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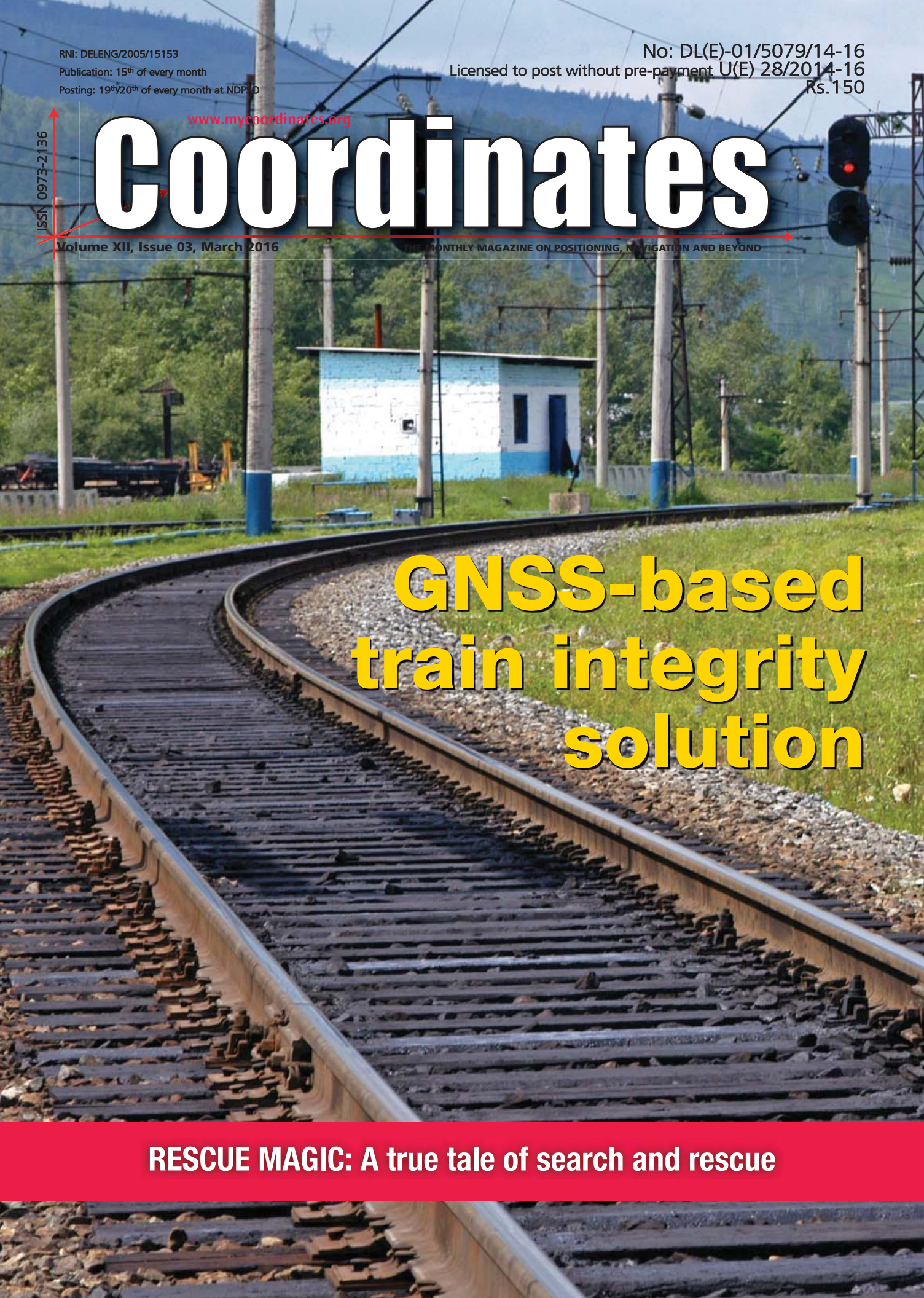

GNSS-based train integrity solution

RESCUE MAGIC: A true tale of search and rescue

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Mailing Address
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
Phones +91 11 22632607, 98102 33422, 98107 24567
Fax +91 11 22632607

Email
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
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India has launched IRNSS-1F.

Sixth out of seven in the Indian Regional Navigation Satellite System series of satellites system.

China successfully completed its first BeiDou launch of the year.

Russia sends GLONASS-M navigation satellite into orbit.

US has added another satellite to its Block IIF satellites series.

Initial services of Galileo are expected to be made available by the end of 2016.

QZSS is coming up with various applications.

A happening time for GNSS

Bringing the world together!

Bal Krishna, Editor
bal@mycoordinates.org

RESCUE MAGIC
A true tale of search and rescue

Much of the credit going to the amazing world-wide capabilities of the Cospas-Sarsat and GPS satellite constellations silently watching over all the sailors and fishermen of the Earth and helping to take the "search" out of search and rescue

Masterchief Quartermaster (Retd.) Rick Hamilton
CGSIC Executive Secretariat, GPS Information Analysis Team Lead, U.S. Coast Guard Navigation Center

In August of 1990, I was a U.S. Coast Guard Chief Petty Officer at the newly established Coast Guard Group Honolulu operations center. I managed day to day operations in the rescue center and radio room and was the primary search-planner for the Group. We were very, very busy with search-and-rescue in this open-ocean, island environment.

One afternoon, the rescue center got a call from an Auxiliarist named "Mamasita." Mamasita lived up on the west side of the Island of O'ahu. She was talking on her Citizen Band (CB) radio with a man that was in trouble on the water. The Coast Guard operates on HF (high-frequency) and VHF radios (very-high-frequency) but not CB. So, for CB, a hold-over from the 1970s long-haul trucker community, we depend on the help of the talented, all-volunteer assistance of the Coast Guard Auxiliary.

The man Mamasita was talking to on the radio had been a fisherman his whole life. Reportedly, he would motor north from Haleiwa on the North Shore of O'ahu for one hour, fish for a few hours, and then return south for an hour back to Haleiwa, all without a compass. He had been doing this his whole life without a problem. On this day, he ran into fog on the way home. Fog is not usual in Hawai'i but that day

Haleiwa Harbor, O'ahu Hawai'i ©Dan Merkel/A-Frame

there was fog….thick fog. He had been on his course back to the island for two hours and had not run up on shore. So, worried about fuel, he called for help.

Searching in fog is problematic and several of the islands were completely surrounded in dense fog. This was, possibly, a huge search area. Over the course of several hours, we tried, in vain, to determine the area where this boater was drifting. I say "we" because all Coast Guard search and rescue efforts rely on a team of highly trained and organized individuals, diverse people from all over the country serving the public for the greater good. We made an educated guess, given the position of Mamasita's radio antenna, that he was somewhere off Makaha, maybe, but we could not be sure.

