sets is used. This applies mainly in two cases:

a) Although the registration process has so far been relatively expensive and complicated for Azerbaijani relations, many owners have already let to register their properties in the sense of sporadic registration.

The boundaries and buildings are, however, re-measured in each case. This is strongly recommended because the measurement results are often faulty in combination with the sporadic registration. This is mainly due to the following reasons:

- lack of surveying equipment,
- lack of knowledge for correct use of GNSS and electronic tachymetry,
- measurement with local control points without connecting to the official position reference system,
- imprecise identification of the boundaries, etc.

These inaccuracies and measurement errors can be detected and corrected only in the context of the systematic cadastral surveys. For this reason, the already registered lands were not recessed from the systematic re-measurement. However, the property data is retained from the existing registers.

b) With regard to the apartments and commercial units, there are very detailed documents by the local authorities. This is due to the fact that in the socialist times of the Soviet Union living space was very limited and was therefore managed carefully by the "Bureau of Technical Inventory" (BTI). This tradition was continued, although after the privatization a state or municipal housing management no longer is required. By now it doesn't take place anymore. Nevertheless, all apartments and commercial units are continued to be registered by real allowance and tangible data collection for the creation of a "technical passport" for each object. These data are taken from analogue documents and are entered into the databases by the contracted survey companies in Azerbaijan. Due to the quality, this data can be used further for the systematic inventory and transferred to the unified database. This approach contributes to cost reduction in the systematic inventory, especially for the apartments.

Tasks of the consultants in the KfW financed project in Azerbaijan

The financing of the project in Azerbaijan has been agreed as a result of government negotiations between the two countries Azerbaijan and Germany. It was decided that an international and experienced consulting company will assist in the implementation of the project.

Below are shortly represented some of the key tasks of the contracted consortium GFA/GCI, without claim of completeness.

Project Management

If projects concerning the implementation of a land administration are awarded to suitable consulting companies, this companies are responsible for the realization of the project in technical, financial and personnel terms and in terms of achieving the objectives and effects.

The consortium GFA/GCI supported SCPI with relevant activities to realize the project. From the beginning the main focus was to build up local capacities and to enable them to execute the necessary works. The consultant focused mainly on following activities:

- Elaboration of the technical instruction for systematic inventory of all real estate objects including an exact cadastral survey
- Elaboration of a guideline for quality assurance within the project
- Supporting SCPI on tendering surveying technology

- Training of more than 80 technicians of local surveying companies
- Training of approximately 10 GIS operators of private companies
- Supporting SCPI on tendering the lots for surveying works within the project area
- Supporting and control of private companies during field works and processing of cadastral (GIS) data
- Reporting on project progress

In private sector so-called "turn key" projects are common, in which the recipients of services are handed over with turnkey products. In development cooperation projects the goal is very different from that because the partner countries should be involve in all planning and decision processes. It is important to enable the partner countries, upon completion of projects, to apply the newly established procedures, methods and more efficient processes independently and to achieve the associated effects in terms of a sustainable strengthening of their economies.

Creating the legislative framework

In addition to the project management one of the most important tasks is the creation of proper conditions. Many project approaches neglected that a systematic creation or improvement of land administration usually requires an adapted legislative framework, where the basic relationships of the actors to each other in this sector are regulated. This includes both institutional, organizational and technical issues. What's the use of, for an example, a fully digital data flow in a project, if such a procedure is not permitted by law or regulations?

A thorough analysis of the existing legislative framework has to follow a recommendation for urgent new regulations on a statutory, regulatory or technical requirements level. It should be a maxim of every project manager to involve local experts, both in conducting the analysis and for the necessary conclusions. Additionally, at an early stage policy authorities should be involved. Once it is determined what needs to be regulated, the draft of the new regulations has to be developed corporately with the involvement of experts from the project country. It can be quite useful when a first draft will be prepared by the consultant, which then serves as a basis for discussion. So already exemplary methods and procedures were tested in the pilot process in 2011. As a result, technical requirements have been developed and adopted for this particular case. Therefore the results of the data collection can be transferred and used in the official register.

Education and training

In the context of sustainable project implementation emphasis must be placed on ensuring a broadest know-how transfer to local institutions and experts. The private sector should be involved as well, because in most land administration projects private surveying companies are responsible for carrying out of the surveying work and the attribute data collection. The trainings were usually designed for different levels. Both the technicians and engineers who will carry out the field and office work as well as decision-makers should be trained (figure 3).

It must be guaranteed, that a sufficient number of employees are sufficient qualified. Because experience has shown that the fluctuation of the well-educated and mostly low-paid employees in the administrations is very large. Especially qualified experts who have been trained during a project have better earning potential in the private sector. Therefore, you meet very often new staff, which must trained again, since trained people very often leave the public administrations.

Another important aspect of training programs is the preferably concept of "train the trainer". In larger projects suitable trainees are found in competitions, which are trained especially intensive in order to independently conduct training in the future in cases of proven merit. They act as multipliers of the training. This ensures that even after completion of a project experts can continue to be educated and trained.

Quality Management

For data collection methods it is important to provide an effective quality management. Since in accounting process, further processing, storage and output of data errors can occur, they should be identified and eliminated. At the same time it is necessary to check the completeness, accuracy and consistency of data. Along with the verification and documentation of quality of pragmatic origin, status and time accuracy of the data, the quality of the received data will be guaranteed.

Collecting and processing of data will be carried out after extensive (productive) theoretical and practical training of all personnel involved, both the private sector and the administration. Regularly occurring mistakes and wrong methods will be identified in such a way until they become typical. The local project workers and the employees of companies

Figure 3: Training of local experts

involved and the administration will be trained in the use of quality control measures. That way they could execute these tasks themselves in the future.

Software development for quality testing and data management

For a sustainable use and for the acceptance of software in developing cooperation project a participatory approach is necessary.

In nearly all land administration and cadastre projects, in which GCI is involved, a geographic information system (GIS) and a geodatabase is used. The development of the database is the first step in the process of the software development. During intensive discussions the data model and the "digital illustration" of the working processes are developed. Subsequently the design of user interfaces and the code programming is realized. During first test runs the database, GIS and code is adjusted.

Below the common procedure of a participatory software development is described (as it is done by GCI in Azerbaijan):

1. Development of a simple example application
   To give a first idea of the software to the stakeholders a first example application is developed. Using this software the users gain experience and know-how. On this basis the further development is realized in a collaborative manner.
2. Database development
   2.1 Requirement analysis
   During the requirement analysis the consultant together with the decision makers and users clarify which processes should be supported and which information is needed by the users.
   2.2 Conceptual design
   The conceptual design is a plain structured model containing the database objects and their relationships. Generally the design is illustrated using the entity-relationship-model (ER-model). The terms used in the conceptual design originate from the 'real world', using words of the users everyday work. The conceptual design is created in close cooperation of users and developers.
   2.3 Logical design and implementation
   The logical design is used to transfer the conceptual design into a logical database model like the relational data model used by the database management software PostgreSQL. Finally, on basis of the logical design, the database is implemented. The logical design and the implementation is generally the task of the developers. Nevertheless, if qualified local developers are available, they are involved in this working step. Sometimes local developers are trained beforehand, as it was realized in a GIZ project in Cambodia in 01-02/2016.
3. Design of graphical user interfaces
   In cooperation with the users the design of the graphical user interfaces is determined using sketches (analog or digital). That way, the users get an impression of the software and may contribute to it at an early stage, which is very important for the acceptance of the software.
4. Software programming
   If possible, local developers are involved for programming tasks supporting the main developers. By favorable circumstances qualified persons are available already. Normally, the staff is low qualified and must be trained according to the requirements. The inclusion of local developers is crucial for the sustainability of the software because they are responsible for the maintenance and enhancements of the software after the developing project had finished.
5. Presentation of a first version
   After the completion of the programming tasks a first application version is presented to some users. Based on user feedback the software is adjusted. Generally, only small adjustments are necessary.
6. Implementation, training and support
   After successful test runs the software is implemented. If the local project partners already have digital data, they are transferred into the database for using the software immediately. Subsequently, the users are trained intensively - preferably, following the principle "train the trainer". After finishing the project these trainers serve as contact persons for the users and take care for the continuance of the software. The main developers should be reliable contact persons even after the departure from the project country and should support the users via online services as Skype or TeamViewer.

