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Coordinates

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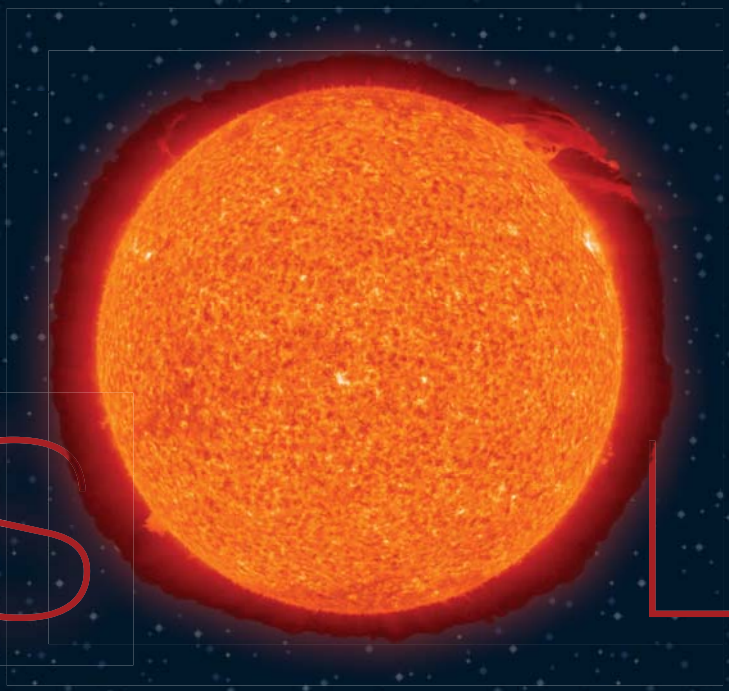
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND



SOLAR Cycle 24 and SBAS impacts

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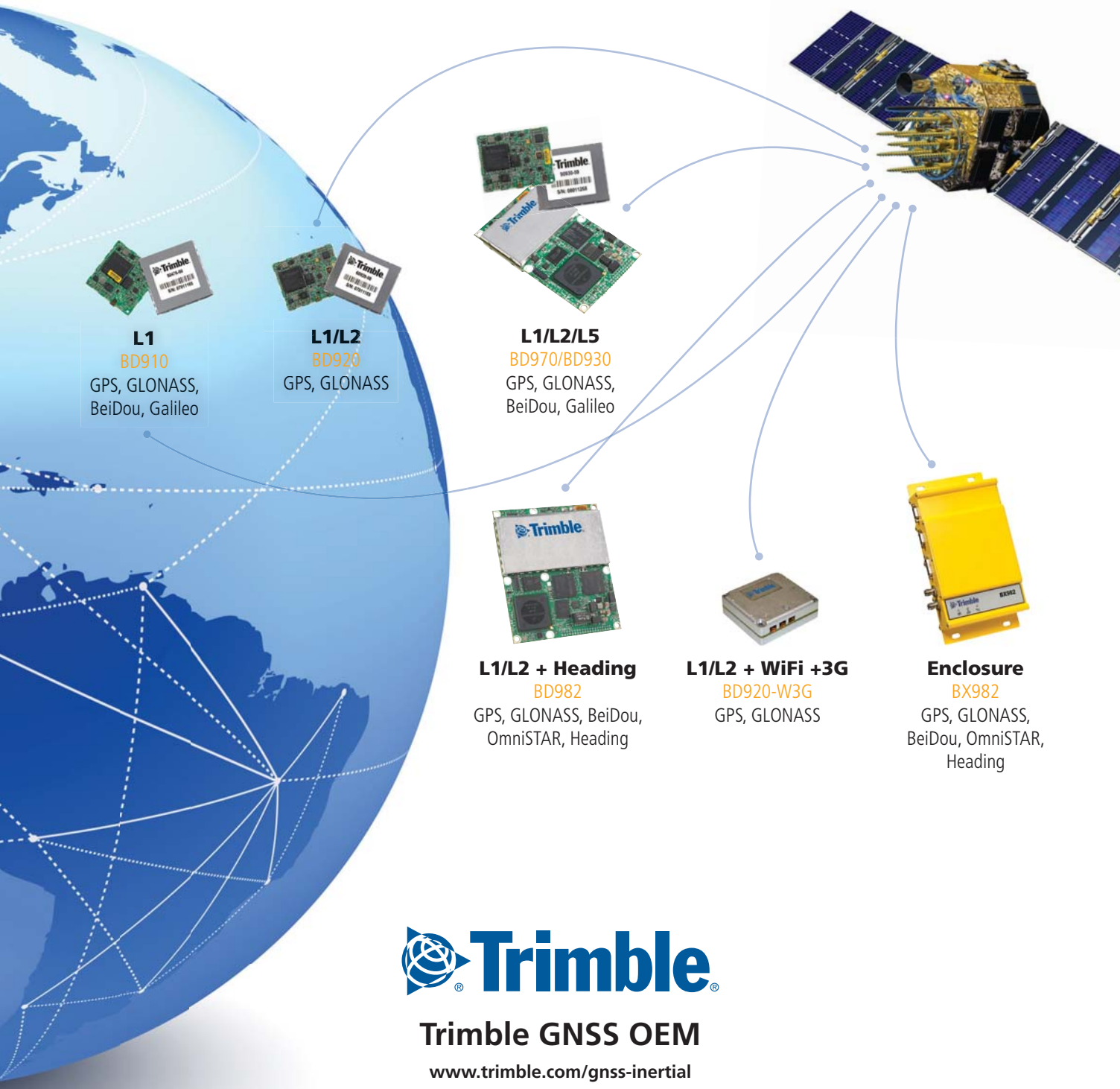

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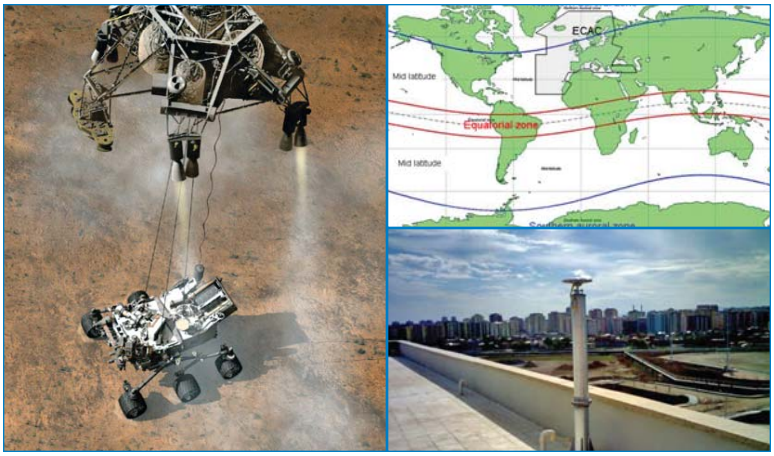

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Maximize Your Uptime

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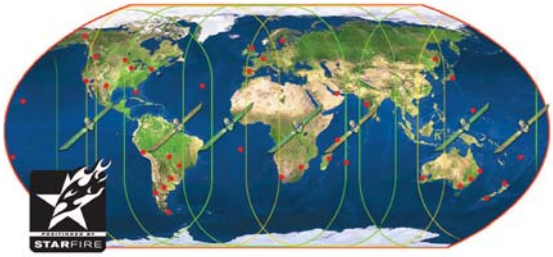

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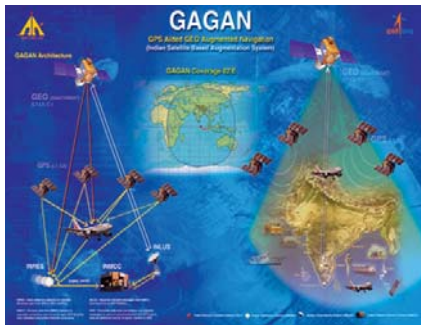

GAGAN certification

Satellite Based Augmentation System gets another boost,

As India joins USA, Japan and Europe to implement the operational SBAS.

GAGAN (GPS Aided GEO Augmented Navigation) achieves
RNP 0.1 certification on December 30, 2013.

Type 2 message will be available in February 2014.

This enables Indian Flight Information Region (FIR) to support satellite based augmentation services for precision navigation by suitably equipped aircraft.

GAGAN has its own advantages and challenges too,

Being the first SBAS in equatorial ionospheric region

There are reasons to cheer by the aviation sector,

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Bal Krishna, Editor
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Solar cycle 24 and SBAS impacts

This paper presents briefly the recent (From Q1 2011 to Q1 2013) evolution of the solar and ionosphere/magnetosphere activities, the data collection network set for Eurocontrol and the CNES Navigation and Time Monitoring Facility, the different observations done on EGNOS and WAAS and some analyses performed to characterize these observations

Norbert Suard
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Navigation expert, Eurocontrol, Brussels, Belgium

Philippe Yaya
Project Manager, CLS, Toulouse, France

The solar activity generates Electromagnetic radiations and Energetic Charged Particles in addition to the Galactic Cosmic Radiation that directly impact the earth magnetosphere and then the ionosphere. There are some regular cyclic activities (a daily one in relation to the sunlight presence, a 27 days one in relation to the Sun rotation, an approximately 11 years one in relation to the Sun Dynamo effect called solar cycle) but there are also solar events such as Sun Flares, Solar Proton Ejections, Coronal Mass Ejection … that create irregularities in particles radiation flow impacting the earth magnetic and ionosphere activities: these impacts are called storms. It has to be known that the delay between the solar event and its impact on earth varies according to its nature:

- The electromagnetic wave impact is quasi immediate.
- The Energetic Particles impact is in a ten minute range.
- A solar wind impact is observable on earth in a 2 or 3 day range delay.

These events have great impact on navigation systems such as sudden changes in the ionosphere delays, increased gradients and/or sudden changes in navigation signal strength often coupled with ionosphere scintillations effect causing navigation signal loss of lock. These impacts observed at the navigation signal reception have then an induced impact in the system applications such as Satellites Based Augmentation Systems (SBAS) in terms of availability and continuity of services.

The risk to face a major magnetosphere event was observed to depend on the time in the solar cycle, the higher risk being in the 2 or 3 years after the peak of the solar activity (on figure 1 -0.5 is the solar cycle start, 0 is the solar cycle maximum and 0.5 is the solar cycle end).

Figure 2: We are now approching the peak of solar cycle 24 that is predicted to occur in the Fall 2013 [2].

To take a maximum of benefit of such situation, Eurocontrol has contracted in 2009 a study with Egis Avia leading a consortium composed of CLS, CNES, DSNA/DTI, ENAC, M3Systems aiming at characterising the impact of the solar

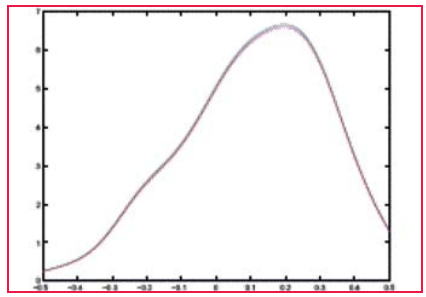

Figure 1: Risk of Storm occurence along a solar cycle – Level severe ap=179 [1]

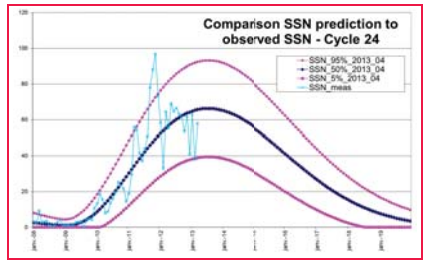

Figure 2: Solar Cycle 24 monthly SSN – prediction [2] vs observations [3]

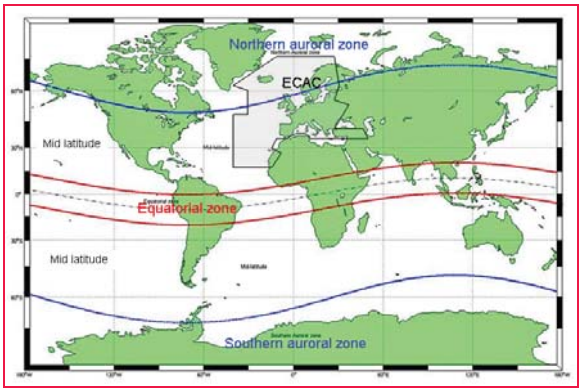

Figure 3: ECAC region and its location among magnetic zones

activity on civil aviations GNSS based applications for different phases of flight during the next period of maximum solar activity and at developing, validating and assessing performance of adequate mitigation actions for the different phases of flight impacted [4]. The first part of this study was a bibliography on past events and the definition of a data collection network to support impact of solar cycle 24 events over the ECAC region (Figure 3).

We are now in the second part of the study where the data collection network has been set up and is delivering information enabling to analyse the impact at receiver level and to validate the modelisation done for different ionosphere scenarii to assess the impact at user service levels.

On a second hand CNES has set up in 2010 a facility (NTMF – Navigation and Time Monitoring Facility) aiming at assessing on a regular basis the performances achieved by different navigation systems such as GPS or GLONASS and in the future GALILEO and by the different Satellite Based Augmentation Systems. At the beginning, only EGNOS and its time function, WAAS and GPS performances were assessed but now after a ramp up phase, other SBAS GAGAN and MSAS have been added to the NTMF and GLONASS is expected to be so in the coming months.

These two initiatives enable to observe the recent solar and ionosphere/magnetosphere activities and the impact on SBAS and to perform relevant analyses. Several events were monitored and analysed but this paper focuses on only some of them for which the impact was more or less important (August, September, October 2011, March and July 2012).

Facilities

Eurocontrol Ionosphere Data Collection and Products

The Network

The data collection network (Figure 4) is done by a file transfer protocol from several public networks delivering RINEX observation files sampled at 1 or 30 seconds enabling to have:

- A large scale network based on IGS, EUREF and national networks for large effects
- Some small scale networks in some areas (Toulouse, Madrid. Canary Islands) for more local effects
- Completed when relevant by additional stations from the EDCN [5] and EGNOS networks [6], integration of additional EGNOS stations is foreseen in 2013

In addition to these observations, data from some Ionosphere Scintillation Monitors (ISM) belonging to ESA MONITOR project [7] can be used in the analyses.

Products and External data

Data from the different sensors are processed to provide Eurocontrol and partners with

- TEC and TEC gradient maps
- ROTI, STEC, Rate of TEC parameters
- loss of L1 (S1Nb) and L2 (S2Nb) measurements
- S4 and sigmaPhi parameters

Some external and public data are also used:

- Geomagnetic data
  - Kp index (Planetary; from 0 to 9)
  - ap index (High latitude; from 0 for quiet to over 200 nT for severe extreme storms)
  - Dst index (equatorial)
- Solar data
  - Sun Spot Number (SSN)
  - Radio flux
  - Proton flux
  - X-ray flux

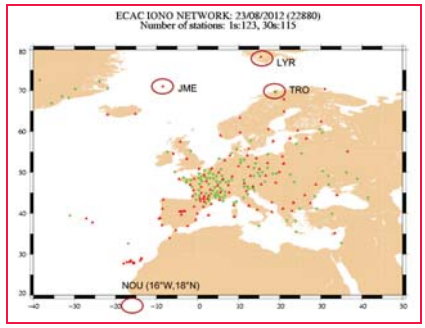

Figure 4: Stations used for Eurocontrol Study – summer 2012 (red: 1s sampling, green: 30s, circle: EGNOS RIMS)

CNES Navigation and Time Monitoring Facility

CNES NTMF is able to collect different sources of data and to process them in order to evaluate the performances at different levels for different key parameters by comparison. For a particular key parameter, the same method and the same tool is used for each system and the quality of the results is ensured thanks to the possibility to run in parallel two tools developed on the same requirements but by two different teams.

The different performances that are currently monitored in the NTMF are:

- Accuracy, Integrity, Availability, Continuity of each system
- System offset to UTC (EGNOS time only for the moment)
- Interface compliance to standard (MOPS DO229 for SBAS, ICD200 for GPS)

In addition to these parameters that are currently only available on an internal private CNES web site, NTMF is able to deliver on a public FTP server [8] and in the right RINEX format SBAS messages that were broadcasted by EGNOS (Europe), GAGAN (India), MSAS (Japan), WAAS (USA) and even SDCM PRN125 (Russia).

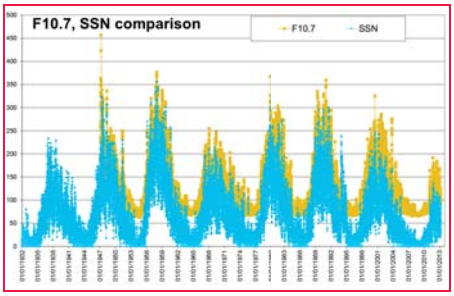

Figure 5: SSN from 1932 and F10.7 from 1947

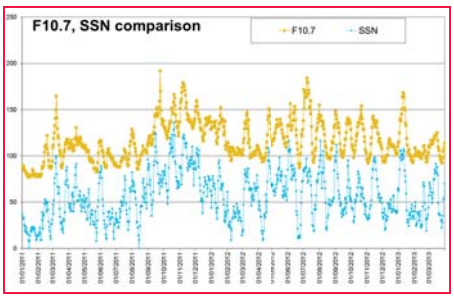

Figure 6: SSN and F10.7 from 01/01/2011

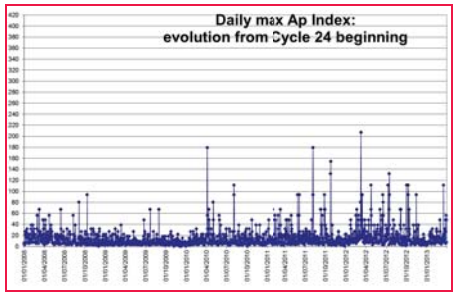

Figure 7: Max 3 hour ap from cycle 24 start

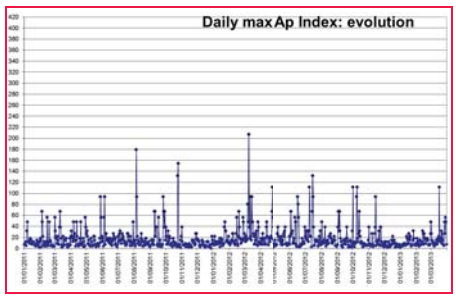

Figure 8: Max 3 hour ap from 01/01/2011

Solar and Ionosphere activities from 2011

Solar Activity

The solar activity can be characterised daily by the daily SSN or the daily F10.7 index. The latter measures the noise level generated by the sun at a wavelength of 10.7 cm at the earth's orbit at local noon at the Penticton Radio Observatory in Canada. On Figure 5, both indices are plotted over a long period. The recent period is plotted on Figure 6.

Both SSN and F10.7 indices have variations mainly due to the solar rotation, but the high values are moderate regarding previous cycles and no important spike is highlighted for the moment, events that occurred were not exceptional. Nevertheless we will see later that some impacts on magnetosphere were observed.

Ionosphere/magnetosphere activity

Several indices exist to rank the ionosphere/magnetosphere activity, but for the purpose of this section only the 3-hour ap index, directly related to Kp in order to have a linear scale, is used. Eight values are provided per day. In order to determine the level of activity in the day, we simply look for the maximum over each day (figure 7 and 8).

The table 1 is used to define the status of the ionosphere.

Only one extreme storm has been recorded from the beginning of solar cycle 24, and several were observed in the severe+ category:

- 05/04/2010: ap reached 179 nT (not analysed in this paper)
- 05/08/2011: ap reached 179 nT (partly analysed in this paper)
- 24&25/10/2011: ap reached 154 nT (analysed in this paper)
- 09/03/2012: ap reached 207 nT, the highest magnetic event of cycle 24 until now, just at the limit of the extreme classification (analysed in this paper)
- 15/07/2012: ap reached 132 nT (partly analysed in this paper)

In addition there were several occurrences of other storm categories (table 2).

Particular attention has to be paid on the fact that these figures do not represent exactly the number of storm events due to the fact that some storms can occur over two consecutive days.

In order to demonstrate that the impact is not in a simple relation to the intensity of a storm, an event in September 2011 will be also documented.

Observations

A. 05/08/2011 event

Figure 9: The storm began in the evening of the 5th of August and had continued in the morning of the 6th.

As no important activity occurred on that day, the 4th of August is used as a referenced day for both EGNOS and WAAS.

If we have a look at the service availability daily maps, we can observe a reduction for the two systems (figure 10).