However hard they tried, the helicopter dispatched from Barber's Point Air Station could not find a way around the fog. They could not just go right into it because the aircraft would have had to be right down on the water where risk of running into a boat or ship was way too high for the air-crew. The C-130 Hercules aircraft we had circling overhead kept confirming the persistence of the fog and, all the while, the un-located boater's radio signal was getting weaker and weaker. As sundown approached, still with no way to establish the position of the distressed vessel, we lost contact. We had lost him. His radio had run out of power and we had lost him. Imagining the worst, I was horrified to think that, wherever he was, the next stop for this man was the Gilbertese Islands 3000 miles to the South. A previous, unsuccessful rescue case had shown that's where the currents take you if you get lost on the very large ocean surrounding the Hawai'ian Islands. Search and rescue can be very personal. Any loss is very, very personal. I was devastated!

Then, the phone rang. A resident of Kaua'i was reporting that he was talking to a guy on the CB radio. "He says you guys are looking for him." Yessss!!!! It was so obvious now. He'd been caught in the current that comes together from both sides of Kaena Point on O'ahu and was drifting across the Kaua'i Channel. He had just drifted out of Mamasita's radio range as the strong current pulled him towards Kaua'i. The man on the phone then said "He says he has this beacon thing. You want him to turn it on?" This whole time, our boater had a Cospas-Sarsat EPIRB, an Emergency Position Indicating Radio Beacon, in the boat with him. Polar orbiting and geostationary satellites automatically relay the signals from these 406 MHz beacons to rescue centers with the position of the disabled boater. These days, in 2015, a 406 MHz EPIRB will also relay the Global Positioning System (GPS) coordinates of the beacon. Also, the new generation of GPS satellites will have Medium Earth Orbit Search and Rescue (MEOSAR) packages on them as we move Cospas-Sarsat from low earth orbit NOAA environmental satellites to GPS as the NOAA satellites reach their end of life. Once fully populated, every corner of the globe will be visible at all times to the SAR system for almost instantaneous receipt of the beacon distress calls. Worn out by the hours of anxious searching, but now very thankful for the satellite technology, I rubbed my weary eyes saying "Yes, that would be nice. Please tell him to turn it on."

There must have been a satellite already overhead, in view of the Hawai'ian Islands because less than 5 minutes later we got a call from the Coast Guard Fourteenth District Joint Rescue Coordination Center. They reported an EPIRB hit in the Kaua'i Channel. Rescue organizations usually wait for a composite solution, a second hit in the same location to confirm the distress call. That usually takes an hour and a half for another satellite to pass overhead and given what we knew, I wasn't waiting. I immediately had the Radioman on watch call the circling C-130 and relayed the approximate location indicated by the Cospas-Sarsat system.

In earlier conversation with the pilot, I had asked him to consider lowering the aircraft's back ramp when they found the vessel, fly low over it and start dropping

CG File Photo: Coast Guard Base Honolulu

COSPAS-SARSAT

COSPAS-SARSAT is a satellite search and rescue system established in 1979 by Canada, U.S., France and the (then) Soviet Union. Polar orbiting and geostationary satellites automatically relay the signals from these beacons to rescue centers with the position of the disabled boater determined by analyzing the frequency-difference-of-arrival (the Doppler-shift of the signal) and/or the time-difference-of-arrival of the distress signal at the satellite. In February of 2009, the COSPAS-SARSAT System stopped processing signals from older 121.5 MHz and 243 MHz beacons and now only processes signals from 406 MHz beacons. These days, in 2016, a 406 MHz EPIRB equipped with a positioning chip, will also broadcast the exact Global Positioning System (GPS) coordinates of the beacon. The beacon transmits a code, along with the GPS coordinates, which is stored by the satellite until it can download to a "satellite downlink receiving and signal processing station" called a LUT (local user terminal). When registering beacons, owners will have the opportunity to populate the registration file with as much information as they want. The code broadcasted by the beacon is associated with this file and can be accessed by rescue centers to assist in the rescue process. Beginning in 2005, the U.S. SARSAT Program began testing the capability to detect these distress signals from GPS satellites with a system called the Distress Alerting Satellite System (DASS). DASS is functional aboard all IIR-M and IIF GPS satellites. As the current Low Earth Orbit (LEO) COSPAS-SARSAT satellites are quickly reaching their end of life, this portion of the satellite search and rescue system is moving from LEO, approximately 528 miles up, to medium earth orbit (MEO) about 11,000-12,000 miles away. Beginning with the next generation of GPS satellites, all future GPS-III satellites #11 and beyond will carry a "Medium Earth Orbit Search and Rescue (MEOSAR)" auxiliary payload. The MEOSAR system will allow for detection of distress signals within minutes, and will improve location accuracy by an order of magnitude above the current system. In addition, when coupled with the use of the "second generation beacon" signal that is currently under development, the new system will have a reduced risk of signal interference. All satellites in the developing European "Galileo" and Russian Federation "GLONASS" global navigation satellite systems will also carry the MEOSAR receiver package and, in fact, several Galileo satellites and one GLONASS-K satellite are already equipped with MEOSAR. Once fully populated, every corner of the globe will be visible to the MEOSAR system for near instantaneous receipt of the beacon distress calls.

USCG file photo: U.S. Coast Guard MH-65 Dolphin Helicopter

USCG file photo: Cospas-Sarsat Becacon

USCG file photo: U.S. Coast Guard C-130 Hercules Fixed-Wing Aircraft

orange smoke flares while flying in the direction of Haleiwa. The fisherman could then follow the smoke all the way home. After quickly considering the coordinates, the pilot said he was very close to that position and "As it happens, there's a hole in the fog here. I'll dip down and see what we can see." The boat was right there, right below the aircraft. All this happened in the space of ten minutes or so. The pilot dropped the smoke flares as we had planned and the fisherman successfully followed them in to Haleiwa Harbor.

The next day I had a happy conversation with the wife of the fisherman to make sure she and our fisherman were both OK. I had been in constant contact with her the previous day and she had been worried sick….for good reason. The Pacific Ocean can be mercilessly unforgiving of mistakes, (his, all for want of a compass). I suggested to her that a VHF radio would have made things easier. "Most Coast Guard boats, cutters and aircraft have VHF direction finding equipment and we could have gone directly to him." Extremely grateful now for the U.S. Coast Guard, she said that her husband had told her "It was like MAGIC! I turn the beacon on and this huge airplane just fell out of the sky, just like that." Still, I have no doubt his boat had a brand new VHF radio the next trip out to sea. Thankfully, another successful rescue, with much of the credit going to the amazing world-wide capabilities of the Cospas-Sarsat and GPS satellite constellations silently watching over all the sailors and fishermen of the Earth and helping to take the "search" out of search and rescue.