Using open-source software QGIS and PostgreSQL/PostGIS

Not only in the cadastre project in Azerbaijan, GCI is using open-source software. Only if there is no suitable open-source software for a particular task proprietary software is used. Compared to proprietary software open-source software has many advantages, especially for the use in developing cooperation projects.

In development cooperation projects GCI uses two open-source software applications: the geographic information system QGIS and the database management system PostgreSQL/PostGIS. Both applications belong to the most used and popular open-source products. Because of the popularity, the professional organization, the active communities and a sound financing by sponsorship operational safety is guaranteed in the long term.

The applications interact via interfaces in an optimal way (figure 4). In the database all data is stored. In addition the database is responsible for spatial analysis and geometry processing. In QGIS the data is presented in maps. QGIS offers the possibility to create extensions to supplement the basic functionality with custom-built functions. Thus, project-specific menus and dialogs for a particular process can be created. The extension dialogs in QGIS can be translated in any language. This is a big advantage in countries with non popular languages as in Azerbaijan,

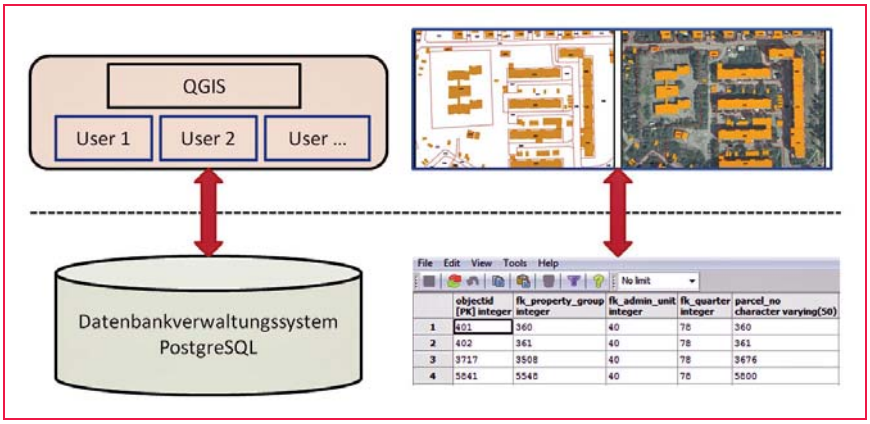

Figure. 4: Interaction of QGIS and PostgreSQL

Mongolia, Laos etc. In development cooperation projects this advantage leads to more acceptance of the software.

Conclusion

In the frame of the project SCPI, the consultant and involved private companies contributed a lot to establish a sustainable land administration system in Azerbaijan. In the course necessary data was not only collected to register ownership but also for a sustainable Land Management. The Republic of Azerbaijan is on a good way, but there is still a lot to do, e.g.:

- Simplification of first registration process
- Reformation of the surveying and cadastre law
- Continuation of systematic first survey in additional districts
- Establishment of an effective system of cadastre maintenance on demand
- Provision of all cadastral data to state and communal institutions to improve their administrative performance

The experiences gained during the project show definitely:

- The technologies applied are highly efficient and guarantee a sound legal security, hence the owners are involved in the process of determination of the parcel boundaries
- The used surveying equipment is highly efficient and works also with limited GNSS availability reliably
- Open-source software can be used reliably for data processing, checking and storage
- The methodology of project execution specifically involving the private sector to a large extend is reusable in other countries.

References

Open Source 2015. https://opensource.org/osd-annotated, last access 30th of November 2015.

Challenges to Climate Action and Resource Use Efficiency in South Asia

This study tries to understand the impacts of climate change and its effects on the available resources

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The South Asian region is highly sensitive to the consequences of climate change[1]. It is known to be the most disaster prone region in the world supporting a huge population of more than 1.3 billion (UNEP 2003). This is critical as climate predictions for the future highlight increase in frequency and intensity of extreme weather events like droughts and floods (IPCC 2001); indicative of the huge population that is likely to be exposed and affected in the region. Tendencies of increase in intense rainfall with the potential for heavy rainfall events spread over few days are likely to impact water recharge rates and soil moisture conditions. Rapid depletion of water resource is also a cause for concern in many countries within the region. In South Asia alone, 2.5 billion people will be affected with water stress and scarcity by the year 2050 (Human Development Report, 2006). While estimating these numbers, however, changes in climatic conditions have not been considered. This paper presents the prevailing challenges to climate action in South Asia and its impact on the available resources. The study was based on an extensive review of available documents and reports as well as through collection of survey data from the individual countries.

Review of the Challenges Faced by Countries in South Asia with Regards to Climate Action

Afghanistan

Afghanistan is a landlocked, mountainous, and dry country which has an arid and semi-dry continental climate with cold winters and hot summers. The climate substantially varies from one region to another due to varying topography. The country as a whole can be considered within the desert or desert steppe climate classification. It seems that the key to long-term economic development of the country may lie in natural resources and many other known mineral deposits (estimated more than USD 3 trillion) which are still untapped due to political and economic instability. Similarly, sustainable surface water (estimated 2775 cubic meters per capita), mineral resources, and well positioned geographical location for trade and business make an attractive opportunity and potential for economic development in the future. However, a number of political and economic issues poses serious challenges. Thus, country has not yet developed its own economic and social system in order to transfer traditional economy to a sustainable growing, environment-friendly and resource-efficient industrial economy.

[2] Afghanistan presents a number of specific challenges in terms of climate change assessment. Climate projections for Afghanistan require significant refinement due to the lack of availability of reliable historic meteorological records. Complex topography in Afghanistan also means that local variations in response to global warming, particularly precipitation, are likely to be large and many areas may vary from the regional trends. In addition, sporadic and poor quality socio-economic data make econometric modelling or robust cost/benefit analysis of adaptation and mitigation policy nearly impossible. Poor national security also restricts the

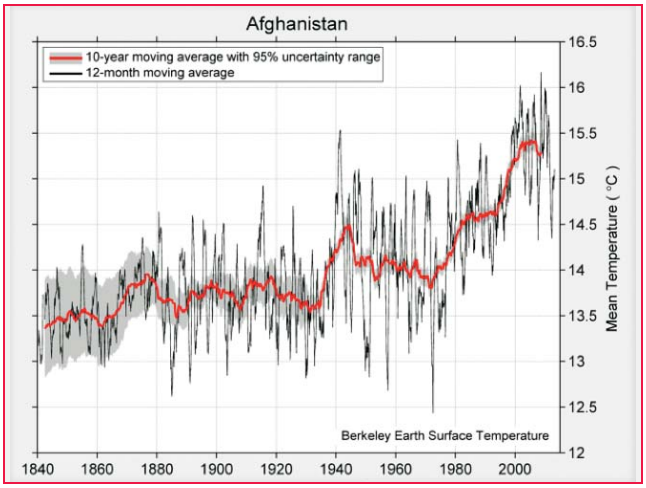

Figure 1: Graph showing the mean temperature change in Afghanistan[3]