At both locations (figure 11), the vertical protection levels were higher when the storm occurred and degradation was really time correlated with the high values of the magnetic index. For WAAS, the

Table 1: ionosphere activity definition

Ionosphere condition	Kp Index	3-hour ap index (nT)
Quiet	0-1	<7
Unsettled	2	7 to <15
Active	3	15 to <27
Minor storm	4	27 to <48
Major storm	5	48 to <80
Severe storm	6	80 to <132
Severe+	7	132 to <207
Extreme	8	207 to <400
Extreme +	9	400

Table 2 : number of stormy days by level

Storm level	2011	2012	2013Q1
Minor	26	47	10
Major	19	21	4
Severe	4	12	1
Severe+	3	1	0
Extreme	0	1	0
Extreme +	0	0	0

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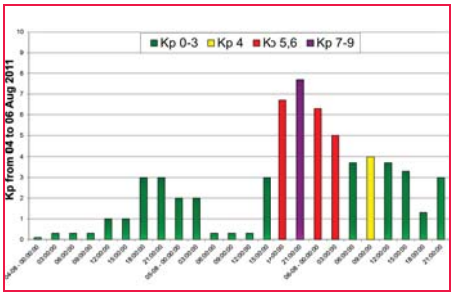

Figure 9 : Kp evolution from 04 to 06 Aug 2012

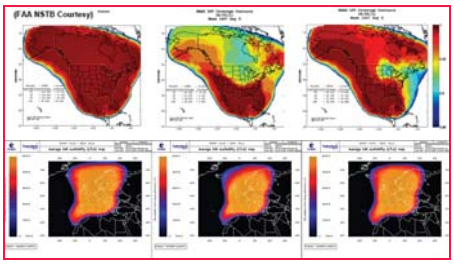

Figure 10: WAAS (top) & EGNOS (bottom) daily availability maps 04/08 to 06/08/2011

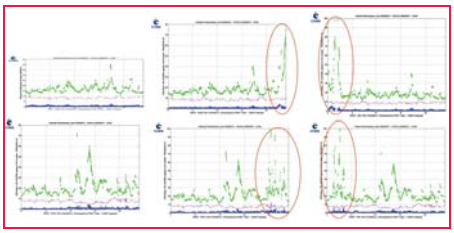

Figure 11: Vertical error (blue) and protection level (green) at Washington (top) & Tromsoe – Norway (bottom)

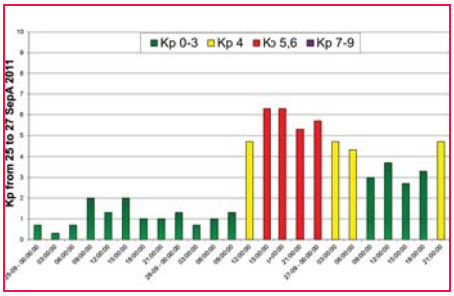

Figure 12: Kp evolution from 25 to 27 Sep 2011

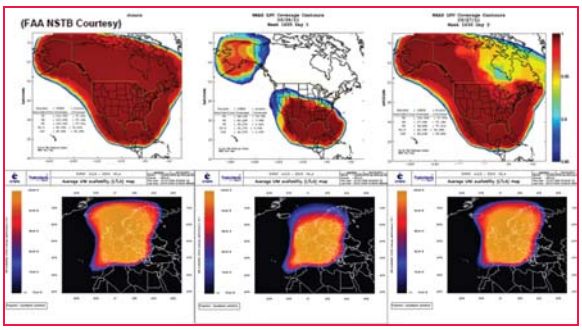

Figure 13: WAAS (top) & EGNOS (bottom) daily availability maps 25/09 to 27/09/2011

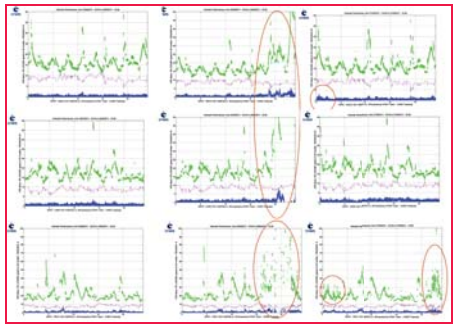

Figure 14: Vertical error (blue) and protection level (green) at Colorado Spring (top), Washington (middle) & Tromsoe – Norway (bottom)

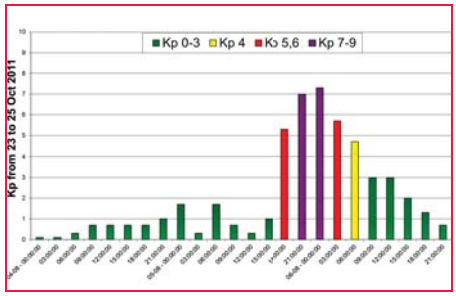

Figure 15: Kp evolution from 23 to 25 Oct 2011

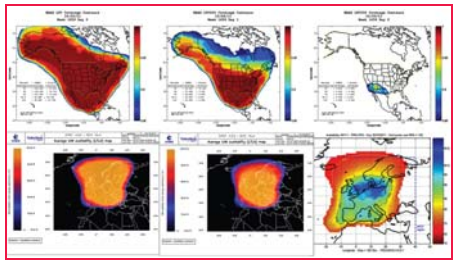

Figure 16: WAAS (top) & EGNOS (bottom) daily availability maps 23/10 to 25/10/2011

protection in the ionosphere domain (GIVE) were set to high values while for EGNOS, some Ionosphere Grid Points in the North of Europe were set to Not monitored, reducing the number of satellites usable for this type of precision approach service. Note that a satellite is usable for the precision approach services when the ionosphere delay affecting its path to the user can be corrected by the ionosphere information sent by an SBAS i.e. there are enough monitored IGP in the surrounding of its ionosphere pierce point (IPP) corresponding to the intersection of the user/satellite path with the ionosphere layer modelled as an ellipsoid with a 350 km constant height above WGS84 [9].

B. 26/09/2011 event

Figure 12: The storm began in the middle of the afternoon of the 26th and had continued until the beginning of the day after. We can observe a more active magnetosphere on the rest of the 27th finishing by a major storm. Over that period, the ap index reached only 92 nT as a maximum

As no important activity occurred on that day, the 25th of September is used as a referenced day for both EGNOS and WAAS.

Figure 13: Degradation in the service availability is observed for both systems but even if the intensity of the event was less important than during the August event, degradation is more important for both systems.

At each location (figure 14), the vertical protection levels were degraded during the storm: either higher (Colorado Spring) than the day before or not computed (Washington, Tromsoe). The impossibility to compute a protection level is due to numerous Ionosphere Grid Points set to Not Monitored in the vicinity of these locations reducing the number of usable satellites under the minimum number (four) required to be able to compute a position solution. We can observe also at Tromsoe an additional degradation in the evening of the 27th of September when a sub storm occurred.

C. 24&25/10/2011 event

The storm began after 18:00 UTC on the 25th and had continued until 06:00 UTC the day after (figure 15). On the period, the ap index reached 154 nT as maximum.

As no important activity occurred on that day, the 23rd of October is used as a referenced day for both EGNOS and WAAS.

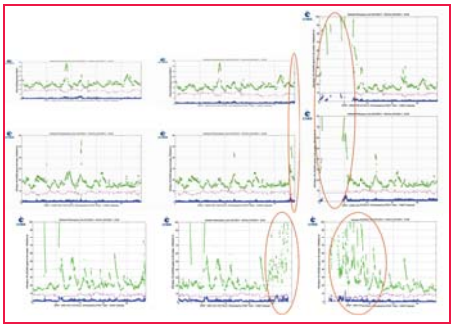

Figure 17: Vertical error (blue) and protection level (green) at Colorado Spring (top), Washington (middle) & Kiruna – Sweden (bottom)

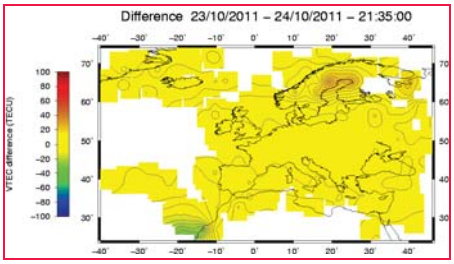

Figure 18: TEC comparison – 24/10 to 23/10/2011

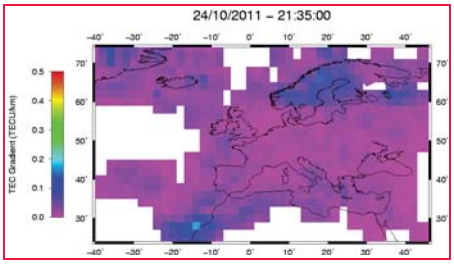

Figure 19: TEC gradient over ECAC – 24/10/2011

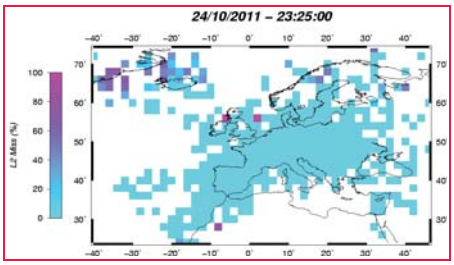

Figure 20: L2 loss ratio – 24/10/2011

Degradation of service availability is observed for both systems (figure 16). For WAAS the Canada and Alaska were impacted on the 24th while the day after, the degradation is observed on the whole service area. For EGNOS (even if the map for the third day is provided by a different tool due to a regular tool issue), the degradation was also observed but with less impact.

At each location (figure 17), the vertical protection levels were degraded during the storm: either higher than the day before or not computed due to the lack of usable satellites. The periods without position at Kiruna with EGNOS was very short compared to the outage observed at Colorado Springs and Washington (several hours).

For EGNOS, additional information over ECAC is available (figures 18 to 22).

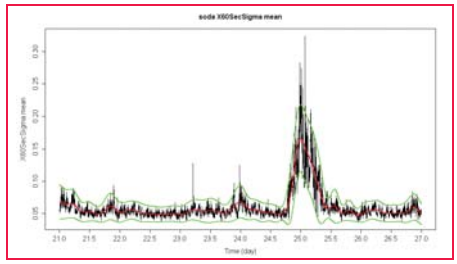

Figure 21: mean SigmaPhi (black curve), spline of mean (red curve), 2σ confidence interval (green curve)

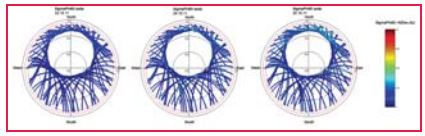

Figure 22: SigmaPhi at Sodankyla

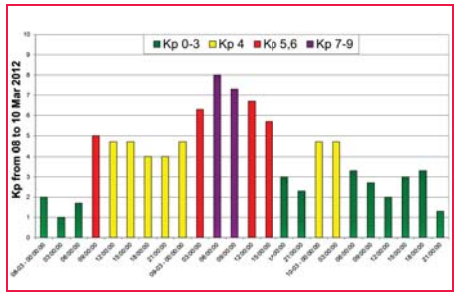

Figure 23: Kp evolution from 08 to 10 Mar 2012

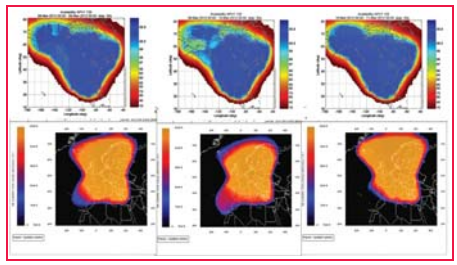

Figure 24: WAAS (top) & EGNOS (bottom) daily availability maps from 08 to 10 mar 2012

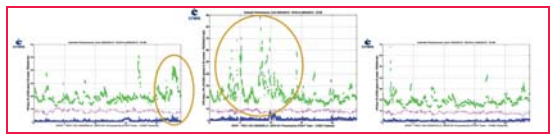

Figure 25: Vertical error (blue) and protection level (green) at Tromsoe – Norway

The ionospheric perturbation was visible by a TEC enhancement at the auroral oval on the ECAC region in the evening of October 24, with values up to 40 TECU above the TEC of the day before, near 21h35TU, over Sweden. Large scale smoothed TEC gradients of 0.2 mm/km were observed. The loss of L2 lock when L1 present, increased up to 60% at certain grid points of the auroral oval and was of a quasi 20% ratio over Iceland and Greenland (figure 20).

The mean variation of SigmaPhi measured at Sodankyla (Finland) and plotted from the 21st of Otober to the 27th pointed out a clear enhancement in the evening of the 24th and beginning of 25th.

The polar plots of SigmaPhi parameter from the 23rd to the 25th show that satellites that were in the North but also in some others directions were affected (clear blue)

D. 09/03/2012 event

Figure 23: The storm began in the morning of the 8th and achieved its maximum one day later and finished in the evening of the same day. On this period, the ap index reached 207 nT as maximum.

The 10th of March is used as reference day.

Degradation of service availability is observed for both systems (figure 24), mainly on the 9th (Alaska and West Canada for WAAS, Iceland and North of Scandinavia for EGNOS). Nevertheless, the impact is less important than for Aug, Sep or Oct 2011 event. It has to be noted that both systems were upgraded between last quarter of 2011 and March event to improve their reliability during ionosphere events ([10], [11]).

No local degradation has been observed at US locations used

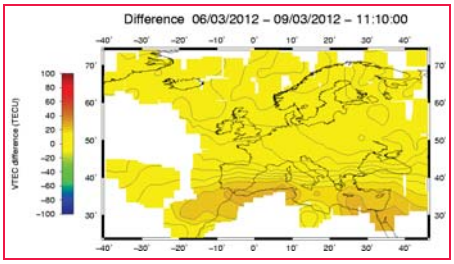

Figure 26: TEC comparison – 09/03 to 06/03/2012

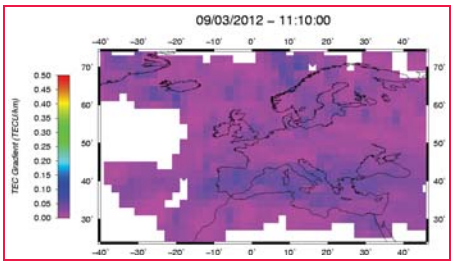

Figure 27: TEC gradient over ECAC – 09/03/2012

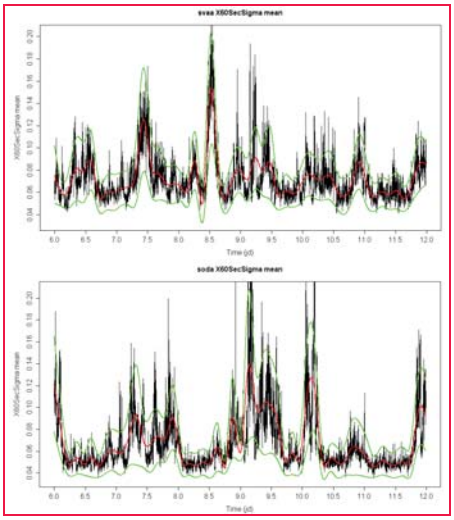

Figure 28: mean SigmaPhi (black curve), spline of mean (red curve), 2σ confidence interval (green curve) at Svalbard (top) and Sodankyla (bottom)

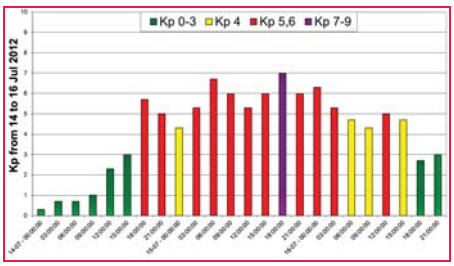

Figure 29: Kp evolution from 14 to 16 Jul 2012

in the NTMF to monitor WAAS performances. At Tromsoe, degradation is observed late in the evening of the 8th and in the morning of the 9th due to some high GIVE or not monitored IGP (figure 25).

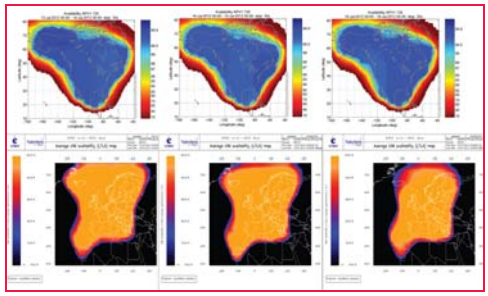

Figure 30: WAAS (top) & EGNOS (bottom) daily availability maps from 13 to 15 Jul 2012

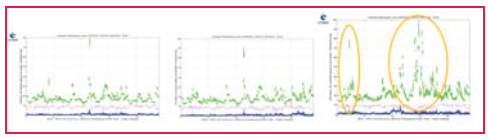

Figure 31: Vertical error (blue) and protection level (green) at Tromsoe – Norway

Table 3: Event impact synthesis

Event	Max ap	WAAS	EGNOS
05/08/2011	179	++	+
26/09/2011	92	+++	++
24/10/2011	154	++++	++
09/03/2012	207	+	+
15/07/2012	132	0	+

The main characteristics of the event on March 9th are a TEC enhancement in Southern Europe, with values 30 TECU above the TEC at the same hour on March 6th, the last quiet day before. The large scale gradients were up to 0.1 mm/km at different places, half of what was observed for the October event (figure 26 and 27).

Over the period between the 6th and the 12th of March, especially the 7th, 9th and 10th March, the SigmaPhi is well correlated to the ap index for the Sodankyla station. But, for the Svalbard station which is much higher in latitude this is not the case because the most intense perturbation of SigmaPhi occurred during the 8th of March (figure 28).

E. 15/07/2012 event

Figure 29: The storm began on the 14th evening, achieved its maximum 24 hours later and has continued until the 16th in the afternoon.

The activity was calm on the 13th; this day is chosen as reference day.

No real degradation was observed for WAAS (figure 30). EGNOS was slightly impacted on the 14th at its northern edge and a little bit more on the 15th (towards Iceland area).

Figure 31: Some degradation is observed at Tromsoe on the 15th during the night and in the afternoon.

Duration of the degradation is not so important than the one for previous event.

F. Qualitative synthesis and discussion

A qualitative assessment of the impact of each event has been established in regards to the importance of the degradations observed in the availability maps (table 3).

The use of ap (or Kp) index is suitable for detecting ionosphere/magnetosphere events. A clear relation can be highlighted between the loss of dual frequency data in L2 codeless technique and this index [4], but it is not possible based on the analyses presented here to forecast the importance of the outage caused by the detected event. Indeed, no relation can be put in evidence between the impact importance and intensity (max ap) of the illustrated events.

The effects of 2012 events are less important than those of 2011. It is not sure that this can merely be explained by the modifications brought to both system releases ([10] & [11]). Some other factors are likely to play a role such as the gradient of activity, solar events type and energetic particle flux arriving on Earth, as well as the GPS constellation situation over the stations network. Part of these factors and observed parameters will be taken into account to define scenarios for modelling the impact at service level [12].

Conclusions

This paper shows that the solar activity is lower than previous cycles (as it has been forecasted for more than a couple of years now). Nevertheless, the ionosphere and magnetosphere activities are onset and storms occur. Even if no extreme+ event was detected from the beginning of the current solar cycle, some severe storms and an extreme one occurred. Their impact on WAAS and EGNOS was observed but it has to be noted that the importance of the observed impact is not in a mere direct relation to the intensity of the storm.

As current and future work in the scope of the study performed for Eurocontrol, it is expected to have a better modeling of this impact on the civil aviations GNSS based applications, including SBAS thanks to the observations performed with the Eurocontrol Ionosphere Data Collection network.

Acknowledgment

Part of the activities developed to achieve some results presented in this paper, were created by EUROCONTROL for the SESAR Joint Undertaking within the frame of the SESAR Programme co-financed by the EU and EUROCONTROL. The opinions expressed herein reflect the authors view only. The SESAR Joint Undertaking is not liable for the use of any of the information included herein. The analyses cover only the first quarter of 2013 as this work was presented at ENC-GNSS 2013 (23-25 April, Vienna, Austria).

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Vision-based sensor for relative navigation

LiDAR has unique features that will allow the success of future complex space exploration missions

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Project Manager, Swiss Centre for Electronics and Microtechnology

For space faring nations or group of nations, maintaining their autonomy in the engineering of technologies allowing the success of exploration missions is mandatory. This article focuses on one of these technologies - the flash imaging Light Detection and Ranging (LiDAR). This technology has unique features that will allow the success of future complex space exploration missions.

Placing in-orbit of the targeted celestial body an orbiter – like the Mangalyaan Mars probe recently launched by India – is a first important step towards the exploration of this body. However, the most difficult part of the exploration comes with the missions that shall drop off at the celestial body ground either expensive scientific payloads or human beings.

The smooth landing of the rover Curiosity on Mars in the frame of the NASA Mars Science Laboratory (MSL) (http://mars.nasa.gov/msl/) mission in August 2012 with a precision never previously achieved is a remarkable example of what can be accomplished by autonomous exploration space crafts. In the near future, several planned European or international exploration missions (e.g., Mars Sample Return, Marco Polo-B) (http://sci.esa.int/marcopolo-r/49559-spacecraft/) also include a phase of controlled descent and soft-landing with even higher precision requirements. Their success stands largely in the ability to perform Terrain Relative Navigation (TRN) and surface Hazard Detection (HD) as these missions will land in areas pockmarked by craters, crevasses and boulders.

The landing of Curiosity was possible mainly because of the precision of the distance measurements achieved by the Terminal Descent Sensor (TDS) embarked on the sky-crane which dropped off Curiosity smoothly on the ground. The TDS is in fact a radar equipped with 6 directional antennas. Its main features and functionalities are mentioned in table 1.

The TDS allowed the landing of Curiosity in an ellipse of 20 by 7 km. Even though this is the best landing precision ever achieved, it is not sufficient to ensure the success of exploration missions currently planned by the space agencies around the world.

For exploration spacecraft, autonomy is the key functionality, when the aim of the mission is a smooth landing on a faraway celestial object where remote commands from Earth to Mars

Figure 1: Illustration of the landing of the rover Curiosity on Mars (Courtesy NASA/JPL-Caltech)

Table 1:

Features		Functionalities	
Weight (kg)	25	Absolute altitude	Available
Electrical power consumption W	100	Absolute velocity	Available
Size (length cm x width cm height cm)	100 x 40 x 20	Terrain Relative Navigation	Not available
Range of operation (m)	10-3500	Hazard Detection	Not available
Precision (m)	> 0.5	3D target imaging	Not available
Data update rate (Hz)	20		

needs at least 3 minutes and 7 seconds to reach the exploration spacecraft. This is by far too long to ensure the success of a mission where some sub-phases of the entry, descent and landing last only a few seconds.

New requirements are surfacing in relation with the ambitious objectives of new exploration missions. An example of such a mission is the Marcopolo-R mission planned by the European Space Agency (ESA). The mission's main objective is to collect ground samples on a Near Earth Object (NEO) and to bring them back to Earth.

The scenario of Marcopolo-R is split in several sub-phases either focused on the characterization of the asteroid or on the landing and on the collection of samples.

Marcopolo-R (http://sci.esa.int/marcopolo-r/49560-mission-operations/) mission operations description defines the requirements related to each sub-phases. The table 2 summarizes the characterization sub-phases main parameters.

The table 3 summarizes the proximity navigation sub-phases main parameters.

The definition of the parameters above shows the performances that must be achieved by the proximity sensor. These performances have to be provided with limited resources (e.g., power supply, total sensor size, total weight, etc.,) for the proximity sensor. The features of the benchmark, the MSL TDS must be improved by the following factors:

- The maximum mass has to be divided by a factor 6,
- The power consumption has to be decreased by a factor 3,
- The total size has to be decreased by a factor 4,
- At the same time, the ranging precision has to be improved by a factor 50.

The proximity sensor performances should allow to reach a landing precision of 30 by 30 m (MSL is 20,000 by 7,000 m).