An analytical assessment of a GNSS-based train integrity solution

This paper deals with the use of the GNSS to monitor the train length and to estimate the position where the last carriage of a decoupled train is stopped

A Neri
RadioLabs, Corso d'Italia 19, Rome, Italy

F Rispoli
Ansaldo STS, Via Mantovani 3-5, Genoa, Italy

P Salvatori
Università degli Studi Roma TRE, Via Vito Volterra 62, Rome, Italy

The signaling system plays one of the most important roles in railway applications. In fact this segment is not only responsible for providing safety, but it has also in charge the traffic management. This entity has two main tasks: provide safety by reducing the probability of accidents due to human error and manage railway operations by increasing the efficiency of the lines [1].

In order to guarantee interoperability between national networks, the standard ERTMS/ETCS (European Railway Traffic Management System/European Train Control System) has been developed; in fact, beside ERTMS there are more than 20 train control systems across the European Union and each train used by a national rail company has to be equipped with at least one system but sometimes more, just to be able to run safely within that one country as in [2]. This means that generally it is an hard task to manage the cross-border traffic. In this sense, having a unique standard can provide interoperability and increase the freight and passenger transport across the European countries. Furthermore the ERTMS standard has been adopted by other countries outside the Europe.

Within the ERTMS, three different application layers, known respectively as L1, L2 and L3 level, can be identified. While L1 and L2 are already in operation, L3 has not been implemented yet, but it represents the next frontier for improving the ERTMS performance. Figure 1 shows the three operational levels.ERTMS L1 has been designed to operate on conventional lines already equipped with traditional trackside signals and track circuits. In this level, communications between the devices deployed in the track area and the train are provided by means of dedicated balises (known as "Eurobalises®"). These devices are usually located adjacent to the lineside signals and connected to the train control centre. The onboard equipment, by receiving the Movement Authority (MA) through the balises and knowing the train characteristics, is able to evaluate the maximum speed and the next braking point. These data are shown to the driver through a dedicated display called DMI (Driver Machine Interface). However, the train speed is continuously monitored by the ETCS onboard equipment and, if the speed exceeds the one stated by the Moving Authority, the train will be automatically stopped. Despite L1 increase substantially the safety level and the interoperability between the railway signaling systems, the original solution has not an high efficiency.
Let us look at this exemplum: the train has received a Moving Authority that states that next signal is red and so the driver expecting to stop the train before the signal reducing the speed; in the meanwhile the signal has come to green but the driver doesn't know this event until he has the signal in sight. This means that he can't increase the speed until the train catches a new balise obtaining the new moving authority. To mitigate such an issue, it has been designed the infill technique in order to earlier notify to the train the signal changing event.

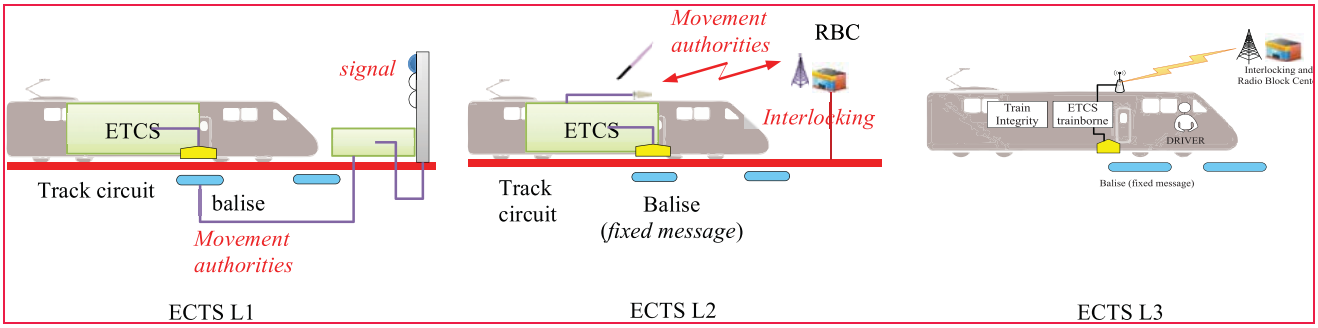

Figure 1: ERTMS paradigms

In the more advanced phase, called ERTMS L2, the Movement Authorities are sent directly from a Radio Block Centre (RBC) to the onboard unit using the GSM-R (Global System for Mobile Communications – Railway) technology. In this level, the balises transmit only "fix messages" containing information about the line. A continuous data-stream notify to the driver of line-specific data and signals status on the route ahead; in this way the train is able to reach the optimal speed guaranteeing a safe braking distance factor. By using L2, it is possible to reduce maintenance costs (e.g. fewer lineside signals) and increase the capacity of the line.

The main limitation in the traffic management efficiency of L1 and L2 technologies is the "fixed block" approach used to determine which portion of the line is occupied by a train. In fact, the line is split in several sections, called blocks, of predefined length; the main idea is that one block can be occupied by no more than one train at the same time. To determine whether a section is occupied, the system makes use of Track Circuits deployed along the track.

This solution, despite it guarantees an high level of safety, is expensive (in terms of device to be deployed and of maintenance costs) and does not guarantee an efficient use of the railway network. If we were able to allocate the block dynamically, we would increase considerably the capacity of the line. This new concept known as the "moving block" approach is the mainstay of the future phase of the ETCS called L3. In L3, it is the train that has in charge of supply continuous and accurate position data to the control centre; in this way the track based detection equipment are not needed anymore. The absence of physical track circuits is one of the things that allows the "moving block" approach; in fact, if we wanted to reduce the section length (e.g. assuming that the section is as long as the train itself) we have to define a Virtual version of them. In [3] authors referred to this concept as the "Virtual Track Circuit".