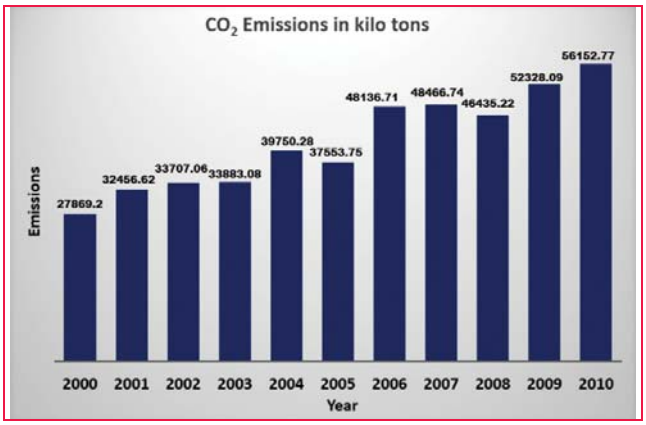

Figure 2: Graph showing carbon-dioxide emissions in Bangladesh (Source: World Bank 2013)

ability to undertake structured fieldwork to assess potential mitigation and adaptation options. Despite the absence of good long term climatic records, available data and trends from neighbouring countries indicate that mean annual temperature has increased by 0.6°C since 1960, at an average rate of around 0.13°C per decade. Increases have been most pronounced during the autumn with increases at an average rate of 0.29°C per decade and a significant increase in the number of exceptionally hot days and nights. The country also faces increased climatic hazards. Among them the most adverse impact is from drought associated with the dynamics of desertification and land degradation. The worsening climatic conditions in Afghanistan will continue to impact socio-economic development, creating stresses for vulnerable groups. Agriculture and water resources management are likely to be severely impacted by changes in climate. Apart from the security concerns which are highly prevalent in Afghanistan, the poor infrastructure, lack of skills and capital, the poor institutional system and the weak intention of involved parties made the situation even worse in terms of actions towards climate change as well as developing reliable natural and man-made disaster management system.

Bangladesh

Bangladesh is in need of urgent climate action. In terms of climate vulnerability, the country ranks as number one in the world (World Bank, 2005). It is particularly susceptible to climate induced disasters. They not only cause immediate collateral damage but have potential to harm long term health and livelihood prospects for the world's most densely populated country. Intergovernmental Panel on Climate Change (IPCC) in 2007 forecasted that a mere 1 meter rise in sea level will inundate 20 percent of its landmass and thus much of the coastal regions and its agricultural systems will be lost. If business as usual continues, then by the year 2050, Bangladesh's rice and wheat productivity will decline by 8 percent and 32 percent respectively.

Carbon dioxide (CO_2) is the primary greenhouse gas that contributes to climate change. Bangladesh like other developing countries is becoming increasingly industrialized and modernized. Therefore, it is not a surprise that its CO_2 emissions are on an upward trend. It is observed that CO_2 emissions have more than doubled from 2000 to 2010 (Figure 2).

Bangladesh is also experiencing rise in another major greenhouse gas, nitrous oxide. According to the World Development Indicators of World Bank, total nitrous oxide emissions in 2000 was 19614.2 kilo tons. A decade later, emissions rose to 26159.6 kilo tons.

Climate change has an impact on culture, tradition and overall livelihood throughout the country. River bank erosion, floods, droughts, etc. are accountable for the suffering of farmers and fishermen and their migration. As an agricultural country, impact on farmers and their production has a great impact on the country's economy. Food security under a changing climate has become a great challenge for Bangladesh. The food production is decreasing which maybe to some extent related to the changing climate.

Bhutan

Environment is an important issue in the development of the Bhutanese nation as it is one of the four pillars of Gross National Happiness (GNH) philosophy of development. The country has pursued a cautious policy in this direction and has deliberately made conscious decisions not to sacrifice its environment on the altar of revenue or GDP. The country has made a voluntary international commitment to remain carbon neutral for all times to come and the constitution mandates that the country should maintain 60 percent forest coverage for all time. The present forest coverage is more than what the constitution prescribes (70 percent) and the protected area is 51.32 percent.

[4] Bhutan falls within the IPCC's South Asia sub-continental region which stretches to latitude 50°N. Averaged temperature and precipitation changes were observed using datasets of 21 global models. For the A1B scenario3, the models show a median increase of 3.3°C by 2100, with increases in daily minimum and maximum temperatures. The largest warming will take place at higher altitudes, for example

over the Himalayas, as surface albedo will decrease with the melting of snow and ice. A 5 percent decrease in precipitation is also projected in the dry season, and an 11 percent increase for the rest of the year. The current evidences of climate change in Bhutan are primarily extreme weather events, but impacts from incremental changes are likely to be evident in the coming decades. The impacts of climate change depend primarily on the people's vulnerability, which is determined by factors including poverty, remoteness, governance, capacity and awareness, natural resources management and other factors that pose challenges to achieving national development targets[5]. Currently climate-related impacts are observed on the glaciers and attention is on the risk of glacial lake outburst floods (GLOF). Future climate change will have potential impacts on development and livelihoods in Bhutan. The impacts of climate change are likely to be mainly felt in the agriculture, hydropower, infrastructure (including roads and urban services), and health sectors.

In the eleventh Five Year Plan which started in July 2013, the main objective is based on "Self-reliance and Inclusive Green Socio-Economic Development" with a focus to mainstream gender, environment, climate change, disaster risk management and poverty both for the central level agencies and local governments. Hence there is a deliberate move to integrate these cross cutting issues in the overall planning and development.

Maldives

Almost 80 percent of Maldives population are within 300m from the shore, living on an island that is hardly 1.5m above mean sea level making them extremely vulnerable to storm surges and flooding. Most of the basic facilities like houses, agricultural land, hospitals, power plants, schools and buildings are located very close to the shore as only 10 out of the 187 inhabited islands are bigger than 2.5km^2.

National Policies are available to address climate related action, resource efficiency and raw materials. Several policies are not implemented effectively due to lack of expertise and resources. Some initiatives are already in place to protect the communities. Planting trees and protecting the trees along the shoreline of many Maldives islands has helped reduce erosion. It also protects the island from storm surges. Mining of sand from the beaches and lagoons surrounding the islands is prohibited as sand mining aggravates erosion. Government has designated sites for sand mining. Coral mining is banned throughout the country. Imported aggregates are used for construction. Mangroves also helps protect communities from climate change impacts. Mangroves acts as sumps absorbing flood waters during storm surges and heavy rain. It is also rich in biological diversity and provides suitable environments for both marine and terrestrial organisms to breed. Campaigns by both government and private sector have helped create some awareness among public to protect critical ecosystems. Some mangroves have been designated as protected areas.

Maldives has signed 14 conventions related to environment which shows Maldives concern to climate actions and as a stimulus of these, in June 2012, at the UN Conference on Sustainable Development, RIO+20 meeting in Rio de Janeiro, Brazil, the President of Maldives announced the intention to declare the whole of Maldives as a UNESCO Biosphere Reserve. This announcement was inspired by the success achieved in designating Baa Atoll as the first UNESCO Biosphere Reserve in Maldives. Environmental threats area in Maldives have been identified in the Biosphere reserve implementation Plan 2013-2017 released in January 2013. Maldives has pledge to become carbon neutral by 2020 and declared carbon neutral aspirations such as, ensure 50 percent of electricity generated from renewable sources by 2015, targeting to achieve 50 percent reduction in GHG emissions in the energy sector compared to 2000 levels, reaching a saving of 7.5 percent of final energy consumption over 10 years until 2020.