In addition to these performances, allowing a precise relative navigation spacecraft-asteroid and making precise topographic and geodesic characterization, the proximity sensor must provide surface hazards detection and avoidance capability. A device with such capabilities will play an essential role for the success of NEO

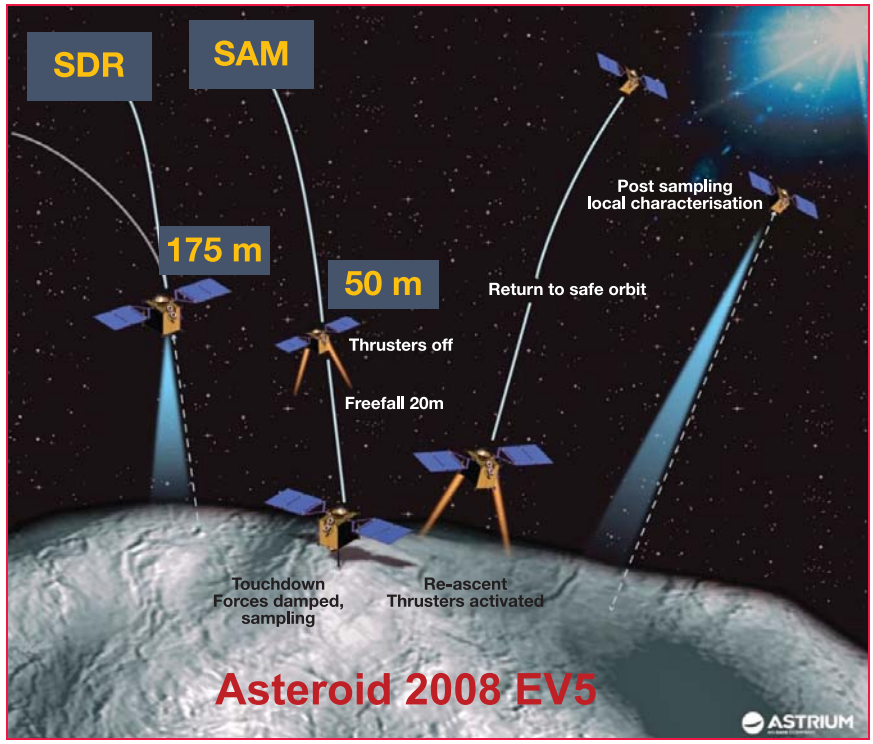

Figure 3: Summary of the Marcopolo-R proximity navigation sub-phases (Courtesy: ESA, Astrium)

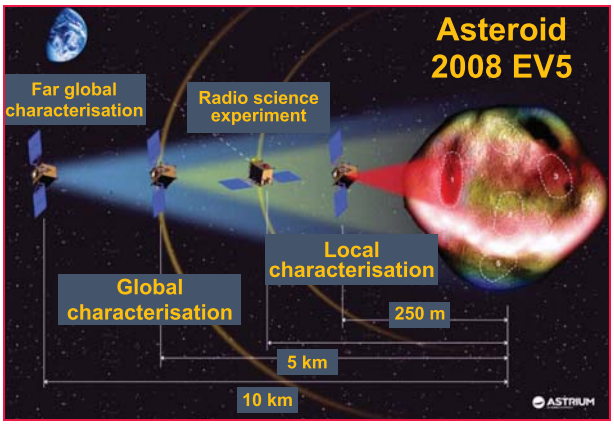

Figure 2: Summary of the Marcopolo-R asteroid characterization sub-phases (Courtesy: ESA, Astrium)

Table 2

Sub-phase	Global characterization	Local characterization
Proximity Sensor type	Altimeter	3D mapper
Range of operation (m)	< 6000 , > 4000	< 300 , > 200
Precision (m)	< 1	< 0.1
Horizontal resolution (m)	-	< 0.2
Data update rate (Hz)	> 2	> 2
Vertical velocity (m/s)	< 1.5	-

Table 3

Sub-phase	Sampling descent rehearsal (SDR)	Descent and sampling (SAM)
Proximity Sensor type	Inclinometer	Inclinometer
Range of operation m	< 250 , > 100	< 100 , > 5
Precision m	< 0.05	< 0.05
Horizontal resolution m	To be defined	To be defined
Data update rate Hz	> 2	> 2
Vertical velocity m/s	< 1.8	< 0.11 m/s

space missions. A proximity sensor with the features above is technologically not mature today to be embarked on a mission to Mars in the close future.

It appears to the space community that a sensor with such features can play an important role in other space applications. Applications often quoted are- rover navigation (as a replacement for the stereo-vision camera used so far), situational awareness sensor and rendezvous-docking operations.

A new space application can make profit of the proximity sensor with the features quoted above- the Active Debris Removal (ADR). ADR missions will become more and more important in the future to maintain an access to space at reasonable risks.

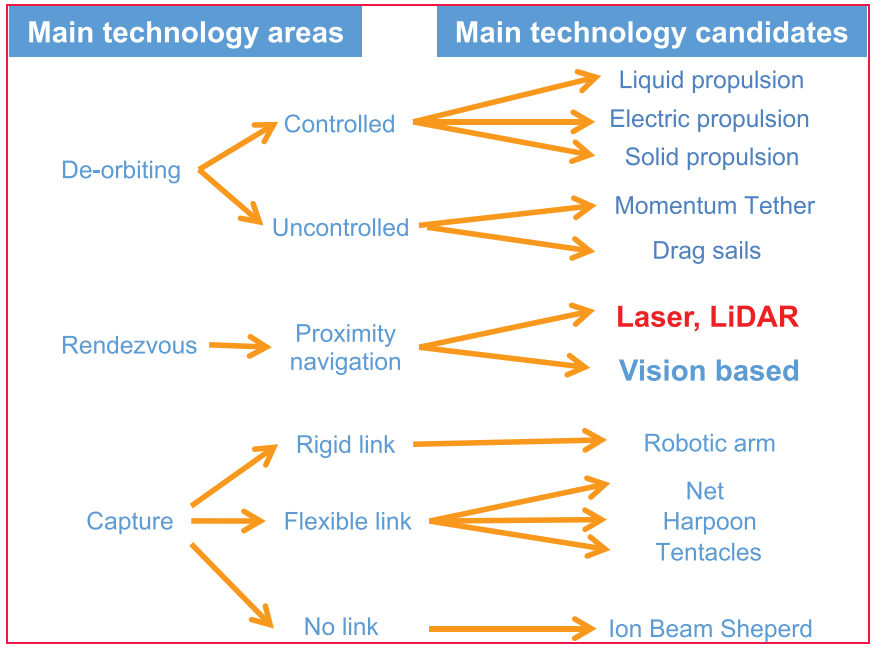

Figure 5: ADR key technologies (according to ESA, DLR (Deutches Zentrum für Luft-und Raumfahrt), CNES (CNES : Centre National d'Etudes Spatiales).

The numbers are breathtaking. Today, amongst the objects orbiting the Earth in the geostationary orbit, 70% of them is garbage. It represents 958 objects in January 2013 (Space News October 28 2013). Collisions between debris and active satellite already happened in Low Earth Orbits (LEO).

The remedy to the situation illustrated on the left above where the sustainable exploitation of space would not be possible is to send ADR missions. ADR missions will allow reaching the situation depicted on the right where debris are either parked in specific garbage orbits or destroyed in the atmosphere through controlled de-orbiting.

ADR missions are split in three main phases- the rendezvous phase between the chaser (the spacecraft sent to catch debris) and the debris, the capture phase where the chaser catches the debris and the orbit-change phase. For each of these phases, enabling technologies must be used to achieve the necessary operations. There is currently a consensus in the scientific community for the identification of the technologies that will allow the success of ADR missions. They are listed in the figure below. Vision-based and LiDAR are the top ranked technologies for proximity navigation.

LiDAR – or more precisely imaging LiDAR, is the technology which offers all the features of the adequate proximity sensor. Other technologies propose only a subset of them (e.g., radar, passive camera).

There are two families of imaging LiDAR technology- the flying spot and the flash technologies. The first step in the design of an imaging LiDAR is the choice between the flash and flying-spot architectures. Considering the optical budget, the available optical power from the illumination source is spread in larger solid-angle in a flash architecture (http://www.fosternav.net/), implying more demanding constraints on the detector sensitivity to maintain equal ranging and imaging performances with flying-spot architectures. However, considering system's complexity, flash architectures makes it possible to avoid the scanning subsystem of the flying-spot architectures. The progresses in major flash LiDAR subsystems, e.g., in miniaturized high energy pulsed lasers, compact microchip lasers, continuous-wave laser modules and photodetector arrays makes this LiDAR architecture a solution that will become the most relevant to address the tough challenges of future space missions.

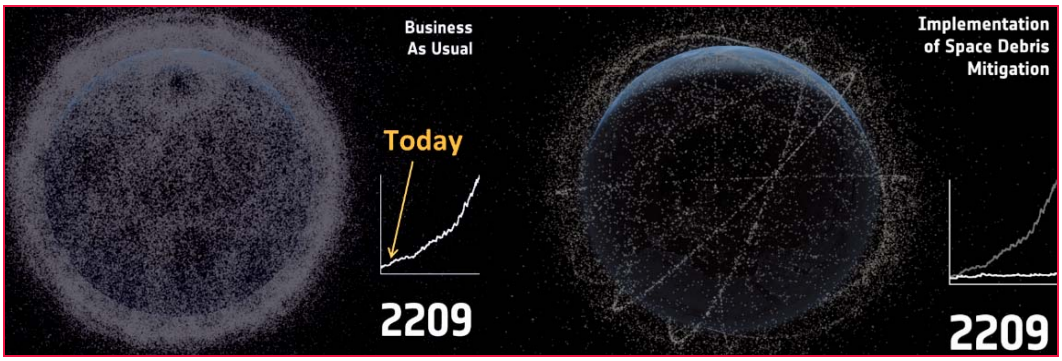

Figure 4: On the left, the current debris situation orbiting Earth if not debris mitigation missions are sent in the future. On the right, the situation with debris mitigation missions (courtesy from ESA).

TUSAGA-Aktif: Delivering benefits to Turkey

This paper gives the infrastructure of the Turkish RTK CORS Network called TUSAGA-Aktif established by Istanbul Kultur University in association with the General Directorate of Land Registration and Cadastre and the General Command of Mapping and sponsored by the Turkish Scientific and Technical Research Agency (TUBITAK)

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Continuously Operating Reference Stations (CORS) networks have been utilized for the last two decades in most developed and some developing countries by surveyors, geomatics and earth scientists and engineers. They handle Global Navigation Satellite System (GNSS) data which support three dimensional positioning not only for surveyors but also for any works in need of high accuracy and time efficiency such as meteorologists, geophysical and geological engineers, construction engineers and so on (http://www.ngs.noaa.gov/CORS/). They have been implemented to contribute towards very high accuracy geodetic tasks since the late 1980s (Evans et al, 2002). The network based positioning provides geometric strength, reference datum stability and of course redundancy to geodetic methods; this is why CORS have become popular globally. Although these CORS networks are extremely useful in providing high accuracy positioning, they are not time efficient, that is, it is not possible to obtain instantaneous accurate positions, requiring static positioning hours of point occupations and later post-processing. This made CORS networks unpopular for engineering-type surveys (Mekik, 2004).

Real Time Kinematic positioning ability was added to CORS networks (or rather passive/static CORS networks at the beginning of 2000) which made a worldwide breakthrough in concept and efficiency of positioning (Bock et al, 2002; Rizos et al., 2003; Eren, 2005; Rizos, 2007; Grejner-Brzezinska et al. 2007). These types of CORS Networks are called RTK CORS, CORS-Active and so on to distinguish them from the old type of passive CORS networks. (Rizos et al, 2003, Wübbena et al, 2001, Retscher, 2002). A CORS Service Provider, who sells user subscriptions, manages the CORS whose Service Provider chooses the Network RTK method the server will use. Therefore, this choice will ultimately influence the quality of RTK solution that can be achieved at the rover. The network is cogitated in a way that it provides data to GPS rover receivers by continuously monitoring and correcting the positional data from the GNSS satellite constellations (URL 2). The transmission of the correction factors via the internet and monitoring and reporting the timing errors to the central computing component allows for real time correction and adjustment of the coordinates to allow the rover to perform the its job higher level of accuracy (Lachapelle et al, 2002; Cruddace et al, 2002; Bray and Greenway, 2004).

Providing that RTK could be carried out in a perfect environment, with no atmospheric biases and no satellite orbit bias, there would be no need to restrict the range between a base station and the rover. Unfortunately, the Earth's environment is never a perfect environment for GPS. This environment leads to distance dependent errors which restrict the range at which a rover can compute an RTK position fix. Atmospheric delays are the main error sources for medium-range relative positioning, hence the main challenge for a NRTK system is the computation and representation of atmospheric delay errors for users. The major difference between the methods is that they use different approaches to make corrections for the rovers. (URL 2).

The network consists of several GNSS stations interconnected by reliable

communications to enable real time computations and control. Each station, as a minimum, requires a receiver, an antenna, communications and a power supply. In most cases a computer is installed additionally for data transmission and control. In ideal cases a supplementary configuration is used for reliability or 'back up' reasons. Additionally a user interface is required to configure and maintain the network. This may be realized remotely e.g. by radio communication or by mobile phones or via internet connection. An offline network that provides the information to the user for post-processing, the stored data files use 'RINEX' format (Wübbena and Willlgalis, 2001). There are a few methods to compute and transmit the corrections given as:

Virtual Reference Station (VRS):

The RTK CORS server collects satellite observations from the CORS Network, performs calculations, and sends RTK corrections to the rover. There are a few RTK correction techniques available, namely Virtual Reference Station method, FKP method and MAC method (Wanninger, 2002). The Virtual Reference Station (VRS) corrections are optimized for the rover position at the beginning of the RTK session. If the rover then moves a considerable distance within the same session (i.e. without disconnecting and reconnecting) the corrections might not be appropriate for the new rover location (Landau et al., 2003). With the Virtual Reference Station method the rover does not receive any observations related to a real reference station. Instead all correction relating to rover's position comes from the virtual reference station (Wanninger, 1999; Vollath et al 2000, 2001, 2002, 2003; Roberts et al, 2004).

Area Correction Parameters Method (FKP: Flächen-Korrektur Parameter):

This method creates area correction parameters represented as simple planes (East- West and North-South gradients) that are valid for a limited area around a single reference station. The FKP method is a broadcast method and does not require the RTK rover to send its current position to the network central server (simplex communication suffices). Instead, the server models the distance dependant errors and sends RTK data from one reference station within the network to the rover, along with the model (Wübbena et al., 2001). In this method the server computes the network solution (so called FKP) to reduce the distance dependent errors. Thus the network solution is not optimized for the rover's position and might be limiting the RTK solution. In this method the correction parameters computed at the server are assumed that the distance dependent errors change linearly between reference stations. However, interpolation errors will occur at the rover if the true errors are non-linear. This can result in poor position quality or problems in the ambiguity fixing. To resolve this issue, the user can disconnect and start a new session to generate a new reference station, or the server may automatically generate a new reference station. However, (in either case) generating new reference stations can cause jumps in position and accuracy. Therefore, the user can end up with inconsistent positions and accuracies throughout their survey. (Wubbena et al., 2001, 2004; Vollath et al., 2000, 2001, 2002, 2004).

Master Auxiliary Concept (MAC):

In this approach the RTK CORS server sends full raw observations and coordinate information for a single reference station, the Master Station, for all other stations in the network, the ambiguity-reduced data of every reference station. Therefore, it maximizes the use of all satellite data to calculate the best possible RTK solution. The Master Auxiliary Concept gives the rover the flexibility to perform either a simple interpolation of the network corrections like FKP, or a more rigorous calculation (e.g. calculate multiple baselines from the auxiliary reference stations). This means the rover can monitor the RTK solution and change its calculation on-the-fly to optimize the RTK solution. The rover has the possibility to adapt to the prevailing atmospheric conditions by using an appropriate number of reference stations. The MAC corrections allow the rover to measure a baseline to the master station – a real reference station (Brown et al., 2006).

This article gives a detailed information on the Turkish RTK CORS Network, CORS-TR Network, later changed its name to TUSAGA-Aktif Network, and its infrastructure. TUSAGA-Aktif Network has been established by Istanbul Kultur University in association with the General Directorate of Land Registration and Cadastre of Turkey and the General Command of Mapping of Turkey and sponsored by the Turkish Scientific and Technical Research Agency (TUBITAK).

As with all CORS networks established all around the world, the TUSAGA-Aktif (CORS-TR) networks aims to determine positions fast, economically and reliably with cm accuracy within minutes, even seconds. However, TUSAGA-Aktif also targets to provide a means to model the atmosphere (troposphere and ionosphere), to predict weather (Roberts et al, 2005; Musa et al, 2005) and to monitor plate tectonics with mm-level accuracy leading to improvement of earthquake prediction and early warning systems (Brownjohn et al, 2004) and to determine datum transformation parameters between the old system ED50 (European Datum-1950) and ITRF97 (NADCON, 2004; Kempre et al, 2006).

Establishing TUSAGA-Aktif (CORS-TR) network

A comprehensive prototype (benchmark) test was carried out in Turkey in the Marmara region (roughly 300 x 150 km) in order to optimize the network design, to test different RTK techniques, the GNSS receivers and control center software packages. As far as the network-base RTK CORS is concerned, this is probably one of the most comprehensive prototype tests in the world (see Eren et al, 2009).

After conducting the prototype test, it is decided, accounting for geographical conditions of Turkey, that reference stations are

a) to be established in city centers in order to meet intense user demands,
b) to be on rigid grounds,
c) easily accessible for logistic purposes,
d) close to energy and communication facilities,
e) to be situated in a way that plate tectonics are suitable to monitor and
f) to be apart less than 100 km (ibid, 2009).

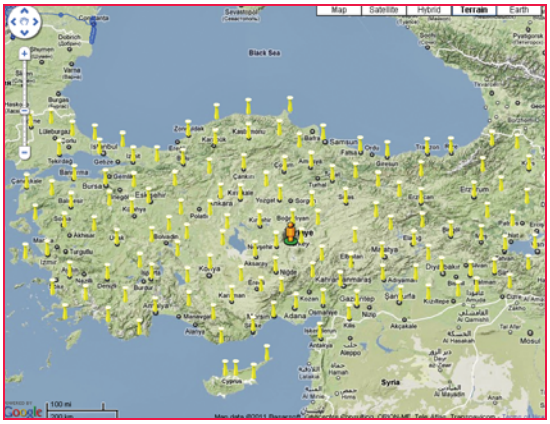

Figure 1. Locations of TUSAGA-Aktif reference stations

According to these criteria a total of 147 reference station locations are determined (see Figure 1).

All the TUSAGA-Aktif reference stations are named in accordance with IGS regulations having only four characters. Table 1 lists all the station names and locations including the four in Northern Cyprus.

Figure 2. Concrete pillar (2 m)

Figure 3. Galvanized steel pillar (3 m)

Figure 4. Galvanized steel pillar (4 m from the base of roof)

The types of monumentation of all 146 reference stations are decided upon ground and regional conditions. Concrete pillar are chosen for rigid ground stations while galvanized steel pillars are constructed for roof tops and roof terraces. However, the heights of pillar change in terms of where they are put up. 86 of them are 2m tall concrete pillars, including the ground pillars (see Figure 2) while 58 pillars on roof terraces are 3m (see Figure 3) and only 3 of them on roof tops is 4 m galvanized steel pillars (see Figure 4)

Controlling the TUSAGA-Aktif

Two control stations (Master and Auxiliary) are established both in the capital city of Turkish Republic, Ankara. Master Control Station is situated in the Photogrammetry and Geodesy Administration of the General Directorate of Land Registration and Cadastre of Turkey and the Auxiliary Control Station in headquarters of the General Command of Mapping of Turkey (see Figure 5).

All the data from TUSAGA-Aktif reference stations are automatically sent via internet to these control centers in which the network computations and positioning corrections are carried out and send them to users in the field. Control centers have a robust central software as well as servers. This software carries out these functions:

- Connecting all reference stations and transferring observations,
- Computing coordinates of reference stations ,
- Modeling errors, computing corrections and broadcasting to rover stations (users),
- RTK services,
- Web services,
- Monitoring rovers,
- Storing all the data,

Table 2 lists all the hardware and software contents of both Master and Auxiliary Control Stations which both have a capability of computing and sending real time kinematic GPS corrections. The software for control stations is provided by Trimble VRS SW and originally designed for 250 NetR5 reference stations and consists of GPSNet, RTKNet, Webserver, Rover Integrity, Coordinate Monitor and Data Storage modules. It is capable of computing corrections for ionosphere, troposphere, multipath and orbit, and also can broadcast positional correction computed using FKP, VRS and MAC techniques.