The control center, to dynamically determine the required safe distance among adjacent trains, needs that the trains report their locations and their actual length. In fact, rarely, it could happen that a section of the train decouples from the rest of the train; in these cases, the real train length (that is the one we need to evaluate the occupied section) is bigger than the nominal one. We refer to train integrity as the ability of the train to determine whether all the carriages are still coupled each others. This implies the needing of a train integrity subsystem that has to measure and trust the train length (with a given probability of success) and to alert (within a time limit) if a portion of the train is decoupled, assessing the length of the line occupied by the train. All this process must be compliant with the CENELEC SIL-4 high level requirements (Tolerable Hazards Rate < 10^{-9}/hour). To assess the train integrity issue, several solutions have been proposed. In [4] authors have envisaged a Train Integrity Monitoring System (TIMS) which relies on hardware equipments deployed on each coach interconnected through serial links. If a carriage loss occurs the Master device in the front of the train is no longer able to communicate with the lost ones. In [5] authors provide a freight train integrity monitoring approach based on a distributed WSN (Wireless Sensor Network) that check real-time the train composition. The main concept is that a carriage loss implies that the train configuration is changed. The main disadvantages of this techniques are the deployment of hardware devices in every carriage and the link establishment between all of them. In the last years, other solutions based on GNSS technology have been proposed addressing the train integrity problem, but, anyway, those solutions have not been proved to be compliant with the SIL-4 stringent requirements. Recently in the USA, Leidos presented a PTL (Positive Train Location system) to fulfill the requirements of the PTC (Positive Train Control) through the data fusion between several sensors including GNSS [6]. However for none of these solutions has been provided the demonstration of meeting the Tolerable Hazard Rate (THR) specified by over mentioned CENELEC norms. In [3] authors defined a GNSS double difference approach to assess the train integrity issue. This approach, despite the double chain GNSS need, is able not only to detect if a decoupling event has occurred, but can be also suitable for the localization of the rear section left on the line; in fact, thanks to the receiver in the last carriage, we can perform a PVT (Position Velocity and Time) estimation and notify the actual location of the lost rolling stock. In such a way the traffic management system can calculate the safe distance that the preceding train must respect to avoid the collision. Further to the results of their research, in this paper we investigate the achievable performance of a multi-

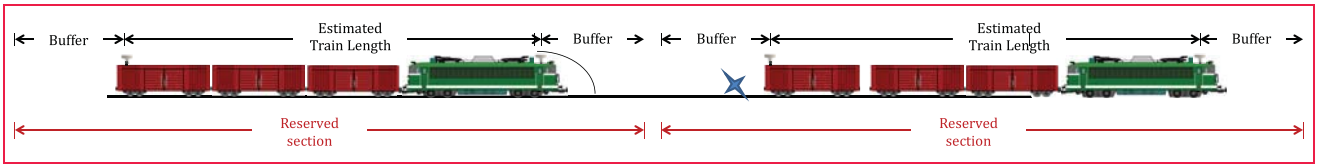

Figure 2: Reference architecture

constellation GNSS-based train integrity system to contribute to the integrity function envisaged for the ERTMS L3. Finally we carry out simulations to assess the analytical model.

Problem statement

As announced in the previous section, the Train Integrity Issue is one of the mainstay problems still to be solve. In fact, even if it is possible, for those trains with a fixed composition, to identify the decoupling by the break of a wire connection linking all the carriages, there is an uncertainty on the final position reached by the parted rolling stock. This happens because the RBC (Radio Block Centre), even if it knew the train position and velocity at the decoupling moment, the breaking distance, that changes with other external variables (such as the track gradient, the track wetness, the train weight, the brakes type, and so on), could not be evaluated with precision. In such a way, the portion of track that must be reserved as guard interval has to be increased to prevent possible collisions with the following convoys. For the variable configuration trains the same consideration can be done by using the pneumatic pipe; if there is a depressurization on the pipe the train is parted in more than one piece. The problem of such an approach is that not always the pressure drop in the duct is as much high to be detected as a decoupling event (this means that the lost rolling stock will be braked while the front section will continue its running as if nothing was really occurred).

More in details, the on-board train control unit notifies the decoupling event to the RBC with an estimated latency between the 10 and the 20 seconds; this means that for a train travelling at 120 km/h, the decoupling point is in a range of about 700 meters (conservative hypothesis). Then 750 meters (plus a conservative margin of 20%) should be taken into account to estimate the position where the last carriage is stopped. Further uncertainty arises in presence of a height gradient along the line. In fact the breaking distance varies when the train is going uphill or downhill and a further margin has to be calculated to estimate the position where the last carriage is stopped.

Our proposed approach, by means of a pair of GNSS receivers located in the extremities of the train, will overpass this issue by assessing the train length during the operational phase (when the carriages are all coupled each others) and by providing directly the position of both head and end cars.

Proposed approach

Let us consider a railway scenario as depicted in Figure 2. If N is the number of available constellations, we have two possible approaches: N out of N or the all in view satellites. The former foresees that the train length is estimated N times by using one constellation at once; finally, if one of them exceeds a certain threshold, than an alert is arisen. The second method is based on a merged constellation approach; in fact we are considering all the visible satellites like they belong to a unique virtual constellation. For the train length estimation algorithm for a single constellation we remand to [3].

To set the threshold in case of the use of all in view satellites we can adopt the Neyman-Pearson criterion, then imposing the target False Alarm probability. The main advantage of the joint use of the visible satellites is the higher accuracy that can be achieved by combing all available measurements with the optimal weights. On the other hand, when using the N out of N approach we have the possibility to optimize the threshold for each constellation. Furthermore, when the statistics of one constellation exceeds the threshold, a second test can be performed to identify the presence of a satellite or even a constellation fault.

For instance, let first consider the case of two constellations. In this case, if P_{fa} is the required False Alarm probability, then we can write:

$$P_{fa} = P_{fa,1} + P_{fa,2} - P_{fa,1}P_{fa,2} \simeq P_{fa,1} + P_{fa,2} \qquad (1)$$

If the required False Alarm probability is low (typically in the order of 10^{-6} or lower), the mixed term is several order lower than the others; so, neglecting this term, we can equally subdivide the false alarm probability between the two detectors. For a given False Alarm Probability the threshold is proportional to the standard deviation of the tested statistics. We can generalize this concept to the use of N constellations. Thus, considering that

$$P_{fa} \leq \sum_{i=1}^{N} P_{fa,i} \qquad (2)$$

we can set

$$\tilde{P}_{fa,k} = \frac{\tilde{P}_{fa}}{N} \qquad (3)$$

where $\tilde{P}_{fa}$ is the target False Alarm probability.

As shown in [3], under the hypothesis of additive Gaussian GNSS receiver noise, the train length estimation error is zero mean Gaussian distributed. This means that for each constellation we can evaluate the threshold by simply inverting an *erfc* function. To evaluate the standard deviation of the distribution we need an on-field tuning that is function of the nominal baseline length.