Nepal

Nepal is known as one of the climatically vulnerable countries in the world due to its fragility, climate sensitive ecosystem and socioeconomic circumstances. IPCC (2007) report states that climate change is already having discernable impacts, particularly in least developed countries like Nepal which are more vulnerable from the impacts because of their inability to cope with these climatic shocks. It is expected to have serious environmental, economic, and social impacts in South Asia in particular, where rural farmers whose livelihoods depend on the use of natural resources are likely to bear the brunt of its adverse impacts (ICIMOD 2009). The region is also confronted with issues like poverty, environmental degradation, depletion in natural resources, shrinking of water resources and desertification. Climatic variability in this fragile ecosystem and nature based livelihood system of the rural communities has further threatened the livelihood of the local people. Climate change may shave off as much as 2.2 percent from Nepal's gross domestic product (GDP) per year by 2050, with chances of losses widening to a whopping 9.9 percent by 2100, if concrete mitigation and adaption measures are not taken, a latest Asian Development Bank report titled "Assessing the Cost of Climate Change and Adaption in South Asia" (ADB 2014) has indicated. Nepal's total emission of CO_2 was four megatons, a negligible proportion of the global total of 29,837 megatons, and its per capita emissions were about 0.1 tonnes, almost negligible compared to the global average of 4.5 tonnes (UNDP, 2013) (Nepal Millennium Development Goals Progress Report 2013). Nepal is an agro-based country and its biggest pie in GDP comes from agricultural production. However, it imports huge quantity of rice, wheat, vegetables, and fruits mainly, from India.

Nepal's natural resources do not have any competition with neighbouring countries. Therefore, it needs to reduce excess exploitation of these to maintain the balance of the ecosystem. Nepal, along with over 150 other countries, signed the United Nations Framework Convention

Figure 3: Climate change impacts in Nepal (Source: USAID)

> Although countries have been taking initiatives to overcome the impacts of climate change, a lot of work still remains to be done. The study has shown that policies have been in place but the institutional mechanisms needs to be further strengthened to effectively implement the existing policies

on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992. With aid from different donor agencies and bilateral organizations, Nepal has successfully prepared a Climate Change Policy, National Adaptation Programme of Actions (NAPA), Local Adaptation Plan of Action (LAPA), and REDD Readiness Preparedness Proposal (REDD RPP). Apart from policy documents prepared and promulgated by the Climate Change Division of the Ministry of Environment, various allied departments have drafted and implemented policies, Acts, and regulations associated with climate change issues both mitigation and adaptation. The main goal of climate change policy is to improve livelihoods by mitigating and adapting to the adverse impacts of climate change, adopting a low-carbon emissions socio-economic development path and supporting and collaborating in the spirits of country's commitments to national and international agreements. The policies seem to be bottom-up planning and implementation. It has provision to allocate 80 percent of the total budget in the local level adaptation program and activities to address the poor and vulnerable communities. But existing mechanisms, intuitional arrangement, and capacity of the service provider have been found to be poor and questionable to achieve goals and objectives of climate change policy.

Pakistan

Geographically, Pakistan has varied landscape and environment like mountains with glaciers, forests, rivers and deserts. This makes the country a perfect candidate for all type of natural disasters like avalanche, floods, droughts, etc. Pakistan has been placed among the high-risk countries on the bases of Global Climate Index. It ranks 16th on the Climate Change Vulnerability Index (CCVI) by Maple Croft, jumping up 13 positions in one year. German watch also places Pakistan as the "most affected" country for 2010 and in top 10 for 1990-2010 by climatic changes. Climate change is costing the economy $14 billion a year, which is almost 5 percent of the GDP. According to the Asian Development Bank, more than 10 million people have been displaced in Pakistan over the last 2 years due to these climate related disasters. Environmental degradation costs the country at least 6 percent of GDP resulting in illnesses and premature mortality caused by air pollution, inadequate and unsatisfactory water supply, and lost livelihoods due to reduced agricultural productivity and direct contact with fertilizers and pesticides. These burdens are compounded by problems such as hazardous solid waste, the loss of forest cover and desertification, soil erosion and loss in soil fertility. Pakistan is placed at 80th position out of 122 nations based on drinking water. Pakistan, which is an already resource stressed country, has been crippled by the process of global warming, as the blatant floods and droughts continue to wreck the country's economy. More than 10 million people have been displaced over the years, the agricultural land lies barren and financial losses have been estimated at $2 billion.

Pakistan has a number of agencies working at the federal and provincial levels (e.g. Pakistan Meteorological Department, Pakistan Environmental Protection Agencies, among others) to work towards understanding the current environmental status, through installing station at Quetta to monitor Ozone layer, geomagnetic variation and global atmospheric watch, which however require to be extended to other locations across the country to improve data collection.

No early warning system and evacuation mechanism exist for floods in Pakistan that results in the loss of lives and livelihoods. The authority can provide reliable information about the floods 2 or 3 hours before, which is not enough for evacuation. Population encroachment to flood plains is routinely observed, which requires remote monitoring systems like the radar technologies that require the government attention and financial support.

The government is committed to mitigate disasters related to climate change, through establishing Climate Change Cell at the provincial level to conduct research, improve service delivery and raise awareness against the climate change for early preparedness and emergency management. Other initiatives includes signing of the Kyoto Protocol with UN and being a signatory of UNFCCC. The federal government has established National Disaster Management Authority (NDMA) and the associated authorities and units at the provincial and district level, respectively, to formulate policies and ensure pre- and post-disaster management mechanisms. Pakistan contributes a tiny to total global greenhouse gas emissions (largely due to use of natural gas as a source of energy); the relative GHG contribution of energy is 51 percent, agriculture sector contribution is 39 percent, industrial process is 6 percent, land use and forestry is 3 percent and waste being 1 percent. The government has launched projects titled Tsunami Trees, which highlights the government efforts to create green society in order to increase Ozone layer to reduce GHG emission.

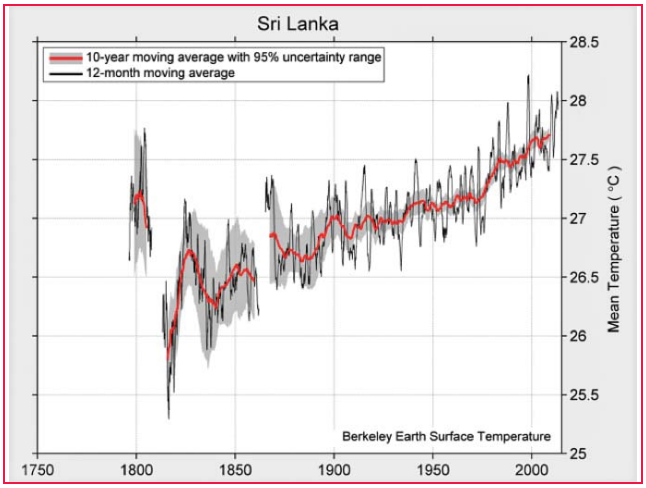

Figure 4: Graph showing the mean temperature change in Sri Lanka

Sri Lanka

Being a developing island nation subject to tropical climate patterns, Sri Lanka is highly vulnerable to climate change impacts. Extreme weather events such as high intensity rainfall followed by flash floods and landslides, and extended dry periods resulting in water scarcity are now becoming common occurrences in Sri Lanka. Any adverse changes in already volatile weather patterns are likely to impact adversely on the socio-economic activities in the country. Therefore urgent action is necessary to take adaptive measures to build resilience of the country to face the adverse impacts of climate change. While taking adaptive measures as the priority, Sri Lanka is also trying to minimize the greenhouse gas emissions within the framework of sustainable development and principles enshrined in the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (KP). Sri Lanka has to address these challenges considering the need for increasing investment for environment friendly infrastructure development, increased volatility to energy markets, problems related to food security, trade, commerce and industrial development together with the climate change challenges.