For the communication between the control center and rovers RTCM 3.0 and higher protocols are used and thus GSM (cellular phones), NTRIP over GPRS/ EDGE and radio links are utilized. NTRIP NTRIP is a protocol for streaming Global Navigation Satellite System (GNSS) data over the Internet. Based on the Hypertext Transfer Protocol HTTP/1.1. NTRIP began as an RTCM standard designed for disseminating differential correction data (e.g in the RTCM-104 format) or other kinds of GNSS streaming data to stationary or mobile users over the Internet, allowing simultaneous PC, Laptop, PDA, or receiver connections to a broadcasting host. NTRIP is designed to be an open non-proprietary protocol and has

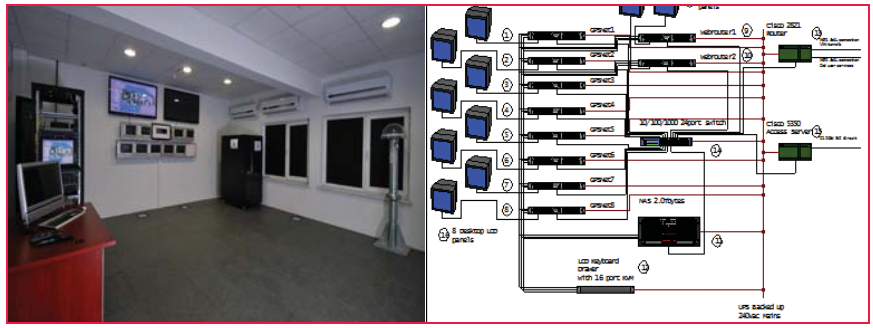

Figure 5. Master Control Station and its schematic representation

Table 1. Station names and their locations

No	Station Name	Province	County	No	Station Name	Province	County	No	Station Name	Province	County
1	ADAN	Adana	Yüregir	51	ERZR	Erzurum	Merkez	101	MIDY	Mardin	Midyat
2	ADIY	Adiyaman	Merkez	52	ESKS	Eskisehir	Merkez	102	MUGL	Mugla	Merkez
3	AFYN	A.Karahisar	Merkez	53	DINA	Afyon	Dinar	103	MURA	Van	Muradiye
4	AGRD	Agri	Merkez	54	FASA	Ordu	Fatsa	104	MUUS	Mus	Merkez
5	AKDG	Yozgat	Akdagmadeni	55	FEEK	Adana	Feke	105	NAHA	Ankara	Nallihan
6	AKSI	Antalya	Akseki	56	FETH	Mugla	Fethiye	106	NEVS	Nevsehir	Merkez
7	AKHR	Konya	Aksehir	57	FINI	Antalya	Finike	107	NIGD	Nigde	Merkez
8	AKSR	Aksaray	Merkez	58	GEME	Sivas	Gemerek	108	ONIY	Osmaniye	Merkez
9	AMAS	Amasya	Merkez	59	GIRS	Giresun	Merkez	109	OZAL	Van	Özalp
10	ANMU	Içel	Anamur	60	GUMU	Gümüshane	Merkez	110	POZA	Adana	Pozanti
11	ANRK	Ankara	Merkez	61	GURU	Sivas	Gürün	111	RDIY	Tokat	Resadiye
12	ANTL	Antalya	Merkez	62	GYUR	KKTC	Güzelyurt	112	RHIY	Erzincan	Refahiye
13	ANTE	Gaziantep	Sehitkamil	63	HAKK	Hakkari	Merkez	113	RZE1	Rize	Merkez
14	ARPK	Malatya	Arapkir	64	HALP	Konya	Halkapinar	114	SALH	Manisa	Salihli
15	ARDH	Ardahan	Merkez	65	HARC	Bursa	Harmancik	115	SAMN	Samsun	Merkez
16	ARTV	Artvin	Merkez	66	HATA	Hatay	Antakya	116	SARY	Tekirdag	Saray
17	AYD1	Aydin	Merkez	67	HYMN	Ankara	Haymana	117	SARV	Karaman	Sariveliler
18	AYVL	Balikesir	Ayvalik	68	HEND	Sakarya	Hemindek	118	SEND	Hakkari	Semdinli
19	BALK	Balikesir	Merkez	69	HINI	Erzurum	Hinis	119	SIHI	Eskisehir	Sivrihisar
20	BAND	Balikesir	Bandirma	70	HORS	Erzurum	Horasan	120	SIRT	Siirt	Merkez
21	BTMN	Batman	Merkez	71	IGIR	Igdir	Merkez	121	SLEE	Istanbul	Sile
22	BAYB	Bayburt	Merkez	72	INEB	Kastamonu	Inebolu	122	SILF	Mersin	Silifke
23	BEYS	Konya	Beysehir	73	ISPA	Isparta	Merkez	123	SINP	Sinop	Merkez
24	BILE	Bilecik	Merkez	74	ISTN	Istanbul	Bakirköy	124	SIRN	Sirnak	Merkez
25	BING	Bingöl	Merkez	75	IZMI	Izmir	Konak	125	SIVS	Sivas	Merkez
26	BOGZ	Yozgat	Bogazliyan	76	IZMT	Kocaeli	Izmit	126	SIVE	Sanliurfa	Siverek
27	BOLU	Bolu	Merkez	77	KRBK	Safranbolu	Merkez	127	SUNL	Çorum	Sungurlu
28	BOYT	Sinop	Boyabat	78	KAMN	Karaman	Merkez	128	SURF	Sanliurfa	Merkez
29	BURS	Bursa	Osmaniye	79	KAPN	Konya	Karapinar	129	SSEH	Sivas	Susehri
30	CMLD	Ankara	Çamlidere	80	KARB	Istanbul	Karaburun	130	TVAN	Bitlis	Tatvan
31	CANA	Çanakkale	Merkez	81	KRS1	Kars	Merkez	131	TEKR	Tekirdag	Merkez
32	CANK	Çankiri	Merkez	82	KSTM	Kastamonu	Merkez	132	TOKA	Tokat	Merkez
33	CATK	Van	Çatak	83	KAYS	Kayseri	Melikgazi	133	TRBN	Trabzon	Merkez
34	CAVD	Burdur	Cavdir	84	KESA	Edirne	Kesan	134	TUFA	Adana	Tufanbeyli
35	CESM	Izmir	Çesme	85	KLIS	Kilis	Merkez	135	TNCE	Tunceli	Merkez
36	CIHA	Konya	Cihanbeyli	86	KIRL	Kirklareli	Merkez	136	UDER	Erzurum	Uzundere
37	CORU	Çorum	Merkez	87	KIRI	Kirikkale	Merkez	137	USAK	Usak	Merkez
38	DATC	Mugla	Datça	88	KIKA	Manisa	Kirkagaç	138	VAAN	Van	Merkez
39	DEIR	Manisa	Demirci	89	KIRS	Kirsehir	Merkez	139	VEZI	Samsun	Veziköprü
40	DENI	Denizli	Merkez	90	KNYA	Konya	Selçuklu	140	VIRA	Sanliurfa	Viransehir
41	DIDI	Aydin	Didim	91	KLUU	Konya	Kulu	141	BASK	Van	Baskale
42	DIPK	KKTC	Dipkarpaz	92	KURU	Bartin	Kurucasile	142	YENC	Çanakkale	Yenice
43	DIVR	Sivas	Divrigi	93	KUTA	Kütahya	Merkez	143	YOZT	Yozgat	Merkez
44	DIYB	Diyarbakir	Merkez	94	LEFK	KKTC	Lefkosa	144	YUNK	Konya	Yunak
45	EDIR	Edirne	Merkez	95	MGOS	KKTC	Magosa	145	ZONG	Zonguldak	Merkez
46	EKIZ	K.Maras	Ekinözü	96	MALY	Malatya	Merkez	146	AHGK	Ankara	Merkez
47	ELAZ	Elazig	Merkez	97	MALZ	Mus	Malazgirt				
48	EMIR	Afyon	Emirdag	98	MARA	K.Maras	Merkez				
49	ERGN	Diyarbakir	Ergani	99	MARD	Mardin	Merkez				
50	ERZI	Erzincan	Merkez	100	MRSI	Mersin	Merkez				

Table 2. Contents of Master and Auxiliary Control Stations.

Contents	Mstr	Aux
DL140G3 Dual-Core X5110 3.00 GHZ-1x4mb 1gb 80gb SATA 1U Rack; Windows 2003 Server	8	4
DL140G3 Dual-Core 2x X5110 3.00 GHZ-1x4MB 1GB 80GB SATA 1U Rack; Windows 2003 Server; 2x1GB FBD	2	1
NAS HP DL380 2TB SATA Storage Server; Dual-Core; 1GB DIMM; 2x1GB FBD	1	1
StorageWorks Backup Unit with Smart Array	1	1
17" LCD TFT Flat Panel Monitor	10	5
CISCO 2811 Router with VPN encryption; 2x DSL interface	1	1
24-port unmanaged switch	1	1
19" 16-port KWM switch	1	1
19" 42U Server Max cabin with FAN and Thermostat module	1	1
19" Rack console with 17" TFT display, keyboard, mouse, touchpad	1	1
HP A4 laser printer	1	1
Trimble VRS SW (including GPSNet, RTKNet, webserver, Rover Integrity, Coordinate Monitor and data storage) for 150 GNSS stations/nodes	1	1
Microsoft Office (including MS Access)	1	1
Working table	3	3
VNCe SW	11	5
IPCluster SW	2	1

gained word-wide recognition as a useful means of transporting GNSS data. Wireless Internet services and Mobile IP Networks like GSM, GPRS, EDGE, or UMTS are all quite capable of carrying NTRIP streams.

The TUSAGA-Aktif (CIRS-TR) network equipped with NetR5 reference stations and control centers provides RTK GPS positioning 24 hours a day all over Turkey and the North Cyprus.

All the reference stations is geographically divided into four regions and thus four GPSnet servers (plus 4 auxiliary servers) in the Master Control Center (Figure 6). Each server is backed with an auxiliary server which automatically takes over the work in case of any failure in the main server. The control centers collect RINEX data from the reference stations in 1 second interval for an hour and 30 seconds intervals for 24 hours, and precise ephemerid data are automatically uploaded by the system.

The Master and Auxiliary Control Centers broadcast the coordinate correction using VRS CMR+, VRS RTCM 3.1, SAPOS FKP 2.3, RTCM3Net (MAC) and DGPS techniques. A separate webrouter transfers all the data from the reference stations to the main GPSnet servers and auxiliary webrouter in real time. A secondary webrouter is designed to step in as an auxiliary in case of any failure. All the correction broadcasting is maintained through NTRIP Caster and CORSIZ program developed by GRAFTEK INC. manages the users and records all the user information. Furthermore, user or rovers are monitored by the software called CORSTAK implemented by GRAFTEK INC. over Google Earth™ in real time (Figure 7)

For static GPS data, a webserver software is run on webrouter and users can obtain RINEX data for observation time and time interval for any reference station. A TB hotswap RAID (plus an auxiliary) is formed on a NAS (Network Attached Storage) server, storing RINEX data (in Hatanaka format), reports, log files and hourly registry back-ups from all the servers.

Reference stations

A total of 146 The TUSAGA Aktif reference stations are established in the field with baseline separation

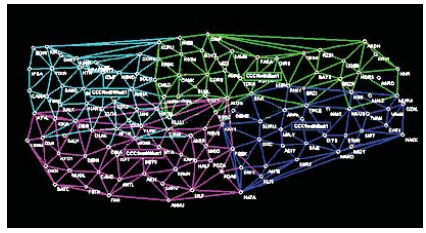

Figure 6. Reference stations and their server regions

of 70-100 km as deduced from the prototype test. (Figure 8)

For every reference station, a GPS cabinet is specially designed for TUSAGA Aktif project. These cabinets have glass doors when used indoors or steel doors on outside use. They are designed to work independent of mains electricity problems, fed on 12 Volt DC batteries; in other words, main grid electricity is only used for charging these batteries which can go on working for 48 hours without any electricity charging. Naturally different battery amperes had to be applied depending on the general temperature values of the region where reference stations are. (Figure 9 left)

Each cabinet contains a) 1 Victron Bluepower charger/power unit, b) 1 Trimble NetR5 GNSS receiver, c) 1 Sarian DR6410 Router/switch (ADSL/EDGE), d) 1 LVD voltage protection detector, e) lightning arrester for telephone and antenna lines and f) fuses and electronic cabling assembly. (Figure 9 right)

The antennas used on all the reference stations are Trimble Zephyr Geodetic II™ and Radome is also installed on antennas where snow load is expected. All the antennas are placed on pillars

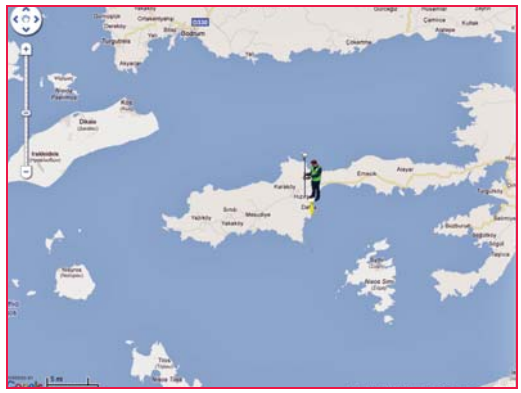

Figure 7. Monitoring users in real time

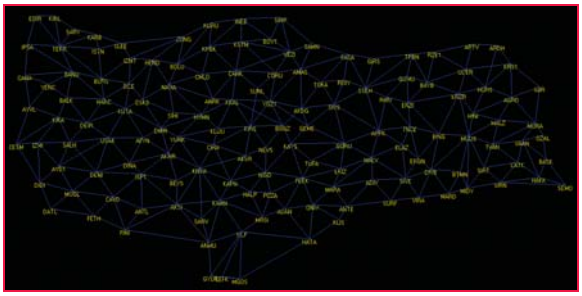

Figure 8. The network of TUSAGA Aktif reference stations

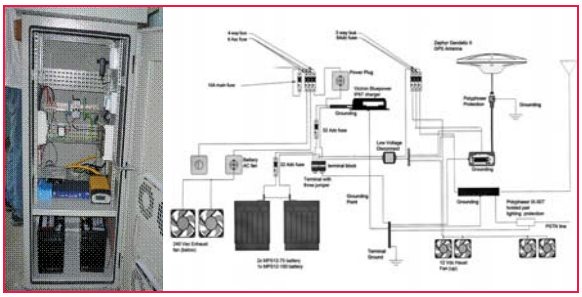

Figure 9. Reference station cabinet (left) and schematic representation of cabinet components (right)

leveled by special tripods with fixed height, yielding an extremely precise and standard antenna height.

All the stations possess static IPs and VPN tunnel (internal IP) communication via CISCO routers. However, in case of any router problem, the system is planned to also work with static IPs through a standard regular router.

Communication

The communication between the control centers and stations are maintained by duplex ADSL and GPRS/EDGE. For this purpose, the Master Control Center has 20Mbit and the Auxiliary 10 Mbit metro internet connection. Moreover it is possible to connect each reference station via GPRS/EDGE.

After carrying out intensive test it is found out that approximately 15 stations do not high quality line connections as the other. The metro connections in the control centers experience some data loss and slowing down especially during the peak times; however, this does not affect the RTK GPS tasks badly because the missing RINEX data are automatically replaced by the back-up ones kept in the centers.

TUSAGA-Aktif test results

The precise coordinates of TUSAGA-Aktif reference stations were calculated in ITRF 2005 datum and at the observation epoch utilizing two-weeks data of all the reference stations together with the IGS stations such as GRAS, GRAZ, KIT3, KOSG, MATE, NICO, NOT1, NSSP, ONSA, SOFI, VILL, WTZR, ZECK. The computations were carried out by using Bernese 5.0 and GAMIT software packages together with precise ephemeris.

As of January 31, 2010, all the reference stations are completed except 1 stations in Northern Cyprus. When the system was in the test stage, there were over 4000 users benefiting from the system throughout Turkey to determine their precise coordinates by RTK or post processing techniques. The number has decreased to 2000 since the first half of 2011 when the fee has been introduced to use the system. Users are able to determine their precise coordinates in matters of seconds.

For the purpose of testing the system, 808 points with their precisely known ITRF2005.00 coordinates are taken into account because they are homogenously scattered around the country in both urban and rural areas. Table 3 lists all the results obtained from the test.

Table 3. Statistics of the Measurements

	Northing m)	Easting (m)	Height (m)
No. of Measurements	808	808	808
Smallest Difference	-0.4990	-0.3280	-0.3077
Largest Difference	0.2178	0.3092	0.2687
Average	-0.0153	-0.0103	-0.0266
Standard Deviation	0.042542438	0.03816926	0.090720529

The data send by each reference stations are about 700 byte per second and the total amount data from the stations to the control centers is approximately 1.2 Mbit; concurrently daily RINEX data recorded at 1 second interval 20 Gb while RINEX data (in Hatanaka format) at 30 sec interval is 239 Mb.

In Table 3 it can be seen that the largest standard deviation, as expected, is obtained in the height component while the values of nothing and easting components are comparable. The following Figure 10a, b and c give error distributions of the measurements in northing, easting and height components.

The TUSAGA-Aktif network commenced working in 2009 and the number of users are increasing exponentially. At the beginning of 2010 the daily user number has reach 350-370 rover on average, and the instantaneous user number in the range of 100-130, evenly scattered over Turkey in terms of their location. However, the frequency in user is high in the Marmara

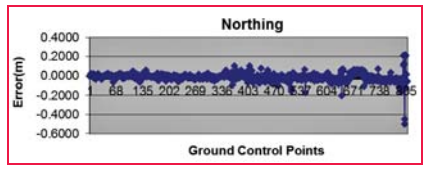

Figure 10a. Error distribution in Northing component

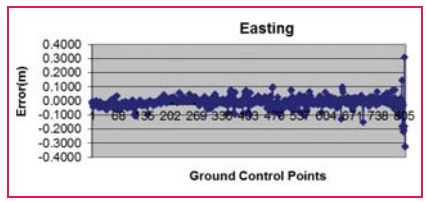

Figure 10b. Error distribution in Easting component

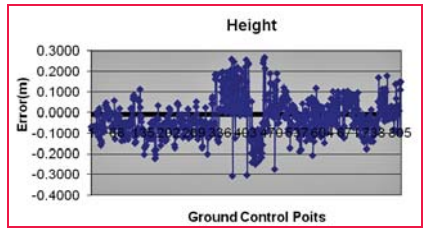

Figure 10c. Error distribution in Height component

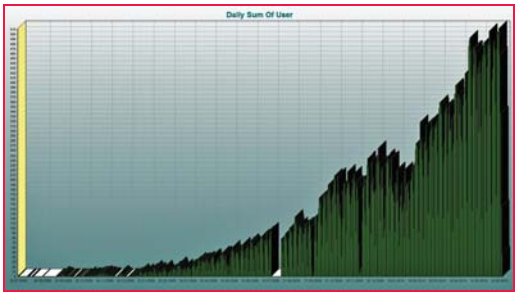

Figure 11. Daily usage from the beginning

Region due to intensive industry while low in the mountainous Blacksea Region and the Central Anatolia with plains (Figure 11)

As for the coordinate correction types are concerned, VRS has the highest preference rate with 46% and the most favored correction formats are CMR+ and RTCM3.1 (Figure 12).

As with all the RTK network around the world, the success in The TUSAGA-Aktif network mainly lies in the quality of the communication between the centers and the reference stations and between the reference stations and users (Landau et al, 2004). In Turkey the copper is usually made used for ADSL lines except for some big cities, and these lines are very old, unfortunately subject to corrosions. Therefore the places with this kind of infrastructure can experience outages, slowing downs and delays in ADSL communications. Nevertheless the system automatically opens up GPRS/EDGE channel in cases of outages and the user in the field are not aware of these outages. Despite all this, the troubled areas, which are generally 15 points and daily 5 stations experiencing one hour or over ADLS connection problem, are being overcome with the cooperation of Turkish Telekom. One of the great advantages of the TUSAGA-Aktif network is the ability to automatically form a new sub network in that region when a reference station is cut off from the world and the users in the field are not affected by this.

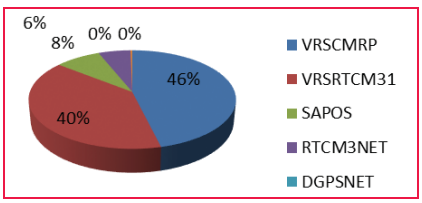

Figure 12. Percentage of the coordinate correction formats used

The data generated in the network are always studied using coordinate-time series. The evaluation of this fashion revealed that 5 reference stations had multipath effects and cycle slips. Fig 13 demonstrates three graphs for the coordinate-time series of ADAN station, one of the stations with low performance. Looking closely at the series one can observe that the northing and easting components show different behaviors than the others. All the stations with low or bad performances are being planned to change their locations.

Conclusions

The Turkish RTK CORS Network TUSAGA-Aktif has been serving increasing number of users since at the beginning 2009 and the number reached over 2100 in two years. It made an enormous impact on around nationwide 4610 GNSS receivers by enhancing their performance %50 in 2013, and presents a great advantage of establishing a base for all kinds of geographical information systems and technologies. Nationwide cadastral and geodetic tasks will be carried out fast, economically and reliably without the necessity of local reference points. Furthermore, the velocities of the national geodetic points will be determined on daily basis and tectonic plate movements will be monitored effectively because of the fact that Turkey is on active earthquake bearing faults such as the North Anatolian Faults and South Anatolian Fault.

The nationwide cadastre renewal tasks worth 220 million US Dollars has been initiated and the geodetic infrastructural works constitute 20% of these tasks and is estimated to bring about a saving of 35 million US Dollars which is about the seventh of the cost of establishing all the TUSAGA-Aktif network. In the first year the network has already compensated the money that went into establishing and running the system. Apart from the countless professional benefits and applications that this kind of system provides, the financial benefit alone is worth considering for all developing countries all around world.

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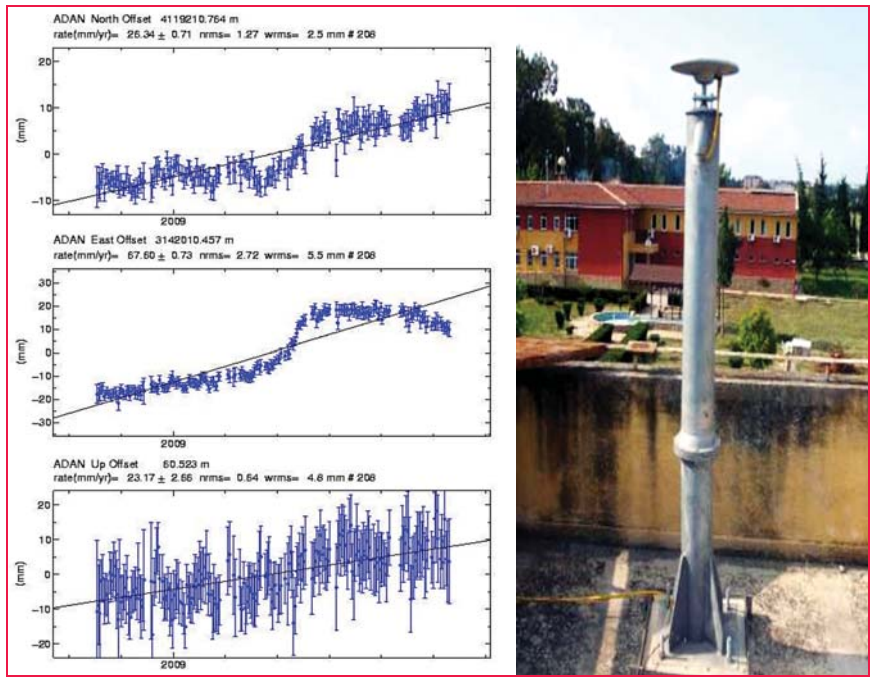

Figure 13. ADAN station and its coordinate-time series

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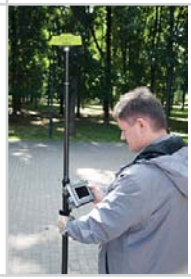
Complete Base/Rover Pair with UHF Radio, Data Collector and field software. Add your own pole and tripod and you are ready to survey! **Base/Rover Pair Total $10,480**		 

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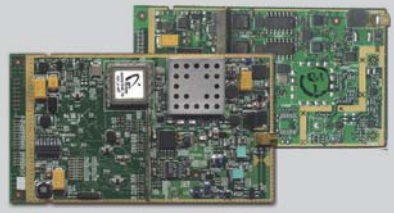

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Space-based precipitation radar for spatio-temporal hydrology analysis

This study informs the potential and opportunities of space-based precipitation radar to fill the gaps of knowledge on spatio-temporal rainfall patterns for hydrology and related fields in tropical region

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Spatio-temporal rainfall changes at tropics had raised concern among scientists. However, comprehensive studies at catchment scale of Southeast Asia where the combined regional and local factor is a tough task to be carried out due to the inherent limitations of rainfall data sources especially in the remote, upper part and difficult access of the watershed. Often the hydrological analysis and reports informed less information [e.g. 1] regarding those areas which are getting more significant for the regional application. Therefore, an alternative support is strongly recommended to improve the spatio-temporal rainfall analysis and fill the gaps of knowledge in this watershed environmental niche.