Under this hypothesis, the False Alarm probability can be written as:

$$P_{fa,k} = \frac{1}{2} erfc\left(\frac{Th_k}{\sigma_k \sqrt{2}}\right) \quad (4)$$

where $P_{fa,k}$ is the desired False Alarm probability for the k-th constellation, Th_k is the threshold for the k-th constellation and S_k is the standard deviation of the length estimation performed by using the k-th constellation and $erfc()$ is the complementary error function.

$$erfc(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-t^2} dt \quad (5)$$

From this relationship we can derive the threshold as:

$$Th_k = \sqrt{2\sigma_k^2} \cdot erfc^{-1}\left(2\tilde{P}_{fa,k}\right) \quad (6)$$

Given the threshold we can evaluate the detection probability. In presence of a decoupling event, the train length will be greater than the nominal value. Because, obviously, the actual train length is unknown, we can consider the distribution obtained comparing the estimated train length with the nominal one. In the instants immediately after the decoupling event, such distribution, for the k-th constellation, is still Gaussian with mean μ_k^{dec} and standard deviation $\sigma_k^{dec}\left[\mu_k^{dec}\right]$ where μ_k^{dec} is the gap between the two sections of the train and σ_k^{dec} is the standard deviation increasing with the gap due to the increasing of the baseline between receivers (in the limit case of the decoupling instant the standard deviation is obviously equal to the nominal condition one). For gap lower than 1 km the dependence of standard deviation from the gap itself can be neglected; so we can state $\sigma_k^{dec}\left[\mu_k^{dec}\right] \simeq \sigma_k$.

Under these hypotheses, we can write the detection probability as function of μ_k^{dec} as:

$$P_{D,k}\left[\mu_k^{dec}\right] = \frac{1}{2} erfc\left(\frac{Th - \mu_k^{dec}}{\sqrt{2} \cdot \sigma_k^{dec}\left[\mu_k^{dec}\right]}\right) \simeq \frac{1}{2} erfc\left(\frac{Th - \mu_k^{dec}}{\sqrt{2} \cdot \sigma_k}\right) \quad (7)$$

The total miss detection probability can be computed by considering that the decoupling event is not detected if none of the single constellation detectors is able to detect it. Due to the statistical independence between the estimation errors we have:

$$P_{md} = \prod_{k=1}^{N} P_{md,k} = \prod_{k=1}^{N} \left(1 - P_{D,k}\left[\mu_k^{dec}\right]\right) \quad (8)$$

Then, we can evaluate the total detection probability as:

$$P_D \simeq 1 - \prod_{k=1}^{N} \left(1 - P_{D,k}\left[\mu_k^{dec}\right]\right) \quad (9)$$

Simulation results

To assess the performance analysis of the over mentioned model, we carried out simulations on a synthetic scenario. More in details, we considered two trains: one passenger train length 500 meters and one heavy freight train 2500 meters long; both trains were running, with a speed of 80 km/h, on a track from "Roma Tuscolana" station to "Zagarolo" station (Rome, Italy) as shown in Figure 3.

As in [3] we adopted the conservative approach by assuming that, after the decoupling, the rear section of the train slows down only by effect of the rolling resistance while the front section continues the running as if nothing has occurred.

Moreover, the gravity effect due to the track gradient has been neglected too. The train length estimation is then performed by using three SIS (Signal In Space) configurations: only GPS, only GLONASS and GPS+GLONASS. In Table 1 we report the estimation error statistics. As expected by using a multi-constellation approach the standard deviation of the estimation error reduces by means of the higher number of visible satellites. Furthermore, because after the decoupling the front section continues its running, the standard deviation of the estimation error increases (at the end of the running the baseline between the receivers is about 30 km).

Figure 4 depicts the trend of the decision threshold w.r.t. False Alarm Probability. The trend is reported for both Single Constellation and the satellite all in view case. As expected by using the Double constellation approach, when all the satellites are healthy, we reduce the standard deviation of the estimation error; by effect of this, for a given false alarm probability, we have a lower threshold. Figure 5 and Figure 6 show

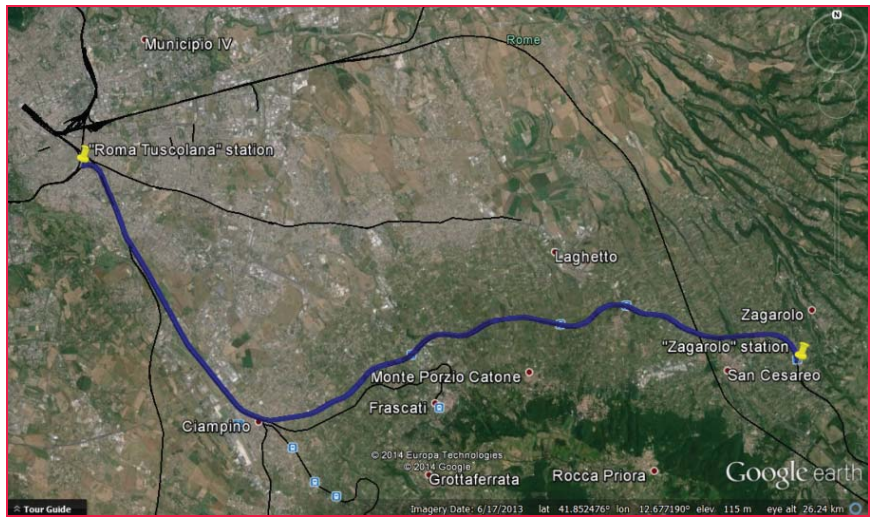

Figure 3: Synthetic scenario

Table 1: Train length estimation error statistics

	Estimation error: GPS only		Estimation error: GLONASS only		Estimation error: GPS + GLONASS	
	Mean [m]	Std [m]	Mean [m]	Std [m]	Mean [m]	Std [m]
Short train all coupled	-0,002	0,831	-0,003	0,841	-0,001	0,572
Short train decoupled	0,059	0,934	-0,003	1,063	-0,010	0,680
Long train all coupled	0,009	0,830	-0,006	0,874	-0,000	0,580
Long train decoupled	0,074	0,933	-0,002	1,071	-0,014	0,677