The increased intensity and frequency of natural disasters and its cost in terms of human, physical, financial and environmental losses have a significant impact on growth in Sri Lanka. If appropriate mitigation and adaptive strategies are not implemented, natural disasters and climate change can have considerable implications

on poverty and inequality. The impacts of climate change also depend on a host of varying factors such as, segments of society; income groups; livelihood categories; and geographical regions, etc. Further, the impacts are becoming more significant for vulnerable groups, with increased intensity and frequency of disaster events as well as changes in rainfall pattern. Therefore, adopting an inclusive strategy for managing disasters is critical.

Conclusions

The study has revealed that there has been considerable impacts from climate change in South Asia. Although countries have been taking initiatives to overcome the impacts of climate change, a lot of work still remains to be done. The study has shown that policies have been in place but the institutional mechanisms needs to be further strengthened to effectively implement the existing policies. Efforts to tackle environmental threats have to be made both at the national and international levels while the use of available resources have to be managed in a way that it is efficiently and effectively utilized. The review further showed the concerns of the countries and the measures and initiatives that they have undertaken to minimize such risks.

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Endnote

[1] South Asian Regional Study on Climate Change Impacts and Adaptation: Implications for Human Development

[2] Socio-Economic Impacts of Climate Change in Afghanistan (DFID)

[3] http://berkeleyearth.lbl.gov/regions/Afghanistan

[4] Strategizing Climate Change for Bhutan. National Environment Commission Royal Government of Bhutan January 2009

[5] Source: Climate Change Screening of Danish Development Assistance with Bhutan, May 2008

Galileo update

Qualcomm supports Galileo

Qualcomm is supporting the Galileo GNSS with its chipsets and Snapdragon mobile processors. Until now Qualcomm's hardware support for Galileo was in selected chipsets only.

The Qualcomm IZat location services platform will connect with up to six satellite constellations which means more than 80 different satellites can be used when calculating global position for navigation or location-based applications.

This is intended to help manufacturers in implementing an important component of the European eCall mandate ahead of the March 2018 deadline.

Galileo will be supported on smartphones and compute devices with the appropriate software release on Snapdragon 820, 652, 650, 625, 617, and 435 processors, automotive infotainment solutions utilizing Snapdragon 820A, and telematics and IoT solutions with Snapdragon X16, X12, X7, and X5 LTE Modems, and 9×15 and MDM6x00 modems. *www.electronicsweekly.com*

Four-satellite Galileo Ariane 5 dispenser in place

Following rigorous testing in France and Germany, a new type of dispenser designed to carry four navigation satellites into orbit at once is now in French Guiana, in place for Galileo's first Ariane 5 launch later this year.

The dispenser is an essential element of launch success, with a double role to play. It first must hold the quartet of satellites securely in place during the stresses of liftoff, and then the nearly four-hour long flight to medium-Earth orbit.

Then, once the Ariane 5 EPS upper stage reaches its target altitude of 23,222 kilometers, the dispenser will release the four Galileo satellites using a pyrotechnic release system triggered by separate igniters, each one firing half a second after the other.

The separated satellites are then pushed away from the dispenser in separate directions using a spring-based distancing system.

The 447-kilogram dispenser, designed by Airbus Defence and Space, must support a satellite mass of 738 kilograms each – nearly three tons total.

Made from a combination of metal and composite materials for maximum stiffness, the dispenser has undergone very comprehensive testing at Airbus Defence and Space near Bordeaux, France, and the IABG testing centre in Ottobrunn, Germany – using both Galileo engineering models and an actual flight satellite, including fit, shock and separation testing.

GSA sets up Galileo Reference Center

Officials signed an agreement recently to build a Galileo Reference Center in Noordwijk, the Netherlands, just across the road from The European Space Agency's European Space Research and Technology Center (ESA/ESTEC).

The Galileo Reference Center (GRC), to be administered by the European GNSS Agency (GSA), will monitor and assess the quality of the delivery of Galileo services, i.e., the performance of the Galileo Service Operator. The GSA is currently selecting said service operator through an arduous tender process.

At a Glance

- FARO releases PointSense and VirtuSurv 17.0 Point Cloud tools
- Autodesk, Trimble sign agreement to increase interoperability
- ESA appoints Josef Aschbacher as new Director of Earth Observation programs
- GeoComm, Micello form partnership to incorporate Micello indoor maps
- GovPilot partners with Pictometry to expand horizon in GIS mapping
- SimActive acquires Correlator3D to process large datasets of thermal imagery
- SuperSurv Helps French Environment Department in Alsace
- CompassCom and Latitude Geographics Announce Application Partnership
- URISA Joins the NextGen911 NOW Coalition as a Partner Organization
- EuroGeographics signs production management agreement with BKG Germany
- Hexagon Safety & Infrastructure Unveils Latest Intergraph Computer-Aided Dispatch Software
- Acquisition of Exprodat Consulting Ltd by Getech Group plc
- 3D Laser Mapping launches new multiplatform mapping system
- Esri launches national green infrastructure initiative for planning
- DigitalGlobe signs contract to provide World Imagery Map for ArcGIS platform`

CompassDrone

The CompassFamily of businesses introduces CompassDrone™ to provide airframes, software, services and support to Geospatial Professionals for UAS remote sensing data collection. For industrial drone based Imagery, point cloud or IR data collection projects, CompassDrone™ can match the right airframe and software to get the results to meet your requirements. Purchase your system today to be ready when FAA part 107 announced recently takes effect in late August 2016. *compassdrone.com*

Icaros Releases 4.2.2 of OneButton

Icaros Inc. has announced the release 4.2.2 of OneButton™. The release contains new features and improvements as well as a new flight planning software module.

Icaros developed the OneButton family for geospatial end users to easily and automatically generate precise, fully orthorectified 2D maps and 3D models from frame-based aerial imaging systems. Originally engineered for manned aircraft sensors, the OneButton software has been modified to accommodate the unique collection conditions of UAS. *www.icaros.us.*

Hexagon Geospatial launches Vegetation Health Smart M.Apps

Hexagon Geospatial officially released seven different Vegetation Health Hexagon Smart M.Apps which make use of remote sensing algorithms to identify plant and crop health from a variety of different sensors. Focused on the burgeoning precision agriculture movement and the increasing ubiquity of UAVs or drones, these Smart M.Apps make the power of remote sensing techniques accessible to everyone.