The opportunities provided by the space-based precipitation radar are significant to satisfy the raising issues. It provides temporal measurement, higher spatial gridded information, cost effective and convenient data inter-operability. There are increasing open source options for such information from wide range of satellites such as Tropical Rainfall Measuring Mission (TRMM), Meteosat, and GOSAT. Their potential to the local watershed application had been immensely studied by many researchers for the past decades [e.g., 2,3]. With the launch of the new Global Precipitation Mission in 2014, there is bright prospect of such rainfall measurement options to become one of the rainfall information sources at global scale. Nevertheless, comprehensive use of this kind of data at local Peninsular Malaysia especially in upper hilly watershed remains less explored.

There are two main issues addressed in this paper. First is the current spatio-temporal condition of rain gauge measurement in hilly catchment of Peninsular Malaysia, and second is to explore how the space-based precipitation data could support to anticipate the sparse coverage and data inter-operability issues. In correspondence of both issues, two preliminary analyses were carried out. First, the spatial distribution and efficiency of rain gauge in hilly forested catchment of Peninsular Malaysia is evaluated with respect to the land use and elevation information using Geographical Information System (GIS) approach. Second, the spatial pattern of rainfall changes is analysed using the TRMM satellite information.

Materials and method

Study site description

Peninsular Malaysia is located in Southeast Asia and experiences humid tropics climate through the year. The hilly and mountainous catchment in Peninsular Malaysia is highly dominated by dipterocarp and montane forest. The elevation ranged from 400m up to the highest peak of 2191m of Mount Tahan. The rainfall distribution pattern over Peninsular Malaysia is strongly influenced by the regional wind flows, and therefore, it is significant to describe them based on the seasonal monsoon flows [4]. Rainfall patterns experienced by Peninsular Malaysia are determined by two main monsoon seasons, the northeast monsoon (November to March) and southwest monsoon (May to September).

Orographic and convective rainfall types characterized the rainfall in hilly catchment through the year. From 1977 to 2001, Peninsular Malaysia produced about 580 cubic km of natural renewable water resources, where 97.6% were generated

from surface water and only a small amount was generated from groundwater recharge (2.4%) [5]. The hilly catchment is pivotal for freshwater resources and also hydroelectric generation. Thus, there are about 20 reservoirs that resulted from the streamflow by hilly catchment areas. Figure 1 depicts the study area and its hydrological description.

Using GIS approach for rain gauge spatial distribution and efficiency analysis in hilly catchment

Major hilly and mountainous watershed areas in four states, namely Kelantan, Selangor, Perak, Pahang, and Terengganu were analysed, and 85% of hilly watershed is located in these four states. A total of 571 rain gauge information was collected from various sources, mainly Meteorological Department and Department of Irrigation and Drainage. The first step of this analysis is determining the spatial rain gauge distribution over the watershed areas by using land cover types and elevation. Elevation information is obtained from Shuttle Radar Topography Mission (SRTM) 90m grid resolution and the height is transferred to local datum. Cross tabular overlay analysis of rain gauge against the land use and forest elevation is implemented. The next step is to analyse the efficiency of the rain gauge which is located in the hilly catchment nearby area (~1.5km radius distance). Five indicators were then used to determine the efficiency of those rain gauges. Those indicators are; (i) Telemetry, (ii) Data logger, (iii) Automatic Operation, (iv) Ownership and (v) International Organization of Standardization (ISO) status. It is suggested that effective rain gauge should possess all those characteristics. The score of each indicator is then plotted using radar chart analysis. A perfect score of 50 indicates 100% efficiency of the rain gauge network system. Figure 2a shows the summary of the methodology flow.

Precipitation change analysis using space-based TRMM precipitation radar data

13 years of satellite observation period from 1998 to 2010 were acquired from the TRMM for this analysis. TRMM 3B43 Version 6 global data product is subset to the local area coverage and projected to the local projection and coordinate system. Then, the monthly rain rate was obtained and the annual basis co-efficient of variation (COV) was computed. Long term in-situ rainfall and evaporation records (>25 years) are also included for supporting the satellite analysis. Figure 2b illustrates the processing flow of the methodology.

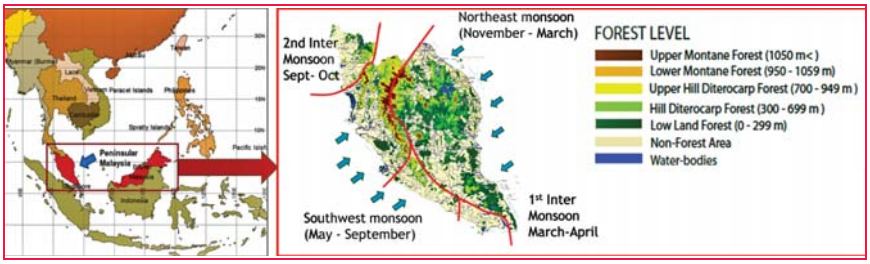

Figure 1: Precipitation zone in Peninsular Malaysia and forest elevation (Source for Precipitation Zone: [20] Dept. of Irrigation and Drainage)

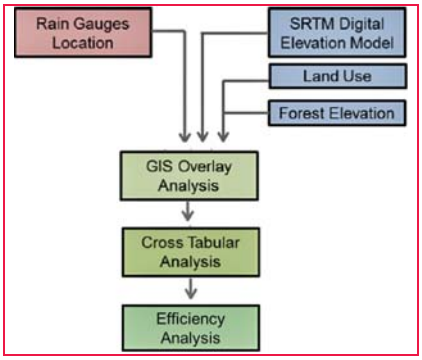

Figure 2a: GIS approach method for rain gauge distribution and efficiency analysis

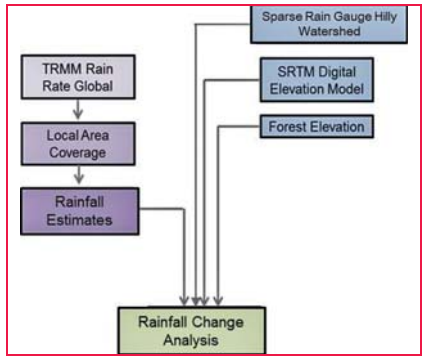

Figure 2b: Rain rate changes analysis using TRMM data methodology

Results

Rain gauge distribution spatial analysis against land use and elevation

Table 1 presents the general classification of rain gauge distribution over major land cover in the four states. Based on the GIS spatial analysis, it showed that the proportion rain gauges located in the forested areas of the watershed were only 12% (Table 1). Further analysis indicates that apart from this 12% proportion, rain gauges coverage over higher elevation forest (300 – 1200m) experienced sparse distribution (Table 2). Spatial analysis also revealed that the hilly watershed in the west part of Peninsular Malaysia is more sparsely monitored compared to the east part. This is confirmed with a detailed view on three major hilly catchments in Kuala Kangsar, Hulu Perak and Kinta where most rain gauges were located in non-forested areas (Figure 3).

Rain gauge efficiency in hilly watershed areas

Figure 4 showed the radar chart analysis on the efficiency of the rain gauge, located in the hilly watershed areas and 1.5km from it. The figure illustrates imbalance scores in all indicators, especially the ISO standard. The overall performance of the rain gauge was only 40% (Table 3). Considering that one of the most critical criteria is the ability of the rain gauge to log and transmit data via telemetry, only 63% of the rain gauge distribution or 14 rain gauges is available to provide rainfall data effectively. This analysis indicates that effective assessment of hilly watershed is a challenging task due to intangible daunting conditions to obtain rainfall information.

From the results, it strongly suggests that there are gaps that must be fulfilled in rainfall measurement especially on the remote, thick and upper hilly areas and forested watershed. By referring to the recent evidence of the local

Table 1: Rain gauge distribution vs major land cover

Landuse	Rain Gauges (Count)	Percentage (%)
Forest	67	12
Agriculture	370	65
Built Up	134	23

Table 2: Rain gauges distributions vs forest elevation

Forest Types	Forest Elevation (m) *a.s.l	Rain Gauges (Count)	Percentage (%)
Upper Montane	>1200	9	13
Lower Montane	950-1200	3	4
Upper Hill Dipterocarp	750-950	4	6
Hill Dipterocarp	300-750	6	9
Lowland	<300	45	68

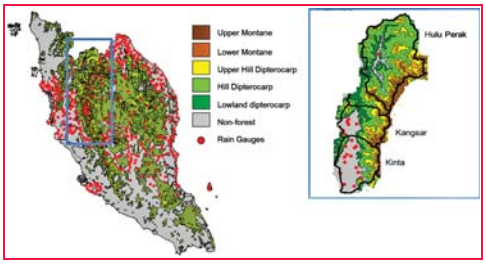

Figure 3: Rain gauges distribution on different forest elevation in Kelantan, Perak, Selangor, Terengganu and Pahang

rainfall spatial variations changes [6,7] it showed that the local hydrological patterns become more unpredictable and intensive studies is strongly needed. A space-based precipitation radar such as Tropical Rainfall Measuring Mission (TRMM) can be useful support systems in this situation, due to its advantages of cost effective operations and data handling complexity, which is suitable with the condition of the developing region which has limited resources and communication system efficiency.

Hilly watershed rain rate changes analysis

From the previous analysis, Hulu Perak watershed is one of the areas which had less rain gauge distribution as well as low rain gauge efficiency scores. The mountainous range reached 1500 m from mean sea level and 90 is covered by the tropical rainforest. It was one of a critical catchment in West Peninsular Malaysia and the main sources of streamflow for three major reservoirs which used to generate the hydroelectric turbines and other reservoirs for agricultural and freshwater resources. TRMM satellite data was used to analyse the rain rate which limited to be portrayed by rain gauge information.

Monthly basis *COV* indicated that for the past 13 years significant rainfall pattern changes was identified in the months of January and February (Figure 5). Spatial pattern map showed that obvious changes occurred at the upper part of the watershed, with an elevation of more than 1000 meter and gradually lower towards the lower elevation

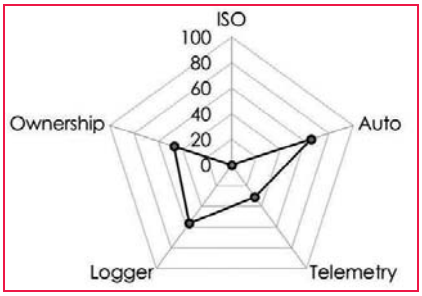

Figure 4: Radar chart analysis on the efficiency of rain gauges located in the hilly watershed and 1.5km near it. The performance of each indicator is scaled from 0 to 100%. Perfect score for each indicator is 100%.

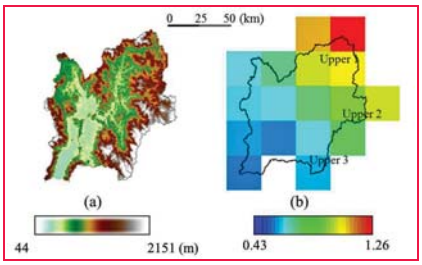

Figure 6: (a) Hulu Perak watershed elevation, b) TRMM Rain rate co-efficient of variation (COV) in the month of February (1998-2010)

(Figure 6). High amount of rainfall had occurred in two separate periods. First is 1999-2001 and the second is 2006-2007. Since January and February are not the typical wet season of this region, there are possibilities that the changes may be due to the influence of external continental factors [8] or seasonal local monsoon shifting changes.

Further, analysis with the global Oceanic Nino Index (ONI) record from the Climate Prediction Center of the National Weather Service, US had indicated that the increased rainfall amount in January and February coincide with the high magnitude ocean cold due to La-Nina event in 1999, 2000, 2006 and 2008 (Figure 7). La Nina phenomena resulted in wet conditions in Southeast Asia [10] and in 1999 several other areas in the world were severely affected [11]. On the other hand, significant evidence of local climate change also had been detected through the individual rain gauge analysis term of increased of longer rainy days (Figure 8) and increased evaporation (Figure 9).

Discussion

There are three main issues discussed:

I) The spatial rain gauge analysis obtained in this study suggest that appropriate utilization of various spatial data and satellite precipitation information in GIS environment can effectively support the hilly watershed productivity assessment. The rain gauge spatial distribution and efficiency reports could be distributed to the local authority or responsible agencies concerned with related matters. Significant measures can be immediately taken and improvement of the existing water management system can be conducted precisely. Eventually, a successful integration of spatial and geoinformation science into sustainable practice of hilly watershed hydrology in this country faced great challenges in terms of human resources capacity as well as substantial financial resources. It was recommended that a sustainable and practical framework should be created that adept in reaching the success attained by the developed countries such as Japan (AMEDAS system), Australia and others.

II) Studying the output of hilly watershed rainfall changes, this study also confirmed that the extent of the impact of climate change on a local scale has increased their variations at spatial location and time. For record, there are growing trends of frequent water induced disasters reported over the past 15 years [e.g. 12, 13]. One of the most recent disaster was a flood that resulted due to extreme heavy rainfall in hilly watershed areas. One of the areas is Cameron Highlands, a hilly area of Malaysia [14], and the second is the lowland high urban settlement areas of Ipoh [15]. Thus, the ability of satellite-based precipitation to provide valuable information, since rain gauge measurement was limited, provided

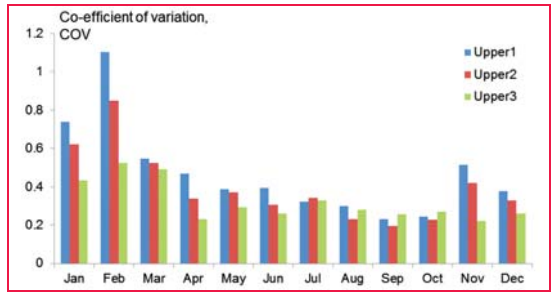

Figure 5: Monthly basis co-efficient of variation (COV) on rain rate derived from the Space-based Precipitation Radar of TRMM at three different upper

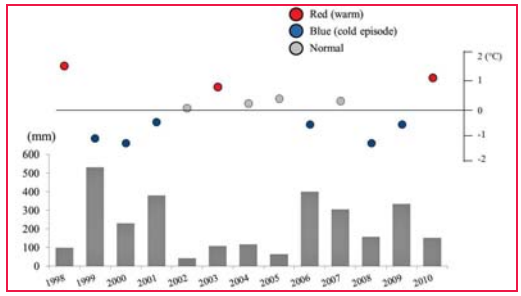

Figure 7: Total satellite derived rainfall in January and February and *Global Oceanic Nino Index (ONI) from 1998 to 2010. (*Source: [21] NOAA National Weather Service – Climate Prediction Center)

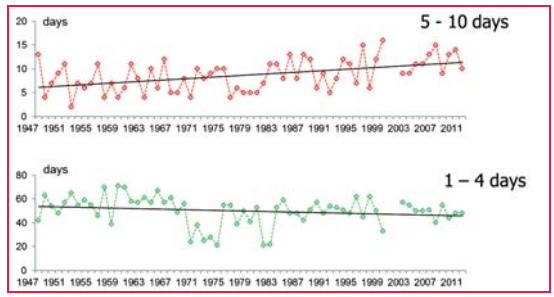

Figure 8: Time series of rainy days pattern from 1947-2011

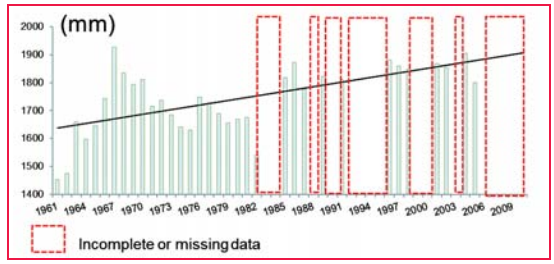

Figure 9: Time-series of the evaporation from meteorological stations from 1961 to 2009

opportunities to realize the effective climate change and natural hazards planning, mitigation and assessment.

III) Successful utilization of space-based precipitation radar which set for global scale basis measurement at local scale environment requires intensive validation and calibration efforts. Even though the preliminary assessment of TRMM rain rate data in Peninsular Malaysia suggests positive correlation with discreet rain gauge [16], however its actual accuracy when converted into rainfall estimates are remained unexplored. Moreover, the rainfall intensity, pattern and seasonality in this region are highly dynamic [6, 7]. A direct use of space-based precipitation radar data into hydrology models revealed that uncertainties vary within geographical conditions and latitudes [9, 17, 18, 19].

Conclusion

The current status of rain gauge distribution spatial analysis in major hilly watershed in Peninsular Malaysia, and the potential of space-based precipitation radar have been presented in this study. The spatial analysis revealed that the rain gauge distribution had sparse coverage on hilly watershed and possessed inadequate efficiency for effective spatial based monitoring. The second analysis indicates that there are significant monthly rainfall changes on the upper part of the hilly watershed for the last 13 years which occurred occasionally in different years of 1999, 2000, 2001, 2006 and 2009. This phenomenon can be associated with the cold temperature of La-Nina. The study informed the potential and opportunities of space-based precipitation radar to fill the gaps of knowledge on spatio-temporal rainfall behavior for hydrology and related fields.

Acknowledgement

We would like to thank everyone who directly or non-directly involved in this study. High appreciation is devoted to the data provider, Malaysian Meteorological Department, Department of Irrigation and Drainage, National Space Administration (NASA) and Institute of Industrial Science, University of Tokyo.

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GIS & GPS in micro-spatial location analysis of solid waste disposal sites

An analysis of dumper bins in different circles of Hyderabad Municipal Area shows that its distribution is highly uneven

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Urban areas garbage is collected either by a government agency or private contractor. Garbage disposal constitutes a basic and expected service or function of urban local body. Urban solid waste management has become a major issue of concern for many under-developed nations, especially with population explosion. The problem is compounded as many nations continue to urbanize rapidly. The percentage of India's population living in cities and urban areas has doubled. The garbage generated in the city has to be stored and collected at some common point from where it can be transported finally to the landfill sites or dumping yards. The primary collection and storage points are the dumper bins. They are large bins/containers which are placed at a location where large quantity of waste can be collected. These bins are directly transported by a dumper placer to Transfer Stations. The placement of bins to various locations depends upon the type of locality and amount of waste generated, access to road. etc.

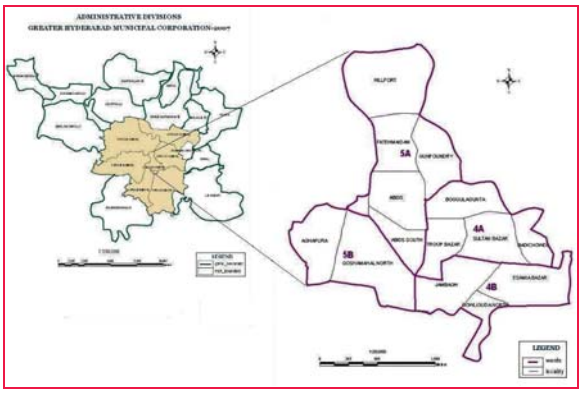

Figure 1: Circle VI–MCH location of ward and localities

Study area

The present study area is a part of Hyderabad Municipal Area Circle VI. It is the centrally located circle of Hyderabad city (Figure.1). It is the smallest of all circles, consisting of four wards. The area covered by this circle is less than six sq km. It is well served by road network. This circle includes the CBD of Hyderabad. Accordingly, the landuse of this circle is mixed in nature, i.e., it is characterized by commercial, institutional and residential landuse. Since it includes CBD and also due to its central location, this circle is well connected with other parts of the city. This circle is divided into four wards, i.e., 4A, 4B, 5A, 5B and 14 localities. Circle VI of Municipal Corporation of Hyderabad covers an area of 5.42 sq km. This circle recorded 38 slums and all these slums are notified slums. Circle VI registered 40,000 households and 6,000 commercial establishments.

Objectives

1. To locate dumper bins with GPS and its spatial analysis
2. To suggest optimal and new location of dumper bins using GIS
3. To generate inter distance dumper bin index

Methodology/Database

The study is based on secondary data which is supplemented by primary data. The secondary data is mostly collected from the Municipal Corporation of Hyderabad, Census of India. Road network is captured from survey of India Toposheets and other published sources. The primary data is collected based

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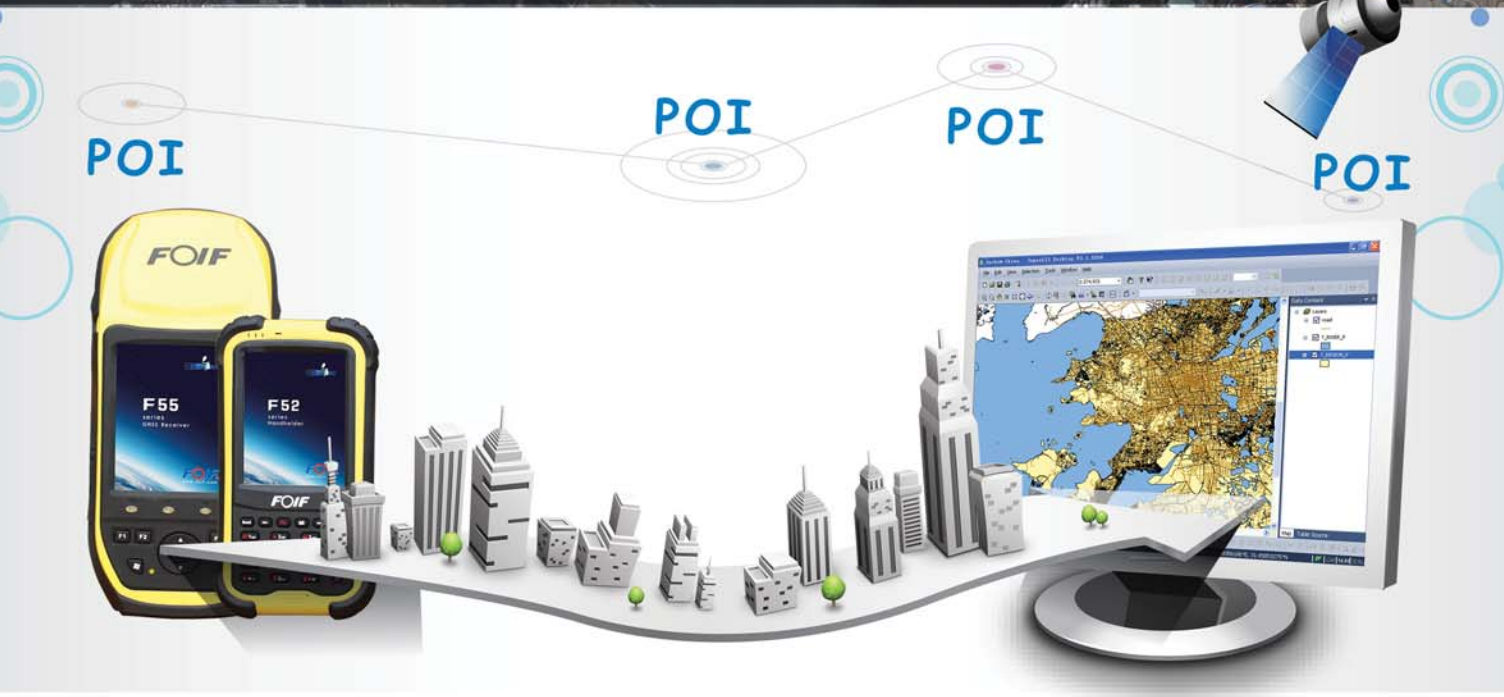

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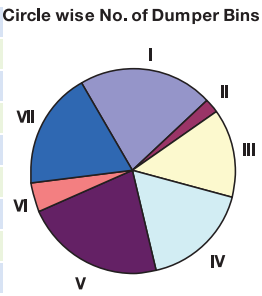
Table 1: Hyderabad city – Distribution of dumper bins–2007

Circle	No. of bins	%
I	488	21.4
II	50	2.2
III	321	14.1
IV	381	16.6
V	509	22.3
VI	108	4.7
VII	426	18.7
Total	2283	100

Source: Municipal Corporation of Hyderabad



on questionnaire surveys. Sampling technique is used for the generation of primary data. Arc GIS software is used in processing, presentation and analysis of data. Buffering and network analysis is used in the location of dumper bins and routing purpose. GPS survey is done to locate dumper bins. Each dumper bin is given an ID No. The data is presented in the graphical and in the form of various types of thematic maps.