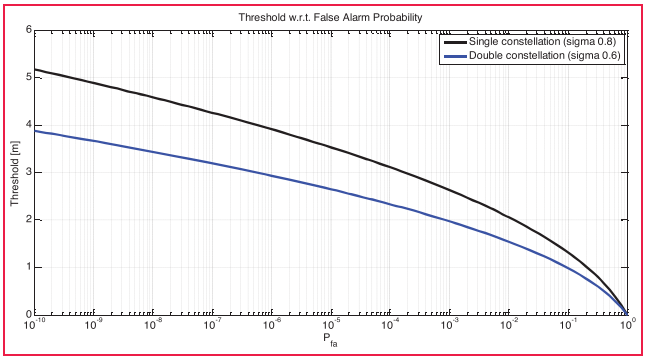

Figure 4: Threshold trend w.r.t. False Alarm Probability

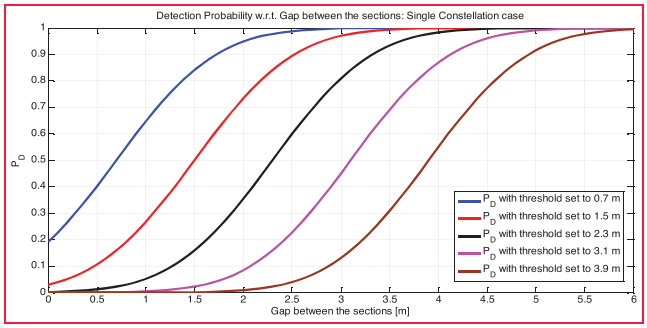

Figure 5: Detection Probability vs train gap for the generic constellation

the trend of the detection probability w.r.t. the gap between the decoupled carriages for several thresholds values respectively for the single and double constellation cases. As expected, the Detection Probability is equal to 50% when the gap is equal to the selected threshold and the lower is the threshold, the higher is the detection probability for a certain gap. Figure 7 shows the Detection Error Tradeoff curves for a Train GAP of 5 meters in the case of healthiness of all the involved satellite. Obviously, when there are neither satellite nor constellation faults, the all in view satellite combination represents the best alternative. However, with the performance are higher than in the single constellation case and we can adopt a secondary screening when the estimations disagree to eventually exclude the faulty satellites or constellations.

Figure 8 depicts the gap that can be protected for a given miss detection probability. As expected the lowest is the miss detection probability we select, the higher is the interval we have to reserve.

Discussion of the results

The analytical modellisation is a basis to assess the performance achievable by selecting the different parameters. Analyzing Figure 8, it is possible to derive, in terms of protected gap, the confidence interval to be considered when reserving the section of line. More in details, if we select a false alarm probability equal to 10^{-4} and a miss detection probability equal to 10^{-9}, we have to consider a tail buffer of about 8 meters with a single GNSS constellation.

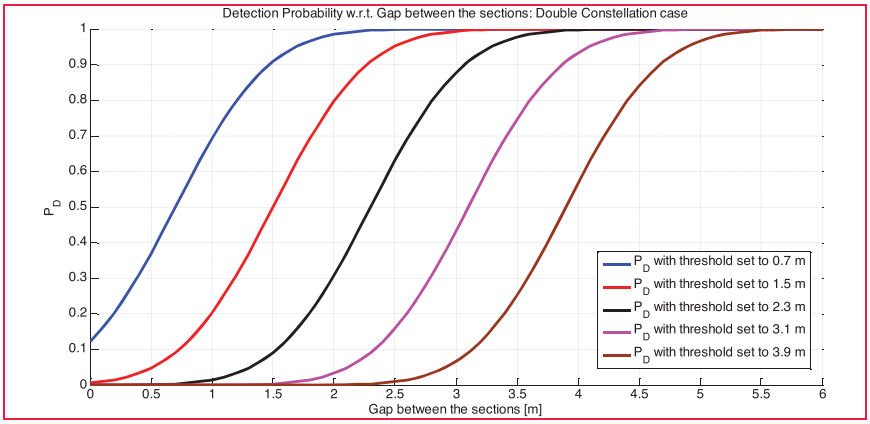

Figure 6: Detection Probability vs train gap for the double constellation approach

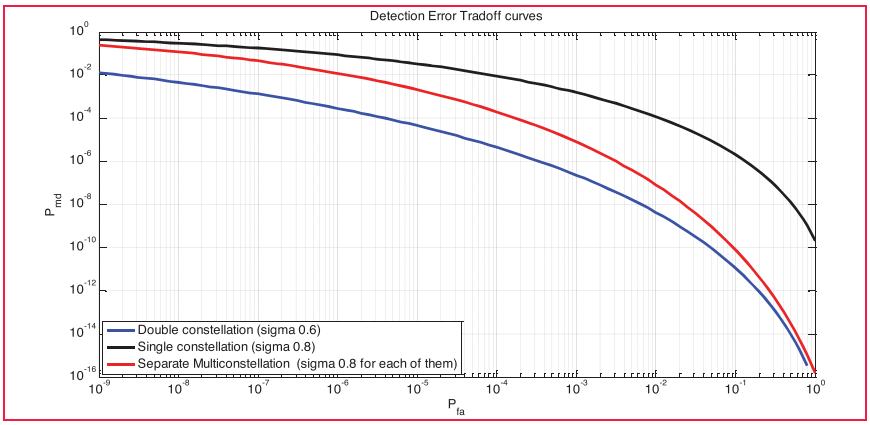

Figure 7: DET curves (Train GAP 5 meters)

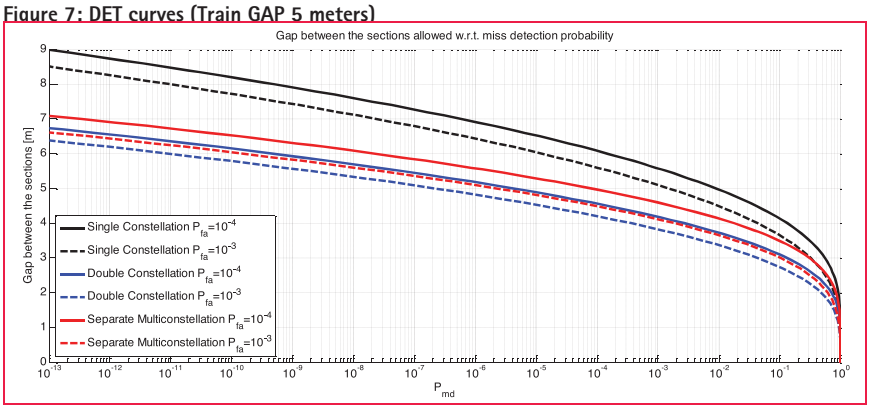

Figure 8: Gap between the sections w.r.t. miss ddetection probability

Instead, if we adopt the 2 out of 2 decision-approach, we have to allocate a tail buffer of about 6.5 meters. The shortest tail buffer is achievable with the double constellation approach, and it is in the order of 6 meters. Therefore the theoretical maximum length of the virtual block will be 12 meter longer than the nominal train length. While the position where the last carriage is stopped depends on the confidence error estimated by the localizer that can be as low as about 14 meters with a dual constellation system [7]. It is important to remark that these results do not take into consideration the impact of the multipath effect and the mitigation techniques that are being investigated in the continuation of this study.

Conclusion

The train integrity monitoring represents a fundamental innovation for the train control systems such as the ETCS L3 system. GNSS is the candidate technology to allow the continuous monitoring of the train length and for estimating the position where the last carriage of a decoupled train is stopped. This paper has provided the analytical results of the GNSS technique in order to assess the achievable performance. Further studies are on-going to characterize the environmental effects, but the advantages of the GNSS have emerged when compared to other solutions.