The seven Hexagon Smart M.Apps all focus on different aspects of crop, vegetation, and agriculture health measurement. *http://store.hexagongeospatial.com*

Drone2Map 1.0 for ArcGIS Now Available

Fresh out of beta, Drone2Map for ArcGIS was released by Esri with new features and enhancements. The desktop app allows people to process images from drones and quickly create imagery products for mapping, analysis, and sharing across the ArcGIS platform. It offers in-field rapid imagery processing that allows the pilot to confirm that the drone's flight has captured imagery of the full area of interest, reducing the need for costly return trips to the field. The app detects camera and sensor parameters, then intelligently applies appropriate defaults. *esri.com/drone2map.*

FAA lays down rules for flying small drones

The Department of Transportation (DOT) and the Federal Aviation Administration (FAA) announced the final Small UAS Rule, effective in late August 2016. The New Small UAS Rule (107) includes all pilot and operating rules for drones weighing less than 55 lbs, which are conducting non-hobbyist operations. Drones weighing between 0.55 lbs. and 55 lbs. must also be registered with FAA.

The rule's provisions are designed to minimize risks to other aircraft and people and property on the ground. The regulations require pilots to keep an unmanned aircraft within visual line of sight (VLOS). Operations must take place during daylight hours, or within the hours of civil twilight (instantly before sunrise and after sunset) if the drone has anti-collision lights. The new regulations also address height and speed restrictions and other operational limits, such as prohibiting flights over unprotected people on the ground who aren't directly participating in the UAS operation. Under the final rule, the person flying a drone must be of least 16 years old and have a remote pilot certificate with a small UAS rating, or be directly supervised by someone with such a certificate.

UK adopts new drone policy for campus safety

UK has adopted a new drone policy for the safety of the university community.

According to UKNow, UK announced the policy regarding drone and unmanned aircraft systems. Hobbyist and recreational drone use is prohibited on campus and to fly drones with the purposes of research or instruction, the operator must have consent from UK's event management office. The policy further prohibits recreational drone and UAS use on all UK-owned property, which includes the main campus, farms the university owns and operates and Coldstream Research Park. These objects must also not fly within five miles of helipads or airports; there is one heliport at UK HealthCare's A.B. Chandler Hospital. Use of drones and UAS near Commonwealth Stadium is specifically prohibited in the policy.

All commercial drones and UAS must be registered with the Federal Aviation Administration before seeking permission from UK to fly the object. Users of commercial drones and UAS must apply for permission from UK at least seven days before their event. *uknow.uky.edu*

Cyprus outlines new laws related to drones

According to the Civil Aviation Department guidelines of Cyprus, any violation of the law on drones constitutes and offence. Due to the current increased interest in unmanned aircraft (drones in Cyprus) flying activity, the Department said that owners and users of drones are required to comply with the provisions of the applicable legislation. Violation of the law constitutes an offence and offenders will be liable to penalties.

All remotely piloted and autonomous aircraft from the small consumer devices used for recreation, to large aircraft used for other purposes, are subject to the provisions of the above legislation which aims to the safety of flights and the protection of persons and property on the ground. *www.mcw.gov.cy/dca*

Bentley and Shell Announce Global Framework Agreement

Bentley Systems has announced a new Global Framework Agreement with Shell. The agreement serves to improve Shells capital project construction execution through automated 4D/5D construction management solutions provided by Bentley as a managed service. The solution, based on Bentleys *ProjectWise ConstructSim*, will be deployed as part of Shells ProjectVantage program. This innovative offering, which simplifies work packaging for engineering, construction, and installation, adheres to the Construction Industry Institutes (CIIs) Advanced Work Packaging (AWP) methodology.

ADM launches submittal of roads layout data standards

The Abu Dhabi City Municipality has compiled and officially launched the submittal of roads layout data standards via the GIS. This e-service comes as part of the vision of both the Department of Municipal Affairs and Transport, and the Abu Dhabi City Municipality, aimed at upgrading services, and expanding e-services on regular basis. It also comes in line with a sustainable drive to meet development needs of customers, realise their aspirations, and achieve the highest customers satisfaction rating.

The team of the Municipal Infrastructure and Assets Sector in cooperation with the Spatial Data Division has developed this service which enables contractors and consultants to submit layouts data via the GIS. The Municipality reviewed the data compilation mechanism and data submittal methods as per the new standards, in addition to the quality control tool designed to carry out the process of auditing and issuing reports to avoid errors. *www.zawya.com*

Shipments of cellular M2M modules reached 96.0 million units in 2015

Berg Insight estimates that global cellular M2M module shipments increased by 19.4 percent in 2015 to a new record level of 96.0 million. A somewhat higher growth rate is expected for 2016. Until 2020, shipments of cellular M2M devices are forecasted to grow at a compound annual growth rate (CAGR) of 21.7 percent to reach 256.0 million units. East Asia, North America and Western Europe were the main geographical markets in 2015, accounting for around 75 percent of the total demand.

Samsung challenges Fitbit with $180 fitness tracker with GPS

Samsung is unveiling a new fitness tracker that aims to undercut gadgets from market leader Fitbit. Beyond offering all-day step counting and automatic sleep tracking, the $180 Gear Fit2 comes with GPS sensors for more accurate measuring of distance and pacing for runners and cyclists. GPS is typically limited to higher-end devices, such as the Fitbit Surge and the Microsoft Band 2. *http://www.theledger.com*

Sierra Wireless and OriginGPS Partnership

Sierra Wireless and OriginGPS, a leading manufacturer of miniature GNSS modules, have announced a partnership to deliver the industry's smallest integrated 2G to 4G cellular and GNSS modules solution. It offers a miniaturized footprint that is one third smaller than other solutions and is targeted at the growing IoT devices market. *http://iotbusinessnews.com*

HERE, automotive companies come together on ITS

Following the success of months-long discussions with the international automotive and mapping companies in Europe, the U.S. and Asia, location cloud company, HERE has submitted a universal data format called SENSORIS to ERTICO – ITS Europe. It is a European public/private partnership for intelligent transport systems, which has agreed to continue as an Innovation Platform to evolve a standardized interface specification for broadly using across the automotive industry.

To date, 11 major automotive and supplier companies have already joined the SENSORIS Innovation Platform now under the coordination of ERTICO. SENSORIS was initiated by HERE in June 2015 when the company published the first open specification for how vehicle sensor data gathered by connected cars could be sent to the cloud for processing and analysis. Currently, vehicle sensor data exists in multiple different formats across automakers.

MapmyIndia launches DriveMate

MapmyIndia has announced the launch of DriveMate, its next-generation Connected Car IoT (Internet of Things) technology. A simple yet powerful plug-and-play device, it offers real-time monitoring of your car and fleet of vehicles from wherever you are. Combining this with MapmyIndia's and location technologies, it continuously and securely monitors, records and transmits the car's live (exact) location down to building-level detail etc. *http://www.mapmyindia.com*

Subaru to equip its cars with Magellan SmartGPS

Japanese automobile manufacturer Subaru will install Magellan SmartGPS navigation systems in its cars, according to company president Billy Ho. According to Ho, cars equipped with Magellan SmartGPS navigation systems will be available in Japan from the third quarter of this year. Magellan is a brand of GPS navigation products operated by Mitac's US-based subsidiary Mitac Digital.

SCIO briefing on China's BeiDou Navigation Satellite System

The State Council Information Office (SCIO), China has released the White Paper on China's BeiDou Navigation Satellite System. This white paper is the 100th one released by the SCIO according to Mr. Ran Chengqi, director of China's Satellite Navigation System Management Office and spokesperson of the BeiDou system.

The white paper provides a comprehensive picture of the system's development, explains its concepts, showcases its achievements and highlights its future. Containing around 5,800 words, the paper consists of three parts, a preface, main text and conclusion.

The white paper reiterates that "the BDS is developed by China and dedicated to the world" and under the principles of "independence, openness, compatibility and gradualness," China will provide continuous, stable and reliable services for global users. It also stresses that China will actively push forward international cooperation related to the BDS, work with all other countries, regions and international organizations to promote global satellite navigation development, and help the BDS to better serve the world and benefit mankind.