Distribution of dumper bins in Municipal Corporation of Hyderabad

For efficient Solid Waste Management, information about the number of bins and its distribution is vital. An analysis of dumper bins in different circles of MCH shows that its distribution is highly uneven. Maximum number of dumper bins are located in circle V (509) constituting about 22% of total number of bins in Municipal Corporation of Hyderabad (Table 1). Circle V of Municipal Corporation of Hyderabad is associated with high income households. This circle has more number of high-rise buildings with upcoming commercial establishments. Minimum number of bins (50 Nos) constituting only 2.2% of total number of bins in Municipal Corporation of Hyderabad is associated with circle II. This circle constitutes a part of Hyderabad south, which includes the old historical core of the city. Even though, most of the localities in this circle include densely populated areas, still the numbers of bins are few. This situation calls for immediate focus of urban local body to locate more number of bins and efficient system of garbage collection.

The spatial pattern of distribution of dumper bins in different circles of MCH is presented in Table 1. It is seen from Table 1 that the least number of dumper bins are located in circle II of Hyderabad. The reason for less number of bins in circle VI may be due to its small size. In case of circle II, it could be due to less densely built-up area and less number of bulk garbage generating units. Highest number of bins (>400) are associated with wards I, V and VII which could be due to its large areal extent. It is thus seen that the dumper bins in a particular ward, to a great extent, is influenced by its areal extent and quantum of garbage generated.

Circle VI – Spatial distribution of dumper bins

The dumper bin locations are captured using Global Positioning Survey (GPS). The latitude/ longitude positions are fed in to the system as a dbf file and a shape file is generated for the same. This way, the exact locations of the dumper bins are captured and they are depicted as point feature. Each dumper bin is assigned an ID number. The location analysis of dumper bins is clearly brought out that distribution of dumper bins to a great extent seems to be uniform in case of ward 5A, but it is not the case of ward 5B and 4B. The dumper bin location in ward 5B seems to be clustered in the western side of the ward boundary and along the southern boundary of the ward. The eastern side of ward 5B is ill served in terms of dumper bins location; where as the central part is not at all served by dumper bins locations. Similar is the observation in ward 4B where location of dumper bins are highly agglomerated in western and eastern margins of the ward boundary with a wide area which is devoid of any dumper bins. It is observed that the location of dumper is not properly distributed.

Ward wise analysis of dumper bins

There are 108 existing dumper bins in circle VI of Municipal Corporation of Hyderabad. The number of dumper bins in different wards of circle VI is not uniform. Maximum number of dumper bins is recorded in ward 5A. The reason for highest number of bins in this ward is due to the fact that the area covered by this ward is more. Wards 4A, 4B, 5B are more or less similar in extant of area, but still there is a marginal variation in the number of dumper bins located. Ward 4B has 26 existing dumper bins. Even though the area is not very large, still there are more dumper bins in this ward due to more number of households recorded by this ward. Besides, garbage generated in this ward is also high. Least number of dumper bins is located in ward 4A. The reason for less number of dumper bins is attributed to more number of institutes, hospitals and commercial establishments where garbage is lifted directly by the trucks.

Pin Point Programme (PPP)

Pin Point Programme defines the schedule of Solid Waste Management from the

Table 2: Circle VI – No of dumper bins before and after Pin Point Programme

Ward	Dumper bins before PPP *	Dumper bins after PPP	Decrease in No. of bins after PPP
4A	30	24	6
4B	27	26	1
5A	38	33	5
5B	26	25	1
Total	121	108	13

Source: Municipal Corporation of Hyderabad -2007

* Pin Point Programme

Table 3: Circle VI- No of houses per dumper bin

Ward No.	Dumper bins after PPP	No. of Houses	No. of Houses/Bin
4A	24	5375	223
4B	26	5425	208
5A	33	5900	178
5B	25	4300	172
Total	108	21000	194

Source: Computed based on MCH data

specified dumper bin locations on a daily basis and shift wise regularly. In this programme, each vehicle is tracked for route and waste collection in this route, and transfer it to the Transfer Station and finally the waste is shifted from there to the Jawahar Nagar dump yard. This programme ensures solid waste collection vehicle-wise and route–wise.

The distribution of dumper bins in circle VI of MCH revealed variations in term of its distribution. An analysis of dumper bins before and after Pin Point Programme is done here. This Programme aims toward efficient and sustainable Solid Waste Management. Keeping this in view, it is expected that the number of bins should increase after the implementation of Pin Point Programme for increasing capacity and efficiency of garbage storage and collection. Contrary to this expectation, it is seen that the number of dumper bins decrease from 121 to 108 after the implementation of Pin Point Programme. The purpose behind reducing the number of bins is to increase the collection efficiency and that can be achieved by efficient transportation, i.e., increasing number of tricycle. As seen from Table 2, it is observed that highest number of decrease in dumper bins is reported especially by Ward 4A (6 Nos). No removal of dumper bins is recorded by Ward 5A.

The efficiency of collecting garbage cans is assessed by computing the number of houses that are covered by each dumper bin. It is seen from Table 3 that the number of houses covered per bin is highest in Ward 4A (223 Nos) and least in 5B (172 Nos). The higher ratio of houses to bin is more in Ward 4A and 4B, which is due to the fact that these wards are densely populated areas.

Dumper bin location and transfer station

The garbage from door-to-door collection is dumped into the dumper bins which ultimately are transported to the Transfer Station (TS). The garbage from Circle VI is transported to two nearest Transfer Stations, i.e., Imlibun Transfer Station (ITS) in north and Tankbund Transfer Station (TTS) in south. The garbage from Circle VI is mostly transported to Imlibun Transfer Station, except the dumper bins located in the northern part of the study area (Figure) which is associated with Ward 5A. It includes localities like Hill Fort, Fathemaidan, Gunfoundry, Abids, Abids south. The reason for transferring garbage from dumper bins to the Tankbund Transfer Station is due to its proximal location. Garbage from only one dumper bin in Ward 4A is transferred to Tankbund Transfer Station (figure 2).

Inter bin distance analysis

An analysis of the distance between one dumper bin and another is very important in the collection and transportation of garbage. As seen from Table 4, there are 108 dumper bins in Circle VI. The distance matrix of these 108 dumper bins in different wards is shown in Table 4. The distance between one bin and another is as high as 469 mt (Ward 4A, bin ID 58) and as low as 60 mt (Ward 5A, bin ID 93).

As seen from Table 4, the distance between the nearest dumper bins vary from ward to ward. Out of 108 dumper bins, only 10 bins are located within a distance of <100 mt, constituting 9.25% only. Out of these 10 bins, 7 bins are located in Ward 4B and three in Ward 5A. On the other hand, there are 9 bins which are located at the distance >400 mt constituting 8.33% of the total number of the dumper bins. Maximum

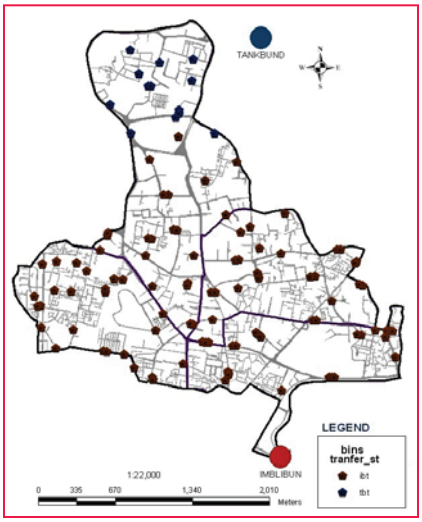


Figure 2: Circle VI-MCH dumper bins and transfer stations

Table 4: Circle VI-Distance to the nearest dumper bin-2007

Ward No.	Inter distance (mts)					Dumper bin (No. s) Total
	<100	100-200	200-300	300-400	>400	
4A	0	2	10	11	1	24
	(0)	(8.39)	(41.66)	(45.83)	(4.16)	(100)
4B	7	4	5	2	8	26
	(26.94)	(15.38)	(19.23)	(7.69)	(30.76)	(100)
5A	3	3	13	14	0	33
	(9.09)	(9.09)	(39.39)	(42.43)	(0)	(100)
5B	0	10	14	1	0	25
	(0)	(40)	(56)	(4)	(0)	(100)
Total	10	19	42	28	9	108
	(9.25)	(17.59)	(38.88)	(25.95)	(8.23)	(100)

Source: Computed based on MCH data

Figures in the brackets are percentages

No of bins at single location

Plate 1 Single bin

Plate 2 Two bins

Plate 3 Three bins

Plate 4 Four bins

number of dumper bins is located within a range of 200-300 mt. Ward-wise analysis of inter distance between dumper bins shows that in Ward 4A, there are no bins located within a distance of <100 mt. Nearly half (45.83%) of the dumper bins in Ward 4A are located in inter bin distance range of 300-400 mt. In Ward 4B, inter bin distance shows that nearly ¼th of dumper bins are located at a distance range of <100 mt. It is due to the fact that the dumper bins are mostly agglomerated in the eastern periphery of the ward. In Ward 5A, most of the dumper bins are located within a range of 200-300 mt. The larger inter bin distance is due to the fact that the area covered by this ward is more.

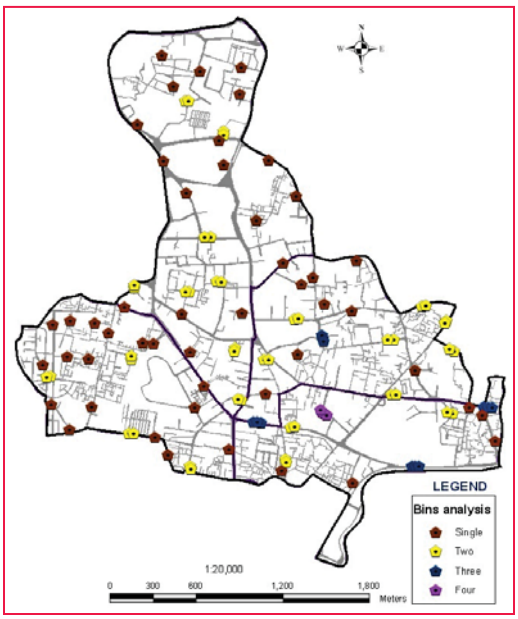


Figure 3: Circle VI–MCH location analysis of dumper bins

Location analysis of dumper bins

As seen earlier, there are 108 dumper bins located in Circle VI. Generally one dumper bin is located at a place, but it is seen in the study area that in different locations, more than a single dumper bin is placed. It is seen that at places the number of bins are more than one. The number of bins at a place is determined based on the quantum of garbage generated, number of houses and houses holds, road conditions, etc.

A cursory glance at Table 5 shows that out of 108 dumper bins in Circle VI, 48 bins are placed at a single location where as in 22 locations two bins are located at a single place. In four locations, three dumper bins are located side-by-side, making a total of 12 bins. Only at

Table 5: Circle VI – No of dumper bins at single location

Ward No.	No. of Bins				Total
	single	two	three	four	
4A	9	6	1	--	24
4B	5	4	3	1	26
5A	17	8	--	--	33
5B	17	4	--	--	25
Total	**48**	**22**	**12**	**4**	**108**

Source: Computed based on Figure

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Table 6: Circle VI- Locality wise distribution of dumper bins

Ward No.	Name of the Locality	NO. OF BINS			
		1	2	3	4
5A	Hillfort	6	2	-	-
5A	Fathemaidan	4	1	-	-
5A	Abids	2	2	-	-
5A	Abids south	2	2	-	-
5A	Gunfoundry	3	-	-	-
5B	Aghapura	11	1	-	-
5B	Goshamahal	6	3	-	-
4A	Boggulakunta	5	1	-	-
4A	Troopbazar	2	2	-	-
4A	Sultan bazaar	1	1	1	-
4A	Badichowdi	1	3	-	-
4B	Jambagh	1	2	1	1
4B	Isamia Bazar	3	2	2	-
4B	Gowliguda	1	-	-	-
	Total	**48**	**22**	**4**	**1**

Source: Computer-based MCH data

Table 7: Circle VI –Location of proposed bins

Ward No.	No. of proposed bins	Locality names
4A	2	Boggulagunta, Troopbazar
4B	2	Jambagh, Esamia bazar
5A	1	Hillfort
5B	2	Goshamahal north, Aghapura

Source: Based on (figure 5)

Table 8: Circle VI – Existing and proposed bins

Ward No.	No. of Existing bins	No. of Proposed bins	Total
4A	24	2	26
4B	26	2	28
5A	33	1	35
5B	25	2	27
Total	108	7	115

Source: Based on (figure 5)

one place were 4 dumper bins placed adjacent to each other. (Plate 1, 2, 3, 4)

The location of dumper bins as seen from Figure 3 reveals that the number of dumper bins in each location is not the same. In Ward 4A, nine locations are associated with single bins whereas in six places, there are two bins placed in a single location. There is only one place with three bins located at the margin of Sultan Bazar, Troop Bazar locality. There are no sites with four bins in Ward 4A. In Ward 4B, single bins are located in only 5 locations, whereas double bins are located in 4 locations and three bins are placed in three locations. The uniqueness of Ward 4B is that it is the only ward where 4 bins are located at a place that is in Jambagh locality. Two bins located at a single point in Ward 4B are associated with locality like Badchowdi, Jambagh, Esamiabazar which are densely populated areas. In Ward 5A, 17 locations are registered as single bins whereas 8 places are recorded as double bins. The circle being commercial and institutional in nature, nowhere in Ward 5A are three and four bins located in a place. At 17 places in Ward 5B, single bins are located whereas in four places, double bins are located. No place with three and four bins is seen in this ward.

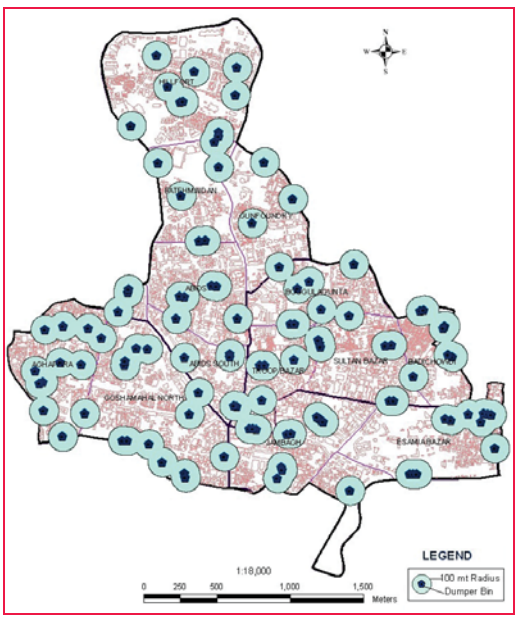

Figure 4: Circle VI-MCH distribution of dumper bins

Locality-wise analysis of dumper bins revealed that maximum number of single dumper bins is located in Aghapura locality of Ward 5B. The problem of garbage collection and storage in this locality is substantiated by the fact that it is one of the largest localities with more number of premises and units. Only in one place are two dumper bins placed at a single location. Gunfoundry locality in Ward 5A is the only locality with a distinction of not having more than one dumper bin located in a single point. Esamia Bazaar locality in Ward 4B is the only locality where three dumper bins are placed in a single location. Ward 5A and 5B are do not have localities with 3 or 4 bins at a single point.

Optimal location of proposed dumper bins

The distribution of dumper bins with a radius of 100 mt is shown in figure 4. The radius of 100 mt is considered here as an ideal distance from the point of view of collection of garbage. Buffering is used here as a decision support mechanism in the identification of gaps in the location of existing dumper bins. The location of dumper bins with a buffer of 100 mt radius revealed that there are gaps existing where new dumper bins can be located. It is observed from the figure that overlap in certain places. An attempt has been made to identify new locations based on the existing gaps.

An analysis of existing dumper bins based on buffering technique revealed that there are certain gaps in the location of dumper bins (Figure 4). To identify new locations of dumper bins, buffers are drawn (100 mt) around dumper bins. Taking into consideration the transportation network, garbage generation, new location of dumper bins are proposed. Already

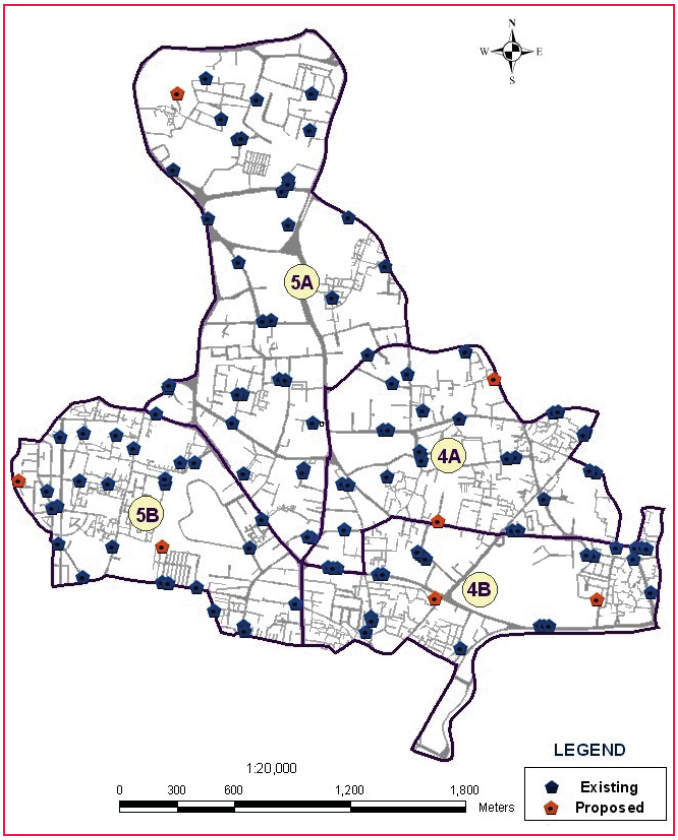

Figure 5: Circle VI–MCH existing and praposed dumper bins

there are 108 dumper bins in Circle VI. Seven more new dumper bin locations are identified. In Ward 4A, two new bins have been proposed, one at Boggulagunta and another at Troop Bazaar.

With two proposed dumper bins, the number of dumper bins in Ward 4A will be increased from 24 to 26. In Ward 4B also, two new places have been proposed for the location of dumper bins - one at Jambagh and another at Esamia Bazaar. The total number of dumper bins in Ward 4B will be increasing from 26 to 28. In Ward 5B, the proposed location of dumper bins are at Aghapura, Goshamahal north. With these two new proposed locations, the total number of bins will increase from 25 to 27 in Ward 5B (Figure 5). In Ward 5A, only one location has been identified in the Hillfort locality. Even though this ward is very big, the proposed location is only one due to the fact that, this ward has large number of bulk garbage generating units where the garbage is collected at the door step. Besides, the number of households is also less as compared to other wards.

Conclusion

It is observed that the location of the dumpers has not been properly distributed. Ward wise analysis revealed that the number of dumper bins to a great extent has been influenced by quantum of garbage generation and areal extent of the ward. The ratio of houses to bin is related to the density of population. The inter distance matrix of dumper bins revealed that there is a wide variation. The four bins at single location are related to density of population. Buffer analysis revealed the gaps and overlaps in the location of bins. Based on buffering technique new location of dumper bins is proposed on terms of inter bin distance.

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Open series map No. E 44 M 11 (56 K / 11), 1: 50,000 scale, 1st Edition 2012, Survey of India

N K Agrawal
Former Director, Indian Institute of Surveying and Mapping (STI), Hyderabad, India

It is good to note that the above map is available on glossy paper and price at Rs. 85/- only. The critique is given in the following points:

Under the heading NOTES.
The two notes are given:

- Note 2, Heights are in metres and above Indian Mean Sea Level.
- Note 4, The triangulated heights and contours in this sheet have not been adjusted to the heights of the spirit leveled bench marks and may not be strictly in accordance with them.

It appears that Note no. 2 has been given in view of the map being on WGS 84 datum. It would therefore be appropriate to make it clear in the notes that Vertical datum in this map is Indian Mean Sea Level.

This map has been published as "1st Edition 2012". I have a copy of the same map which was published as "1st Edition 2006" published under the direction of previous surveyor general Major General M. Gopal Rao. The anomaly needs correction.

It is good to note that qualifications of the Surveyor General do not appear on the map whereas these appeared in the previous map, 1st Edition 2006.

In the COMPILATION INDEX, it is shown that western half part of map marked A and C, has been compiled from 1:25000 scale maps surveyed during 1971-72. Eastern half marked B has been compiled from 1:50000 scale map surveyed during 1972-73. Maps 56K/11/NE 1st Edition 1998 and 56K/11/SE 1st Edition 2000 on 1:25000 scale comprising eastern half marked B. It is hard to imagine as to why these maps surveyed during 1996-97 were not used to compile the map under review.

It is certainly improper to use 1:50000 map of 1972-73 survey ignoring 1996-97 survey maps on 1:25000 scale. This has resulted in many errors/omissions in the map under review. This needs to be explained to user public by the concerned authorities as tax payer's money is involved.