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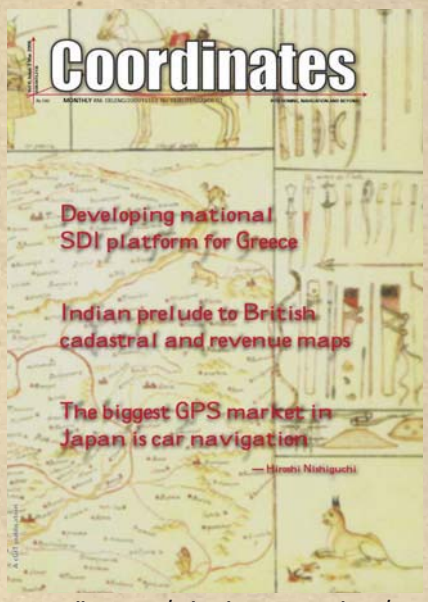

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HIS COORDINATES

"The biggest GPS market in Japan is car navigation."

says Dr Hiroshi Nishiguchi, Secretary General, Japan GPS Council while discussing the trends in GPS applications and market in Japan

In which direction the GPS market of Japan is moving?

Market creation in the everywhere, whoever and anytime LBS such as Ubiquitous world.

The biggest GPS market in Japan is the Car navigation and its synergy effects market such as VICS (Vehicle Information and Communication Services) which provides the traffic jam information and route guidance.

SURVEYING

What does our world really look like?

An attempt is being made by volunteers all over the world to visit the confluence points and document the scenery with pictures and narratives

RAINER MAUTZ

The Confluence project

Fortunately, for the past decade an attempt is being made by volunteers all over the world to visit the confluence points and document the scenery with pictures and narratives. All reports of visits are submitted to the website *www.confluence.org* where they are published. Now, exactly 10 years into the project with several thousand people actively participating, one might guess that all points must have been visited. De facto, only 26.9% of the project goal is fulfilled at the time of writing.

HIS COORDINATES

"Understand. Then implement."

says Dr Mahesh Chandra, Managing Director, National Informatics Centre Services Incorporated while sharing the success and challenges in technology implementation in the context of Delhi utility mapping project

Is Delhi utility mapping in use?

Yes, utility agencies are using it. Most of the agencies have special cell. I think work culture has changed after this project. Now, if any agency wants to dig any area of Delhi, it can do so by coordinating with other agencies by giving a 15 days notice. Not only it brings some comfort to the citizens but also results in saving of a lot of money which otherwise would have wasted.

SDI

Developing national SDI platform for Greece

This paper aims to develop a National SDI model for Greece incorporating theoretical and conceptual aspects

S ALEXIADOU AND A RAJABIFARD

Conclusion

This paper evaluated the current situation in spatial activity in Greece, discussed the major issues for the development of a Greek National SDI and proposed a National SDI conceptual model and its components. Finally, it proposed a roadmap for a complete and consistent implementation of the National SDI platform.

The importance of hydrographic surveying

This paper analyzes the need to conduct hydrographic surveying on our water bodies to determine the level of safety its use for the development of a Water Transportation System

Surv Isaac Larbie, MGhIS
Geomatic Engineer, Surveying and Mapping Division, Ministry of Lands and Natural Resources, Ghana

Transportation in Ghana over the decades has dominantly depended on land either by the road and rail systems. Access roads to coastal and lakeside settlements have not been the best due to the bad road nature and possibly the unavailability of link roads to the settlements. Travelers, goods and food stuffs from these villages and isolated towns along the coast and rivers have to be transported through difficult means to the closest delivery/arrival points. This kind of movement takes so long a time and for that matter its effect on perishable goods either by expiring or getting rotten. In the case where access exists, due to the bad nature of the roads and most often only one narrow access, vehicles are either unable to get to the production sites or vice versa. The use of fishing canoes has been the available mechanism for transporting people and goods which has endangered lives over the past periods due to unavailability of safety measures. In all these, it can be realized that easy and good access roads have become very necessary to these communities and towns along the water bodies in order to have easy transportation of travelers, goods and food stuffs from the cities/towns to the coastal villages and vice versa. To make this possible, we must have new roads constructed to these coastal villages/towns at a cost.

Figure 1: Map of Ghana showing the Lake

Ghana is fortunate to have a major water body along the southern boundary of the country, i.e. the Atlantic Ocean/Gulf of Guinea and a major river body [Figure. 1], the Volta Lake linking the southern section to the northern section, and when used judiciously can improve upon the transportation system in Ghana by reducing the pressure on the use of the road networks. Along this lake and the coast are towns, communities, villages that depend on the use of these water bodies for their livelihood and business activities. Moving from one settlement to the other either along the water body or across has always been a huge problem. The use of fishing canoes has been the available mechanism for transporting people and goods which has endangered lives over the past periods due to unavailability of safety measures. In view of this situation, if the use of the water body will take approximately 30 minutes to move from one place to another, and by land, 3 hours, majority of travelers would prefer to use the land due to fear in the use of the water body.

But the major issue about this development is how safe and reliable is the use of water bodies for transportation? Safety in the use of our water bodies depends greatly on the nature of the water bodies, their depths and what is below the surface of the water. Under this condition, the application of hydrographic surveying will provide solutions to determine safety in the use of the water body for transportation.

Transportation system in Ghana

Geography of Ghana

Ghana is located on West Africa's Gulf of Guinea only a few degrees north of the Equator. Half of the country lies less than 152 meters (500 ft.) above sea level, and the highest point is 883 meters (2,900 ft.) It lies on the Western Coast of Tropical Africa, bordering the North Atlantic Ocean between Cote d'Ivoire and Togo N→S 672 km, b/n latitudes 4.5ºN and

Figure: Geography of Ghana

11ºN;
E →W 536 km b/n longitudes 3ºW and 1ºE.
Land boundaries: total 2,093 km, Burkina Faso 548 km, Cote d'Ivoire 668 km, Togo 877 km
Coastline: 539 km by the Gulf of Guinea and the Atlantic Ocean.
Map references: Africa, Standard Time Zones of the World
Area -total area: 238,540 km2;
land area: 230,020 km2.

The 539-kilometer (334-miles) coastline is mostly a low, sandy shore backed by plains and scrub and intersected by several rivers and streams, most of which are navigable only by canoe.

Transportation

Transportation in Ghana has largely dependent on the use of our road system and to a small extent the water system, rail system and by air [Figure 2]. Road transport is by far the dominant carrier of freight and passengers in Ghana's land transport system. The dominant use of the roads has caused a lot of pressure on our road networks leading to their early damages. It carries over 95% of all passenger and freight traffic and reaches most communities, and is classified under three categories of trunk roads, urban roads, and feeder roads.