Korean KIWI PLUS' smartwatch relies on technology by u-blox

KIWI PLUS has launched a new children's smartwatch developed in collaboration with u-blox. LINE Kids Watch is a tiny and colorful wearable with LINE emojis functioning as an Android-based smartwatch. It enables precise tracking of the whereabouts of children, while also offering educational and interactive content.

LINE Kids Watch uses KIWI PLUS' own IOT platform for wearables, KIWI Edge. Designed with a simple LCD screen for one-touch calling, it also provides real-time accurate location tracking and convenient safety zone setting. *https://electronicsnews.com.au*

Arqiva to trial eLoran timing

Arqiva, the communications infrastructure company is trialling eLoran timing technology – which delivers precise UTC traceable time – from the Anthorn transmitter in Cumbria. Chronos Technology is running the trial through its Innovate UK – the UK's Innovation Agency - grant supported research project "GAUL".

As a provider of broadcast, satellite and telecommunications services, Arqiva is dependent on accurate time and frequency, so by trialling the eLoran technology alongside its existing GPS, it will be able to monitor any time and frequency inaccuracies that can occur as a result of external factors, such as local interference, jamming, spoofing and space weather events. *www.arqiva.com*

Russia to present Era-Glonass road accident response system in China

Russia's State Space Corporation Roscosmos and JSC Glonass will present in China in the coming months their Era-Glonass road accident emergency response system. Russian Deputy Prime Minister Dmitry Rogozin told reporters after a meeting of the Russian-Chinese intergovernmental commission on the preparation of regular meetings of the heads of government that the parties may also establish joint production of sensors for this system. *http://tass.ru/en/science/883495*

China's Beidou navigation network grows with successful launch

A Chinese Long March 3C rocket boosted a fresh satellite into orbit to join the country's Beidou navigation system, deploying the craft into an elliptical orbit ranging more than 22,000 miles (35,700 kilometers) above Earth.

The new navigation platform will power its way into a circular geosynchronous orbit over the equator in the coming weeks, adding to China's independent satellite network beaming positioning and timing signals to users around the world. *http://spaceflightnow.com*

Soyuz launches GLONASS-M No. 53 satellite

The GLONASS-M No. 53 satellite was shipped to Plesetsk on April 22, 2016; however, in the first half of May, the launch was postponed from May 21 to May 29. Liftoff of a Soyuz-2-1b/ Fregat-M vehicle was scheduled for May 29, 2016, at 11:44:37 Moscow Time (08:44 GMT, 4:44 a.m. EDT) from Pad 4 at Site 43 in Plesetsk.

The rocket carried a GLONASS-M-53 (a.k.a. Uragan-M No. 753) navigation satellite for Russia's GLONASS navigation network.

According to Roskosmos, the launch took place at 11:44 Moscow Time and the payload section separated from the third stage of the Soyuz rocket nine minutes into the flight. The Fregat upper stage then initiated the delivery of the satellite to its prescribed orbit, with the separation of the payload scheduled at 15:16 Moscow Time (12:16 GMT, 8:16 a.m. EDT), Roskosmos said.

The Russian Ministry of Defense also announced that the GLONASS-M No. 53 had established communications with ground control and all systems onboard the satellite had functioned properly. The official Russian monitoring service, SKDM, also listed the launch of GLONASS-M No. 753 as Kosmos-2516 and registered the liftoff time as 11:44:35 Moscow Time.

u-blox launches new firmware for ADR GNSS modules

u-blox has released its fourth generation firmware for 3D Automotive Dead Reckoning (ADR) GNSS modules and chip sets. Designed for first mount or aftermarket road vehicle applications, such as in-car navigation, infotainment systems, telematics units and fleet management, the upgraded GNSS receiver now offers real-time continuous navigation output with an update rate of 20Hz, enabling low latency for applications such as interactive head-up displays.

BMC seeks nod for tech feasibility study of GMLR

After being denied permission to conduct a a geo-technical investigation to check the feasibility of constructing a tunnel under Mumbai's Sanjay Gandhi National Park (SGNP) for the proposed Goregaon-Mulund Link Road (GMLR) project by SGNP authorities, the BMC has shot off a letter to the principal secretary(forests) informing him about the need to conduct the same and why remote-sensing investigation will not help.

Officials from the civic body said that they had got IIT Bombay to study whether the data through remote sensing investigations would help them arrive at a conclusion.

While conducting a geo- technical survey, a hollow pipe will percolate and help the authorities decide the soil strata. While the BMC is determined to conduct a geo-technical survey, authorities at SGNP had asked the civic body to procure the required data by undertaking remote sensing. This is because authorities at SGNP fear that conducting a geo-technical survey might affect the natural habitat around the national park. Additional municipal commissioner Dr Sanjay Mukherjee confirmed having communicated to the state principal secretary (forests) about the need for the geo-technical survey, especially after IIT having submitted its report on the same. *http://timesofindia.indiatimes.com*

Lapan launches third-generation remote sensing satellite

The Indonesian National Institute of Aeronautics and Space (Lapan) has launched the third-generation LAPAN-A3/LAPAN-IPB satellite witnessed by Vice President Jusuf Kalla at the institutes Aviation Technology Center. "The satellite is on an experimental remote sensing mission to monitor food resources," Lapans Head of Public Relations, Jasyanto, revealed. The LAPAN-A3/LAPAN-IPB satellite was launched from Sriharikota, India. "The results can also be used to evaluate the governments programs in the maritime sector," he emphasized. The remote sensing satellite has a four-band multi-spectral imaging camera, with a resolution of 18 meters and a swath width of 100 kilometers. *http://www.antaranews.com*

ISRO launches PSLV-C34 carrying record 20 satellites

The Indian Space Research Organisation (ISRO) recently launched a record 20 satellites from Satish Dhawan Space Centre in Andhra Pradesh's Sriharikota. PSLV-C34 is being used to carry the satellites, including India's earth observation spacecraft Cartosat-2, from the second launch pad of the space centre. The 320-tonne PSLV C-34 carried 17 foreign small satellites from Canada, Indonesia, Germany and the US but the main passenger was a 727-kg Indian earth observation satellite called Cartosat-2, which can take high-resolution images. The launch also placed into orbit two Indian academic community-built satellites, Sathyabhamasat and Swayam.

Terra Bella plans to launch more satellite with ISRO

After successfully launching the payload of 20 satellites, Google subsidiary, Terra Bella is negotiating with ISRO to launch more of their satellites. Among various other satellites that were launched by ISRO recently, a 110 kg SkySat Gen2-1 belonging to Terra Bella and 12 of Planet Lab's Dove Satellites, each weighing 4.7 kg, were placed in orbit by PSLV-C34 mission.

SkySat Gen2-1 is a small earth imaging satellite capable of capturing sub-metre resolution images and high definition video. The Planet Labs Dove Satellites (FLock-2P) are also earth imaging satellites. Both the companies have plans for a series of launches and ISRO is in touch with them.

DigitalGlobe gets advanced analytics services contract worth $55 mn

DigitalGlobe has been awarded with and advanced analytics services contract by the U.S. Defense Intelligence Agency. The contract was given at a ceiling value of $55 million. DigitalGlobe provides earth-imagery products and services sourced from own satellite constellation and third-party providers to the United States and to others internationally.