Colour scheme needs improvement. Temples, mosques, churches etc. shown in black seem obliterated due to dark colour of building blocks.

Temples, mosques, churches etc. are being shown in black. It will be better if these are shown in red as s being done earlier. Needs reconsideration.

It will be better if due importance to DISTRICT and STATE is given by showing them as Heading as was being done earlier. It is felt that due consideration and attention is paid to all laid down principles given in chapters of Survey of India.

GAGAN passes certification milestone

30th December 2013 is an important milestone in the history of Indian civil aviation as initial certification of GAGAN (GPS Aided GEO Augmented Navigation) has been issued by DGCA and India joins the elite club of countries along with USA, Japan and Europe to implement the operational SBAS (Satellite Based Augmentation System). The certification will enable Indian Flight Information Region (FIR) to support satellite based augmentation services for precision navigation by suitably equipped aircraft. Airports Authority of India (AAI), plans to develop closely spaced routes that will allow increase in capacity, reduce fuel burns through flexible routings and ensure satellite based approaches to every runway end, thereby reducing the dependence on costlier ground based navigation systems. The transition from ground to satellite based systems will; however depend on the time that will be required for all airlines to operate the suitably equipped aircraft.

The GAGAN certification challenge was addressed through the establishment of expert Technical Review Team (TRT) by DGCA comprising experts from DGCA, AAI, ISRO, Indian Institute of Science, Bangalore, and experts from system integrators from abroad. The TRT worked in collaboration over two years to ensure that GAGAN system met the safety critical standards for its usage in civil aviation. ISRO/AAI developed Operation testing and evaluation tools to analyze the GAGAN performance over Indian region. Indian region lies within equatorial anomaly region and posed challenges that were not experienced by other SBAS providers.

U.S. FAA downgrades India aviation rating

U.S. authorities have downgraded India's aviation safety rating, citing a lack of safety oversight, meaning Indian carriers cannot increase flights to the US and face extra checks for existing ones. India's government said it expected to resolve by March all concerns raised by the U.S. Federal Aviation Administration, including appointing an adequate number of flight operation inspectors, and would approach the U.S. regulator for a review of its decision.

According to the US regulator, "The FAA has determined that India at this time is not in compliance with the international standards for aviation safety oversight," India joins countries such as Indonesia, the Philippines and Bangladesh that have a Category 2 rating. As of November 22, the FAA kept 81 of the 96 countries reviewed in Category 1. *http://in.reuters.com*

Enhanced Differential Loran to back-up GNSS successfully tested

Dutch company Reelektronika has developed and successfully tested Enhanced Differential Loran (eDLoran) to back-up GNSS. When piloting deep-draught vessels bound for Rotterdam - where the pilot boards about 35 miles off the coast - the Dutch Pilots' Corporation (Nederlands Loodswezen) currently makes use of a portable, autonomous navigation aid based on GNSS. By law, ships navigating the Eurogeul and Maasgeul shipping channels in the North Sea are required to carry an autonomous navigation system.

Totally independent of GNSS and working in a completely different part of the spectrum (100 kHz), eDLoran uses signals transmitted by towers in England, France and Germany. Based on these signals, a location can be determined with an accuracy of better than 5 metres, meeting the Government Port Approach Systems specification. The test system that has been implemented includes an eDLoran reference station and eDLoran receivers for the pilots.

No GLONASS stations in US without Pentagon's approval

US President Barack Obama has signed a bill hindering the construction of GLONASS stations on the US territory. The document rules that the matter requires the Secretary of Defense and the Director of National Intelligence to report the case to Congress first. Under the Republican-proposed bill, the Pentagon and CIA chiefs are to provide assurances that GLONASS stations will not be used for spying against the US or for improving the efficiency of Russian weapons, the New York Times says. The signing was preceded by protracted debates between various US agencies and departments.

In 2012, Russia's Roscosmos space agency announced plans to build eight monitoring stations on US soil to improve the accuracy of GLONASS. Russia has 19 ground-based GLONASS stations on its own territory. *http://voiceofrussia.com*

Lack of plow information due to faulty GPS

The New York City Sanitation Commissioner said a map that showed unplowed streets on the Upper East Side was due to a faulty GPS system. It was on a salt spreader, and also blamed traffic problems for streets not being plowed. The city's map showed no plowing at all on numerous Upper East Side streets – specifically east-west streets from 59th Street to 67th Street east of Lexington Avenue. *www.vosizneias.com*

Dark matter surrounding earth a possibility

In a major breakthrough, a GPS expert has discovered more grounds to believe that the earth can indeed be surrounded by an invisible halo of dark matter - the stuff that possesses mass and yet can't be seen. After analysing nine months of data collection from global navigation satellite systems, GPS expert Ben Harris of the University of Texas found that his measurement of earth's mass came in at between 0.005 and 0.008 percent larger than the "official" mass measurements as quoted by the International Astronomical Union (IAU). *www.business-standard.com*

Isro to launch three IRNSS satellites this year

The Indian Space Research Organisation (Isro) will launch three satellites belonging to the Indian Regional Navigation Satellite System (IRNSS) constellation this year. IRNSS is an independent regional navigation satellite system designed to provide position information in the

Indian region and 1,500 km around the Indian mainland. *www.dnaindia.com*

BeiDou declares full FOC

Chinese BeiDou Navigation Satellite System (BDS) has declared full operational capability (FOC) for its regional service. The BDS program also released two new technical documents, including an updated interface control document (ICD) that describes the second civil signal, B2I, and a "BDS Open Service Performance Standard (version 1.0)."

Fighting climate change with GPS mapping

Indigenous communities in Indonesia are using GPS technology to demarcate the boundaries of their ancestral lands; a move many believe could also help mitigate the negative effects of climate change. Indonesia's dense forests are home to an estimated 50-70 million indigenous people, and 10 percent of all known plant species, according to AMAN and the Rainforest Action Network, a non-profit international environmental advocacy group headquartered in San Francisco.

More than 600 cases for land rights have been filed in Indonesian courts by indigenous communities in the past three years, according to the Tebtebba Foundation (Indigenous Peoples' International Centre for Policy Research and Education), based in the Philippines. These advocates of sustainability and tribal rights hope the two- and three-dimensional maps will help the thousands of diverse aboriginal groups to guard the health of the environments they depend on for survival. *www.irinnews.org*

800 GPS-fitted ambulances in rural Jammu & Kashmir

Around 800 ambulances fitted with GPS would be made available for patients in rural areas in Jammu and Kashmir, India. People in rural areas would only need to dial the toll-free number 102 to avail ambulance services fitted with GPS under the National Rural Health Mission (NRHM) *www.business-standard.com*

Tracking underground firefighters

The KTH Royal Institute of Technology in Stockholm has developed sensor-equipped footwear that, using sensors inside the heel of a boot, makes it possible for incidents commanders to follow firefighters' movements independent of the infrastructure they're working in. The system includes advanced sensors such as accelerometer and gyroscope plus a processor. It can withstand shock and extremely high temperatures and remains operational where GPS positioning systems fail. A wireless module worn on the shoulder sends the data to operational command, which provides incident commanders the precise information about responders' location and movements. The system has been tested successfully with firefighters in real time, 25 meters below ground. *www.fireengineering.com*

Enhanced LBS by AT&T & Sabre

AT&T and Sabre are developing and testing solutions that will utilize AT&T's newly enhanced Location Information Services (LIS) – Hybrid, which allows developers to build geo-aware mobile applications. The companies are exploring how device-based location information services can help airlines, airport retailers, and other travel-related companies deliver intelligent, predictive and personalized services throughout a traveler's journey. It has the ability to define custom geofences (a virtual perimeter within a geographic area) in any shape or size, both indoors and out, using cellular, GPS and Wi-Fi information shared by the user from their devices. The app might alert airline staff when a high-status passenger is still clearing security when her flight is due to depart; or notifies travelers of special promotions as they approach an airport bookstore.

Sensor Platforms adds pedestrian dead reckoning

Sensor Platforms has added Pedestrian Dead Reckoning (PDR) to its FreeMotion™ Library, enabling applications such as indoor navigation, activity monitoring, and LBS in mobile devices. The PDR algorithms allow accurate position results using only the mobile device sensors, without the aid of GPS, Wi-Fi, or maps. Sensor Platforms' PDR solution is sensor fusion-enabled to handle magnetic anomalies in real-world environments and context awareness-enhanced. Employing context capabilities allows for naturalistic changes in device placement (in-hand front, at-side, in-pocket, etc.) without compromising performance. With the FreeMotion PDR Library, typical position estimates stay accurate to within 5 percent of distance traveled. Sensor Platforms utilizes context in order to separate the actual travel direction of the user (called bearing) from the device orientation. Other unique features include false-step mitigation, stair-elevation tracking, and in-elevator transport. As with all Sensor Platforms products, the PDR Library is both sensor and platform agnostic. *www.pddnet.com*

Malaysia launches tracking system

A special satellite tracking system will be implemented in Malaysia that will enable authorities to monitor taxis and passengers to lodge complaints immediately. Taxis will soon be equipped with GPS technology, allowing the government to not only direct a taxi to a waiting customer, but also monitor a driver's habits. Known as the Centralised Taxi Service System (CTSS), it is currently being developed by the Land Public Transport Commission (SPAD) and is slated for rollout in the Klang Valley in the third quarter of this year. *www.thejakartapost.com*

Cellular providers to submit report on LBS

Department of Telecom (DoT),India has asked cellular operators - Bharti Airtel, Idea Cellular, Reliance Communications and BSNL, to submit reports for accuracies achieved by them in implementing location-based services. DoT said operators were asked to submit the compliance report with respect to accuracies achieved so far by them, which can be used as input for deciding the methodology of measurement and for preparing roadmap for implementation of the accuracies. In 2011, government had made it mandatory for telecom service providers to introduce location based services across the country within three years. *PTI*

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Galileo update

Galileo satellites locate aircraft by GPS

Galileo satellites have recently achieved first successful in-flight tracking of a test machine using aircraft-generated longitude, latitude and altitude. A pair of Galileo test receivers was used aboard the aircraft, the same kind currently employed for Galileo field-testing.

The evaluations were scheduled during periods in November when all four Galileo satellites were visible in the sky. Positioning fixes require at least four satellites. The receivers fixed the airplane's position and determined key variables such as the position, velocity and timing accuracy, time to first fix, signal-t- noise ratio, range error and range-rate error. Test flights were also conducted during takeoff, straight-and-level flight at a constant speed, circling maneuvers, straight-and-level flight with alternating speeds, turns with a maximum bank angle of 60 degrees, pull-ups and push-overs, as well as approaches and landings. The satellites also allowed positioning to be carried out at speeds up to 245 knots. *www.ainonline.com*

European Satellite Navigation Galileo services will start at the end of 2014

Galileo and Copernicus, the EU Earth monitoring programme, are in decisive phases this year. With the launch of six additional Galileo satellites, Europeans will soon be able to enjoy their own satellite navigation system. The first Copernicus satellite launch in March will also enable considerable progress in improving maritime security, climate change monitoring and providing support in emergency and crisis situations. The progress in both programmes was announced by Vice President Antonio Tajani recently. Galileo services should be available, subject to finalising all technical issues, at the end of 2014/beginning of 2015. *http://europa.eu/rapid*

Czechs to test Galileo satellite system for jamming

The tests of the European Galileo navigation system's resistance to jamming will take place in one of military training areas in the Czech Republic, Czech Defense Ministry's spokesman Jan Pejšek told ČTK. The Prague-seated agency has assigned the test operation to the Czech National Security Office (NBU), which, on its part, invited the Defense Ministry to cooperate on it because the military has both jammers and training grounds suitable to test Galileo.

ESA says it won't be penalized for Galileo delays

The European Space Agency will not be subject to financial penalties following the one-year delay in the launch of Galileo satellites because the commission did not sign an industrial contract with the agency for the Galileo work, ESA Director-General Jean-Jacques Dordain said recently. Under the European Commission's agreement with ESA, the commission pays for ESA's staff costs and ESA acts as technical manager for the program. But the industrial contract to build the coming Galileo satellites was not an ESA-EU affair.

EC Vice President Antonio Tajani in October warned that financial penalties to those building Galileo would cover the cost overruns due to the one-year delay in launching the system. He did not specify the amount, and his remarks appeared to be aimed at ESA as much as the industrial consortium led by OHB AG of Germany and Surrey Satellite Technology Ltd. of Britain. *www.spacenews.com*

In-car ads based on location

BMW's iDrive infotainment system could become a lot more annoying as the company is developing a location-based advertising service. Dubbed the "virtual marketplace of the future," the project aims to deliver "location-based offers and services relevant to a specific route and final destination. The system is currently being tested on a 7-Series prototype.

Nokia's Here launches community mapping pilot in India

Nokia's mapping business Here has launched a community mapping pilot in India. Here will combine its industrial data collection methods with a crowd mapping initiative. With a team of more than 1,000 people in India, the regional Here will work directly with handpicked local experts from universities. To maintain accuracy and ensure map quality, Here has built a community map moderation system to verify edits before integrating them into the base map. The project in India is part of an ongoing series of pilot programmes for community mapping capabilities. *www.telecompaper.com*

Honda to join Google alliance

Honda Motor Co. shall join an alliance of companies that will work with Google Inc. on technological innovations for inboard automotive information networks, such as GPS. Other automakers in the Open Automotive Alliance include Audi AG, General Motors Co. and Hyundai Motor Group. The alliance plans to incorporate Google's Android operating system into automotive communications systems. *http://ajw.asahi.com*

Location-Based Big Data Solutions by GCS and Global Touchpoints

GCS, a geoanalytics company, is teaming with Global Touchpoints Inc. to develop Big Data solutions combining business intelligence and geospatial analytics for state and local government agencies. Both will be targeting government offices with Big Data challenges related to healthcare, energy/utilities, and water resource management. *www.Touchpointsinc.com*

First professional grade civilian mapping UAS successful

Applanix Corp and American Aerospace Advisors Inc have completed a successful series of test flights of AAAI's RS-16 platform equipped with Applanix' DMS-UAV aerial photogrammetry payload. This is the first successful mission for a long-endurance UAS (unmanned aerial system) capable of producing professional grade, directly georeferenced mapping imagery for civilian applications such as pipeline monitoring, power line and emergency response mapping. Tests were conducted over restricted airspace in the state of New Jersey. A joint team from Applanix and AAAI planned and flew a sequence of missions to evaluate the capabilities of the UAS. *www.applanix.com*

Beijing to step up aerial surveys of disputed islands

The State Oceanic Administration (SOA) will conduct regular aerial patrols over all islands claimed by China, intensifying air and sea surveillance in the East and South China seas. The SOA recently issued instructions for patrols that will be supported by high-resolution aerial photography and video and new aerial remote sensing technology. The most important islands will be surveyed at least twice a year. *www.scmp.com*

China's HD earth observation satellite is on

China's high-definition earth observation satellite "Gaofen 1" is now in operation. It is expected to play an important role in disaster relief, resources, and environmental survey. It is China's first high-resolution remote sensing satellite, was launched into space in April. It be followed into space by another four satellites before the end of 2016, forming a high-definition earth observation system. *http://english.cri.cn/*

ScanEx RDC starts to spread COSMO-SkyMed radar images in Russia

ScanEx Research & Development Center and the Italian e-GEOS company have signed a reseller agreement, under which ScanEx RDC began to distribute COSMO-SkyMed radar images in Russia. For now on ScanEx RDC is capable of providing data received from all operating commercial ERS radar satellites! *http://press.scanex.ru/*

EU's first Sentinel to launch 'in April'

Copernicus will fly a constellation of satellites known as the Sentinels to take a continuous "health check" on the planet and to acquire data that can help inform and enforce EU policies. It has been announced that the first spacecraft in the series will go into orbit, most likely, in early April. Sentinel 1a will use radar to map the surface of the Earth. A key role will be to provide rapid damage maps to enable emergency services and aid agencies to respond to natural disasters such as earthquakes and severe flooding events. *www.bbc.co.uk/*

Belgian consortium to build Vietnamese EOS

A consortium of Belgian aerospace companies including QinetiQ Space have signed a pre-contract agreement with the Vietnam Academy of Science and Technology (VAST). The contract consists of the construction of the satellite, ground station and test facilities, the training of Vietnamese partners, and the operation of the satellite for one year. Alongside the aerospace company from Kruibeke, the Walloon companies Spacebel and Amos are also part of the entirely Belgian consortium. *www.spacenv.qinetiq.com*

Italian Predator B UAVs to get maritime wide-area search capability

The Italian Air Force (Aeronautica Militare Italiana [AMI]) is to upgrade its General Atomics Aeronautical Systems, Inc (GAASI) MQ-9 Predator B medium-altitude long-endurance (MALE) UAVs with a new maritime radar mode for search-and-rescue (SAR) duties. The AMI's six MQ-9s will have their Block 30 Lynx Synthetic Aperture Radar/Ground Moving Target Indicator (SAR/GMTI) multimode radars enhanced with a maritime wide-area search (MWAS) mode that is optimised for detecting and imaging very small vessels, such as those used by migrants crossing the Mediterranean Sea from North Africa. *www.janes.com*

French-UAE intel satellite deal in doubt

A United Arab Emirates (UAE) deal to purchase two intelligence satellites from France worth almost 3.4 billion dirhams (US $930 million) is in jeopardy after the discovery of what was described as "security compromising components.

A high-level UAE source said the two high-resolution Pleiades-type Falcon Eye military observation satellites contained two specific US-supplied components that provide a back door to the highly secure data transmitted to the ground station. *www.defensenews.com*

Ground-based UAV radar at five sites by US Army

The US Army plans to install a new ground-based sense and avoid (GBSAA) network at five installations by 2016 to ensure its UAVs can deconflict with other aircraft in domestic airspace. The five sites are Fort Hood in Texas, Fort Riley in Kansas, Fort Stewart in Georgia, Fort Campbell in Kentucky, and Fort Drum in New York. The army decided to develop GBSAA as a more efficient means of complying with Federal Aviation Administration (FAA) regulations for flying in domestic airspace. The FAA requires aircraft in domestic airspace to be able to 'sense and avoid', a problem for unmanned aircraft with no pilot in the cockpit.

Army, LAPAN agree to develop rockets

The Indonesian Army (TNI AD) and the National Institute of Aeronautics and Space (LAPAN) signed a Memorandum of Understanding (MoU) to develop missiles, rockets, and unmanned aerial vehicles. LAPAN will develop technologies for rockets, remote sensing satellites, atmospheric sciences and technology for unmanned aerial vehicles for spying and monitoring activities to support the state defense. *www.antaranews.com*

Views sought on the implementation of the INSPIRE

The European Commission, Directorate-General Environment, is inviting comments on the implementation of the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive (2007/2/EC).

The consultation is being held seven years after the Directive came into force to assess whether actions being taken to establish a spatial information infrastructure are still on course to meet the Directive's objectives. Views are sought from stakeholders including INSPIRE national contact points, regional and local public authorities who produce or use spatial data and services, the academic sector, the private sector and European citizens.

The questionnaire covers issues such as user or producer experiences of spatial data and services; the use of EU, national and regional geo-portals as gateways to spatial data and services; co-ordination efforts by the EU and national governments to implement INSPIRE; and evaluation of its cost-efficiency. Other questions relate to the major challenges, benefits and drawbacks of INSPIRE and its positive or negative effects on environmental and other policies such as eGovernment.

3D National Topographic Model for Singapore

In an attempt to make exchange and utilization of topographic information among agencies easier, the Singapore Land Authority is heading a government-backed program to build up a 3D national topographic model! The initiative will include data acquisition both on ground and in the air. The SLA is trying to create a more efficient 3D topographic database that will allow better maintenance to keep all 3D data updated all the time.

The model will be highly helpful in meeting needs such as flight path planning, flood risk modeling and environment and coastal protection! A key dataset produced from this project will be the National Digital Elevation Model (DEM). Already, SLA has received many requests from Agencies on this for their planning, operational and developmental needs

ERC funds IIASA crowdsourcing project

The European Research Council has awarded a highly competitive Consolidator Grant to Steffen Fritz, leader and creator of IIASA's citizen science project, Geo-Wiki. The €1.4 million grant will build upon work conducted as part of IIASA's Geo-Wiki project, an interactive online project which involves citizen scientists in global land cover research. It will take the team's research from the computer to the real world, building a global network of citizen scientists to provide on-the-ground data such as photographs and land-cover and land-use classifications.

Previous work by the Geo-Wiki team has produced improved cropland maps based on crowdsourced data from volunteers who classify land cover data from high-resolution satellite imagery. Previous research from the team shows that in fact, non-experts can be just as good as experts in performing some of these tasks, such as recognizing human impact on a landscape. *www.iiasa.ac.at*

Donation for prevention of violent, road-traffic injuries

The Jamaica National Building Society Foundation has boosted the progress of the University Hospital of the West Indies (UHWI) Data Mapping Project in the sum of $6.8 million.

The project, which is in collaboration with the Ministry of Health, the Violence Prevention Alliance and Mona GeoInformatics, will, among other things, seek to chart and analyse the burden of violence and motor vehicle-related injuries on hospital services across the island, with emphasis on the UHWI. *http://jamaica-gleaner.com*

CIO and Amity Univ MoU

A memorandum of understanding (MoU) has been signed between Central Informatics Organisation (CIO) from the Kingdom of Bahrain and Amity University from India. The MoU will encompass many promising benefits which will reflect positively on the CIO in particular and the Kingdom in general. The MoU also comprehends the CIO as a distinguished partner in the region and supporting many of the organisational programmes especially training programmes, building technical capacity and other benefits. The MoU also demonstrates the influence of the Kingdom of Bahrain represented by the CIO in the GIS field which complimented many regional and international organizations desire to cooperate with the organisation.