MobileMapper 50 combines Smartphone Design

Spectra Precision has announced its new MobileMapper 50 GNSS handheld device for simple GIS data collection or for use as a data controller for Spectra Precision SP60 and SP80 GNSS receivers. Available with an Android OS, the MobileMapper 50 combines smartphone capabilities with a ruggedized design to improve positioning accuracy. Spectra Precision also introduced two new software applications: an Android OS version of MobileMapper Field software for GIS professionals and Spectra Precision Survey Mobile software to control SP60 and SP80 GNSS receivers.

The MobileMapper 50 is available in two versions: both with Android OS and Wi-Fi, and with optional 4G LTE cellular module. The rugged, smartphone-like device is IP67 rated, thin and lightweight. It supports SBABS, GPS, GLONASS and BeiDou constellations as well as post processing for improved accuracy. *www.spectraprecision.com*

Spirent launches satellite navigation test system for multi-GNSS testing

Spirent Communications has launched its GSS7000 series satellite navigation test system for flexible multi-frequency multi-GNSS testing. The GSS7000 provides multi-frequency testing, with a modular approach to enable this new precision GNSS simulation system to expand with users' needs. The new system suits 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.

Septentrio for Altus NR2 and PinPoint-GIS upgraded

Septentrio is rolling out new enhancements for its Altus NR2 GNSS receivers and PinPoint-GIS software optimized for the new version of Collector for ArcGIS. Septentrio's product suite for drone surveys includes the AsteRx-m UAS GNSS receiver, its companion GeoTagZ software utility and the Altus NR2 RTK base station. The AsteRx-m UAS board is about the size

of a credit card, and has been designed for easy integration into the drone's autopilot and camera. *www.septentrio.com*

VULCANO weapon system to fire with NavFireTM GPS technology

Operating weapon systems in a harsh dynamic environment requires rapid start-up and high accuracy to hit the designated target and dramatically reduce the probability of collateral damages. With that in mind, Rockwell Collins is bringing its NavFireTM Precision Positioning Service (PPS) GPS to Leonardo-Finmeccanica's VULCANO family for naval and artillery applications.

Derived from the field-proven 12-channel NavFire Precise Positioning Service GPS receiver, Rockwell Collins' NavStrike military GPS offers high performance GPS for tightly coupled GPS/INS integrations. The NavFire GPS includes the Selective Availability Anti-Spoofing Module (SAASM) to allow decryption of precision GPS observations through over-the-air rekeying. The positioning information is used by the guidance system of the projectile. *www.rockwellcollins.com*

Gamma 2 Robotics launches Fully Autonomous Security Robot

Gamma 2 Robotics, makers of the world's first artificially intelligent autonomous security robots, launched RAMSEE, a new security patrol robot, at HxGN LIVE, Hexagon's international conference. The launch at HxGN LIVE is part of a new partnership with Hexagon Safety & Infrastructure. RAMSEE is a physical presence that patrols autonomously without supervision and provides real-time data on intruders, motion, heat, fire, smoke, gas and more. As a human-machine interface it creates a powerful force multiplier.

By using RAMSEE as a force multiplier, safety and security can be delivered at a lower cost with greater reliability.

While useful in their own right, the value of robots and other mobile sensor platforms increases when integrated with other safety and security assets, such as video surveillance systems, access control systems, building automation systems and others, into command-and-control software for a comprehensive solution for threat detection, assessment and response. *hexagon.com*

Hemisphere GNSS Announces New Eclipse Positioning OEM Boards

Hemisphere GNSS announces the Eclipse™ P326 and P327, first in a line of new and refreshed, low-power, high-precision, position and heading OEM boards – the latest addition to the Eclipse series of products. The multi-frequency, multi-GNSS Eclipse P326 and P327 are based on an innovative platform that integrates L-band and receives Atlas ® GNSS corrections on a single small board. Designed with this new platform, the overall cost, size, weight, and power consumption of the P326 and P327 are significantly reduced.

The P326 and P327 support 394 channels and are the first truly scalable board solutions that offer centimeter-level accuracy in either single-frequency or full performance multi-frequency, multi-GNSS, Atlas-capable mode.

Ms. Jennifer Keenan, Product Marketing Manager at Hemisphere GNSS further added to the above in an interaction with Coordinates…

Whats new with Eclipse™ P326 and P327 positioning OEM boards?

The all new Eclipse™ P326 and P327 positioning OEM boards include all signal tracking for the most reliable and robust solution, integrated L-band enabling low-cost system integration and Atlas® GNSS Global Corrections with 4 cm level accuracy worldwide, and efficient power management system 1W GPS L1.

What are the different applications Eclipse™ P326 and P327 best suited for?

The Eclipse™ P326 and P327 positioning OEM boards can be used in land and marine survey, marine navigation, machine control, seismic monitoring, positive train control, GIS, and unmanned systems.

Please highlight some of the advanced technology features of the new OEM boards?

- Integrated L-band for Atlas® GNSS Global Corrections
- SureFix™: High-fidelity quality indicators for RTK with virtually 100% reliability
- aRTK™: RTK position in the absence of RTK corrections powered by Atlas® GNSS Global Corrections. Mitigates land based intermittent data connectivity
- Tracer™: Maintains position during correction data outages

Seafloor SEABAT T50-P MBES to rental pool

Seafloor Systems has announced the addition of a second SeaBat T50-P to their multibeam echosounder rental pool. Combined with the Portable Sonar Processor the SeaBat T50-P provides unprecedented survey data, providing faster operational surveys and reduced processing time.

Seafloor Systems is known for their turnkey singlebeam and multibeam hydrographic sonar systems, and maintains the largest multibeam echosounder rental pool in the U.S.A. *www.seafloorsystems.com*

Madhya Pradesh Police protect 72 million citizens

The Madhya Pradesh Police, India have implemented an integrated suite of public safety software from Hexagon Safety & Infrastructure for emergency call handling, officer dispatch and incident management in India's second-largest state. Hexagon's solution expands Madhya Pradesh Police's incident response capabilities through map-based views of calls, events and units in the field. Madhya Pradesh Police's solution features Hexagon's Intergraph® Computer-Aided Dispatch (I/CAD), industry-leading

incident management software, including Mobile for Public Safety, a powerful in-vehicle field application for mobile dispatching. The agency's new dispatch system also includes EdgeFrontier®, an integration platform that enables the organization to develop interfaces to IT systems, including dispatch and other systems used by fellow public agencies, without the associated costs of custom development. *www.hexagonsafetyinfrastructure.com*

Trimble Unity Enables SESW to Improve Field Ops

Trimble has announced that Sutton and East Surrey Water (SESW) in the U.K. has implemented the Trimble® Unity™ 3.0 software suite of GIS-centric cloud and mobile applications. Developed to support smart water management, it focuses on workflow and business process improvement with the added benefit of better information for decision making and regulatory compliance.

By deploying cloud-based information management with embedded Esri ArcGIS mapping technology, Trimble Unity provides increased transparency and efficiency in job control and field data collection. In addition to helping streamline the field operations, it also supports SESW collection of site specific information to document compliance. *www.trimble.com*

Harxon releases new GNSS + L-band antenna

Harxon, a high-precision GNSS antenna manufacturer in China, has released a new GNSS + L-band antenna. The GPS1000 receives GPS L1/L2/L5, BDS B1/B2/B3, GLONASS L1/L2, Galileo E1/E2/E5a/E5b and L-band frequencies, which can be used in land survey, marine survey, channel survey, seismic monitoring, bridge survey, container operation and agriculture applications. Customers can use the same antenna for GPS only or dual-constellation applications. *www.harxon.com*

MARK YOUR CALENDAR

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/

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