Japanese public and private sectors to help set up geographical database

A central government ministry in Japan is preparing to compile a hodgepodge database of infrastructure locations, flows of people and other geographical information for improved disaster management measures, such as where to send disaster victims and how to transport relief supplies. The database, to be set up by the Ministry of Internal Affairs and Communications, will be compiled from information provided by local governments and private-sector companies. The ministry also plans to make the database available to the public to encourage the development of new business ventures. The ministry, which allocated 1.4 billion yen in the fiscal 2014 draft budget to help build the system, plans to start operating it fully in 2016. *http://ajw.asahi.com*

Marine Mapping Program in Ireland

Ireland's Minister for Natural Resources, Fergus O'Dowd, has set out details of upcoming projects in the National Marine Mapping Programme (INFOMAR), and pledged Government commitment of €15m ($21m) for the next five years, for the continuation of what he called "the most valuable resource for marine

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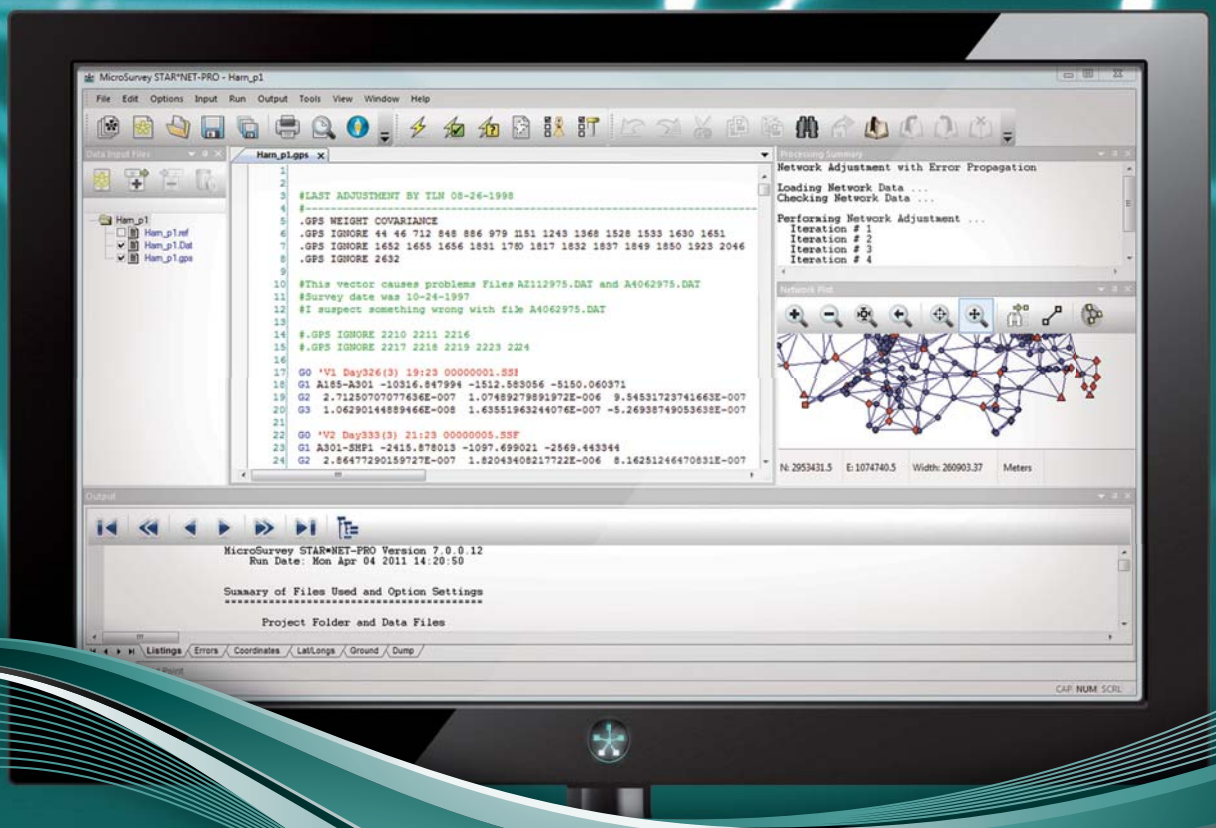

MicroSurvey®

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www.microsurvey.com +1 250 707 0000

research and development in Ireland and beyond". Covering some 125,000 square kilometers of underwater territory, the INFOMAR project is producing new mapping and integrated products covering the Irish maritime space. It provides seabed surveys, which are used in all activities from planning for offshore renewable energy projects to ensuring shipping lanes are safely charted. *www.maritime-executive.com*

KCSC in Spatial Information Market Vietnam

The Korea Cadastral Survey Corporation (KCSC) will export its spatial information technology to Vietnam. It will establish a comprehensive land information management system. The US$3.5 million project is a part of the official development aid of the Korea International Cooperation Agency (KOICA) in Vietnam, and is scheduled to be completed in 2015. The corporation is going to move ahead with the project on a public-private cooperation basis in conjunction with the Korea Research Institute for Human Settlements and some small to mid-sized enterprises. *www.businesskorea.co.kr*

SuperGIS Desktop 3.2

Supergeo Technologies has announced the release of SuperGIS Desktop 3.2, the newest desktop GIS software. It integrates abundant GIS tools, helping GIS users from various domains develop a professional platform to effectively geoprocess and analyze, display, edit, manage, and query spatial data. *www.supergeotek.com*

SGI conducts survey at Indo-Myanmar border

To settle the existing border dispute at the Manipur sector of the Indo-Myanmar border, Surveyor General of India (SGI) conducted a survey. An official team of the SGI currently camping at Moreh, the border town of Manipur at the border with Myanmar has been conducting the survey. The team is conducting the inspection with the help of satellite imagery. *www.nagalandpost.com*

Juniper Systems' rugged handheld computer goes fishing

Rugged handheld computers from Juniper Systems are being used to help protect native species of fish in rivers in the US. The Utah Division of Wildlife Resources (DWR) is managing an invasive fish removal program. Using a Juniper handheld device loaded with custom fisheries software, field scientists monitored native fish species and removed invasive fish along the Green River, near scenic Dinosaur National Monument. The researchers rode along in a boat with electrodes protruding into the water. The electrodes send out an electrical current, temporarily stunning the fish, which subsequently float to the surface, where they are netted and inspected. *www.junipersys.com*

NovAtel's GAJT® GPS Anti-Jam Antenna for Canadian Army

NovAtel has announced that Public Works and Government Services Canada (PWGSC) has selected its GAJT-700ML antenna for testing on Canadian Army armored vehicles. The GAJT-700ML is the world's first single-unit GPS anti-jam antenna system for land vehicles. The testing is being conducted through PWGSC's Build in Canada Innovation Program (BCIP). NovAtel was selected to participate under the BCIP's "safety and security" priority area. PWGSC will procure a number of GAJT-700MLs on behalf of the Department of National Defense (DND). The Directorate of Land Requirements (DLR) with the assistance of the Quality Engineering Test Establishment (QETE) and the Land Force Trials and Evaluation Unit (LFTEU) will oversee all testing on DND's behalf. *www.novatel.com*

Hexagon Topcon agreement

Hexagon AB and Topcon have announced an agreement for Hexagon to purchase Veripos, which operates a network of more than 80 GNSS reference stations through its subsidiary TerraStar. The regulatory announcement explains that Hexagon, Topcon Europe B.V. and Topcon Corporation have entered into a memorandum of understanding (MoU) related to Veripos, Inc.

Hydrography Geospatial Data Management and Production System for Malaysia

The Hydrographic Directorate of the Royal Malaysian Navy (HDRMN) has a mandate to collect measurements using modern techniques, and provide adequate and timely hydrographic information to support safety of navigation, national development, defense and security, and numerous other activities related to the use of Malaysia's marine environment.

CARIS and local Alliance Partner OKENOS Sdn. Bhd. were selected to implement a Hydrographic Geospatial Data Management and Production System (HGDMPS) at the National Hydrographic Centre (NHC). The enterprise GIS, comprised of Bathy DataBASE and HPD, will allow NHC to increase organizational capability for the management of elevation datasets, production of multiple paper and electronic chart types from a single database source, and improve the sharing of spatial information through a Marine Spatial Data Infrastructure (MSDI).

Epson electronics teams with Geodetics for INS

Epson Electronics America has partnered with Geodetics Inc of San Diego, California, for production of a new variant of its Geo-iNAV product, which is a fully-integrated GPS-aided inertial navigation system that provides real-time, high-precision positioning and navigation for manned and unmanned air, sea and ground vehicles. It combines GPS and proprietary sensor fusion technologies to achieve centimeter-level real-time positioning and navigation for dynamic platforms.

Garmin updated GPSMAP series with GPSMAP 64 range

Garmin have unveiled the latest update to its GPSMAP handhelds. The GPSMAP 64 sports a 2.6 in colour display which, enhanced internal memory to 4GB and

Nine GNSS frequencies available through new JAVAD GNSS receiver

The 864-channel TRE-3 receiver, recently announced by JAVAD GNSS, can simultaneously access all current GNSS signals, with room to spare for multiple-channel tracking of select signals, according to the company. The new product offers many features, including:

- Three ultra wide-band (100 MHz) fast sampling and processing, programmable digital filters and superior dynamic range. After 12-bit digital conversion, nine separate digital filters are shaped for each of the nine GPS L1/Galileo E1, GPS L2, GPS L5/Galileo E5A, GLONASS L1, GLONASS L2, Galileo E5B/ BeiDou B2/GLONASS L3, Galileo altBoc, Galilee E6/BeiDouB3/QZSS LEX, and BeiDou B1 bands.
- Each band consists of a combination of a digital cascaded integrator-comb (CIC) filter and a digital finite impulse response (FIR) filter (up to 60-th order) where signal selection is performed.
- Two types of digital in-band anti-jamming filters (automatic 80-th order and "user selectable" 256-th order).
- Multiple channels to acquire and track each satellite signal. For example, 20 channels can be assigned to acquire the GPS L1 signal, each spaced one millisecond apart. Up to 5 channels can be assigned to track each signal, each with different filter parameters and tracking strategies. This supports acquiring and tracking weaker signals in difficult conditions, especially under trees and canopy — potentially using up to the 864 channels available in the receiver! Several patents are pending.
- 80 dB out-of-band interference rejections: high dynamic range of wide RF bands and highly rectangular digital filters make the receiver much more resistant to out-of-band jamming.
  • High-speed high-dynamic automatic gain control (AGC) to respond to interferences and signal variations.
- Programmable filter width.
- Highly stable digital filters.
- Improved GLONASS inter-channel bias performance.
- New multipath rejection technique.
- 60-MHZ-wide Galileo altBoc band takes advantage of the full benefit of this signal. Its multipath resistance is improved even beyond that of the company's new multipath reduction technique, it asserts.
- 864 GNSS channels allow tracking all current and future satellite signals.
- Three wide-band RF sections enable monitoring spectrums and interferences in three 100-MHz-wide bands.
- TRE-3 can track and decode the QZSS LEX signal messages, making it a unique product on the market in this regard, according to the company.
- Features for time -transfer applications: In time sources where the zero crossing of the input frequency defines the exact moment of the time second, the receiver monitors zero crossings and accurately defines the moment of the time second. An external time interval measurement unit is not required to measure zero crossing and 1-PPS offset.
- Embedded calibrator measures phase and code delays of each of the nine bands in timing applications. External calibration is not required.

TRE-3 is form, pin-out, and command compatible with the company's earlier TRE-G3T receiver. It uses 8-Watts of power, compared to 4-Watts of the TRE-G3T

a quad helix antenna with dual GPS and GLONASS support. *www.garmin.com*

ASR Workbench for Software Defined Radio Module by Loctronix

Loctronix Corporation has launched ASR Workbench, a development toolset for the company's recently released ASR-2300 software-defined radio (SDR) module. The ASR-2300 is a function-rich SDR for high-performance positioning, navigation and timing (PNT), and communication applications. It is a Windows-based Integrated Development Environment (IDE) for SDR applications development and testing.

Bluesky Soars with UltraCam Eagle

Aerial mapping company Bluesky is taking to the skies with a new large format digital aerial photogrammetric camera. Purchased from Microsoft's photogrammetry division the UltraCam Eagle has a larger image footprint and a higher rate of image capture than other cameras on the market. *www.bluesky-world.com*

CHC introduces CGO Software

CHC released CHC Geomatics Office (CGO), a software solution dedicated to post processing static and kinematic GNSS raw data. It supports GPS+GLONASS+BeiDou data in various raw data formats and is compatible with major brands allowing a seamless integration with an existing pool of equipment. *www.chcnav.com*

Mexican Positioning Contract for Veripos

Veripos has been awarded a three-year contract by Marinsa de Mexico SA de CV of Cd Del Carmen, for provision of services aboard two anchor-handling tug supply (AHTS) vessels, Amethyst and Turquoise. Operating in the Bay of Campeche in Mexico, both vessels are being provided with Veripos's Standard2 dual beam service featuring both GPS and Glonass capabilities while significantly increasing observational redundancy to ensure more robust positioning accuracies of better than 1 meter. *www.maritime-executive.com*

Northrop Grumman gets $200 million DoD contract

Northrop Grumman has emerged as the second-biggest winner of Department of Defense contract. As per a $200 million sole-source, partial-foreign military sales, indefinite-delivery/ indefinite-quantity contract to carry out "acquisition and sustainment" for the Embedded Global Positioning System Inertial Navigation System (EGI), Northrop will be responsible to work on platform

integration, modernization, flight test support, technical support, training, engineering, and other efforts associated with EGI. The EGI system according to the Navy is a small, reliable, light weight unit which contains full Precise Position Service GPS on a single standard electronic module, plus a state-of-the-art Ring Laser Gyro inertial navigation system. *www.hispanicbusiness.com*

MDA signs contract with US Air Force

MacDonald, Dettwiler and Associates Ltd has signed a contract valued at US$4.9 million under its Indefinite Delivery/Indefinite Quantity (IDIQ) agreement with the U.S Air Force (USAF), to continue operational support and further enhance the flight path safety system that aids the design of airport approach and departure flight paths. Originally announced in February 2012, the value of contracts awarded to-date under the IDIQ agreement totals approximately US$13.8 million. *http://blogs.ottawacitizen.com*

AECOM selects Trimble Software to manage global construction projects

AECOM, providers of professional, technical and management support services for transportation, facilities, environment, energy, water and government, will deploy several solutions from Trimble's Design-Build-Operate (DBO) software portfolio to improve project workflows, increase visibility and accuracy, and enhance team collaboration for construction projects. *http://buildings.trimble.com*

Trimble Navigation Assigned Patent

Trimble Navigation has been assigned a patent (8,614,642) developed by two co-inventors for methods and apparatus "for processing a set of GNSS signal data derived from signals of a first set of satellites having at least three carriers and signals of a second set of satellites having two carriers." The co-inventors are Nicholas Charles Talbot, Ashburton, Australia, Ulrich Vollath, Ismaning, Germany. *www.4-traders.com*

MARK YOUR CALENDAR

March 2014

Munich Satellite Navigation Summit 2014
25 – 27 March
Munich, Germany
www.munich-satellite-navigation-summit.org

ASPRS 2014 Annual Conference
23 - 28 March
Louisville, Kentucky USA
www.asprs.org

April 2014

ENC-GNSS 2014
14 – 17 April
Rotterdam, The Netherlands
www.enc-gnss2014.com

SPAR International
14-17 April 2014
Colorado Springs, CO, USA
http://www.sparpointgroup.com/international/

Interexpo GEO-Siberia 2014
16 - 18 April
Novosibirsk, Russia
http://expo-geo.ru/event/27_Interexpo-GEO-Siberia-2013

IGRSM 2014
21 - 22 April
Kuala Lumpur, Malaysia
http://www.igrsm.com/igrsm2014/

2014 International Satellite Navigation Forum
23 – 24 April
Moscow, Russia
http://eng.glonass-forum.ru

9th National GIS Symposium in Saudi Arabia
28 - 30 April 2014
Dammam, Saudi Arabia
http://www.saudigis.org/default.aspx

May 2014

China Satellite Navigation Conference
May 2014
Nanjing, China
http://www.beidou.org/english/index.asp

IEEE/ION Position Location and Navigation Symposium
5 – 8 May 2014
Monterey, CA
www.ion.org

Esri Africa User Conference
6 – 8, May 2014
Cape Town, South Africa
www.esri.com/events/auc

Annual Baska GNSS Conference
7 – 9 May 2014
Baska, Krk Island, Croatia
renato.filjar@rin.org.uk

MundoGEO Connect 2014
7 – 9 May
Sao Paulo, Brazil
http://mundogeoconnect.com/2014/en/

GNSS: Principles, Augmentations and Evolutions of EGNOS
12-23 May 2014
Toulouse, France
sandrine.castiglioni@enac.fr

GEO Business
28 – 29 May 2014
London, UK
www.geobusinessshow.com

June 2014

Hexagon Conference 2014
2 – 5 June
Las Vegas USA
http://hxgnlive.com/

ION Joint Navigation Conference 2014
16 – 19 June
Orlando, United States
www.ion.org/jnc

INSPIRE Conference
16-20 June 2014
Aalborg, Denmark
http://inspire.jrc.ec.europa.eu/events/conferences/inspire_2014/

5th International Conference on Cartography and GIS
15 – 21 June 2014
Riviera, Bulgari
http://iccgis2014.cartography-gis.com/Home.html

XXV FIG Congress
16 – 21 June
Kuala Lumpur, Malaysia
www.fig.net

International Congress on Remote Sensing and GIS
25-27 June 2014
Casablanca, Morocco
http://siggtcasablanca.univcasa.ma/

July 2014

GI Forum 2014
1 – 4 July 2014
Salzburg, Austria
www.gi-forum.org

Esri International User Conference
14 – 18 July 2014
San Diego, USA
www.esri.com

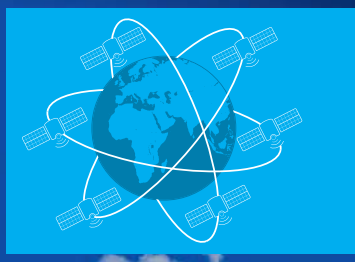
October 2014

ISGNSS2014
22 - 24 October
Jeju Island, Korea
www.isgnss2014.org

November 2014

Trimble Dimensions 2014
3 - 5, November
Las Vegas, USA
www.trimbledimensions.com

Gain perspective in real-world GNSS simulation



The GNSS simulator in the R&S®SMBV100A vector signal generator
Expensive, inflexible simulation of GNSS scenarios is a thing of the past. Now you can easily and cost-effectively test your satellite receivers under realistic conditions.

- Comes with a variety of predefined environment models such as "rural area", "urban canyon", "bridge" and "highway"
- Allows flexible configuration of realistic user environments including atmospheric modeling, obscuration, multipath, antenna characteristics and vehicle attitude

The R&S®SMBV100A generates all relevant communications and broadcasting standards such as LTE, HSPA+, WLAN, HD Radio™ and FM stereo.

To find out more, go to
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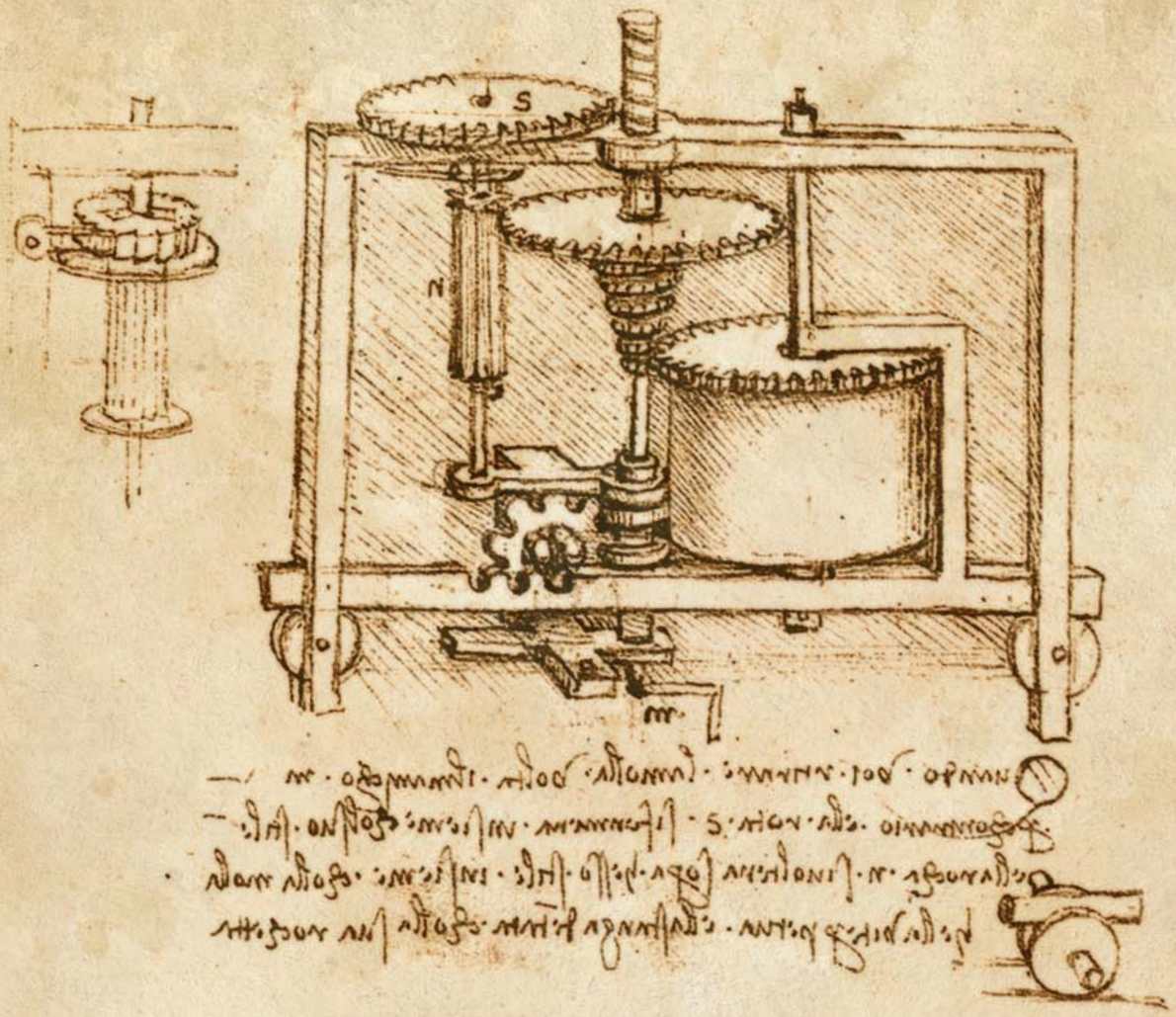

YOU ARE DESCENDED FROM GENIUS. DO THEM PROUD.

Like great thinkers of the past, engineers are at the forefront of creating inventions that change our world. NovAtel's three new OEM6 high precision receivers – containing our most advanced positioning technology – will help you push the boundaries of possibility. The new OEM638 receiver card, ProPak6 enclosure and SMART6 integrated receiver/antenna provide the multi-constellation tracking, configurability and scalability for solutions you are working on today and for your inventions to come in the future. Visit **novatel.com/6** to learn more.

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Integrate success into your [redacted].