Figure 2: Transportation in Ghana

Increased transport investment helped to increase the number of new vehicle registrations and transportation alternatives include rail, road, ferry, marine and air [6]. There has been an increased investment and expansion in the road transportation of Ghana [1], hence with respect to this mode of transport, many people prefer to use the road means of transport for their movements than the use of the other transportation alternatives.

The volta River/Lake

The Volta River is the main fresh water source for Ghana. It is a stream primarily in Ghana that drains into the Gulf of Guinea and Atlantic Ocean and has three main tributaries—the Black Volta, White Volta and Red Volta [Figure. 3]. The Volta River is formed by the confluence of the Black Volta and the White Volta rivers at Yeji in the central part of the country [7]. The river flows in a southerly course through Lake Volta to Ada on the Gulf of Guinea. The total length, including the Black Volta is about 1,500 km (930 miles).

The Volta Lake was created by the construction of the Akosombo dam on the river in the mid 1960's. At about 8482 square km (3275 square miles) [5], the lake is one of the largest artificially created lakes in the world. Lake Volta (located at 6°30′N 0°0′E / 6.5°N 0°E / 6.5; 0) is the largest reservoir by surface area in the world, and the fourth largest one by water volume. It is located completely

Figure 3: The Volta River and the Three Main Tributaries

within the country of Ghana, and it has a surface area of about 8,502 km² (3,275 square miles). Lake Volta lies along the Greenwich Meridian, and just six degrees of latitude north of the Equator. The lake's north most point is close to the town of Yapei, The Volta Lake is a man-made lake created after the River Volta was dammed at the Akosombo gorge. The lake was created to store up water primarily to generate hydro- electricity. Additionally it was envisaged that it would improve inland water transport, boost fishing, ensure enough water for domestic and industrial use and for irrigation, etc.

Although the country boast of limited number of bridges over the Volta River, Ghana has only one Suspended Bridge called the Akosombo Bridge which spans over the Volta River at Atimpoku and it is reputed to be among the few found all over the world. This important tourist attraction which is a masterpiece of civil and architectural work was built in 1956 and has a total length of 805 feet. It provides the vital road transportation piece over the Volta River thus linking by road the central and northern parts of the Volta Region with the other parts of the country especially the Eastern Greater Accra, Ashanti, Central and Western Regions.

Along this river and the coast are towns, communities, villages that depend on the use of these water bodies for their livelihood and business activities [*Figure.* 4]. The use of fishing canoes and small boats have been the available mechanism for transporting people and goods which has endangered lives over the past periods due to unavailability of safety measures. For this reason, many people have avoided the use of water bodies for transporting them from one place to another.

The Volta River/Lake is termed to be a killer because since the gorge was flooded in 1966, thousands of hardwood trees were left standing. Many of them lied in ambush below the water surface much of the year where they snag the nest of fishermen and are a source of danger for the long wooden kayaks and other boats that transport goods and people. The presence of these tree stumps under the surface of water bodies and lack of proper marking of safe channels for navigation by the fisher folks and the communities along the lake over the past decades have caused various categories of river/ lake disasters which have led to the loss of lives and valuable items.

Figure 4: Panorama and landscape of Lake Volta in Ghana

Figure 5: Hard wood trees and tree stumps left standing in the Volta River

The state of hydrographic surveying in Ghana

Firstly it is necessary to consider the IHO definition of Hydrography, which stands as follows:

"That branch of applied sciences which deals with the measurement and description of the features of the seas and coastal areas for the primary purpose of navigation and all other marine purposes and activities, including –inter alia- offshore activities, research, protection of the environment, and prediction services", (IHO Pub. S-32), cited in the Hydrographic Manual, 2005 [2]. With this definition, one can allude to the fact that most of the water bodies in the country have not been measured or chartered to know if they are safe for navigation. Until the recent discovery of oil and gas in the country, hydrography is as less known area that only a few people would venture into because there is no demand for it in the country.

A national Hydrographic Service or a private hydrographic agency for national and international duties in hydrography does not exist at the moment. The existing organization that perform hydrographic activities in the country as shown in figure 6 operate separately and independently and for that matter do not collaborate and this makes it uneasy to know the actual difficulties which the ministries, authorities and the offices are encountering. Even though there are packets of hydrographic survey works done in the country, there are no records or data with the survey and mapping division because they were initiated by private firms for their individual needs or construction purposes. The Volta lake which is the largest man-made lake in the world and span from the south to the north even into neighboring Burkina Faso could serve as the most convenient means of transport of goods and services from the south to the north but then this is not the case simply because most part of the lake have not been surveyed.

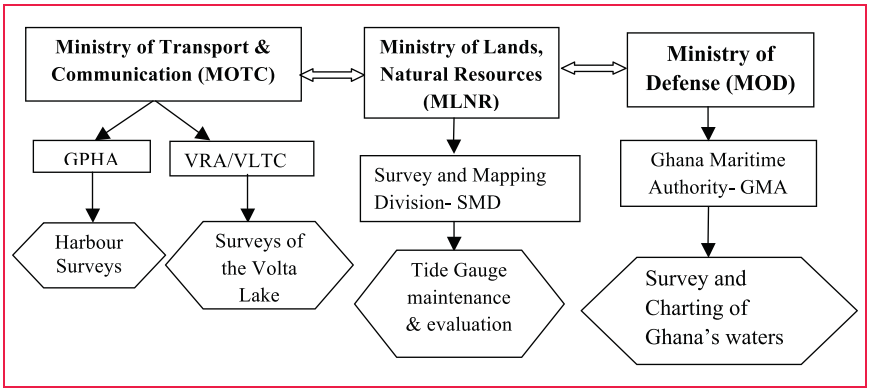

Figure 6: Organizations that perform Hydrographic Activities

Normally, the Ghana Ports and Harbour Authority (GPHA) and the Volta Lake Transport Company (VTLC) who are under the Ministry of Transport should be responsible for the harbours and lake surveys but they do not have common hydrographic surveys. It was therefore very difficult to obtain documents on hydrographic surveys on the coastal waters or the EEZ. Only GPHA has information on the two main Harbours in the country concerning the results of their hydrographic surveys.

Current activities by hydrographic agencies & changes

Various agencies are involves in the field of hydrographic surveying in relation to their field of operations and have established hydrographic sections in their outfits operating on minor scales. These agencies as below either perform activities in relation to hydrography or have established hydrographic sections in their outfits operating on minor scales.

Survey and mapping division

Apart from the geodetic survey activities in the country, the Division is also responsible for the operation and the maintenance of the automatic tide gauges at Takoradi and Tema. They are also responsible for the compilation of data from the observations which help in the tidal levels prediction.

Ghana Ports and Harbours Authority (GPHA)

The GPHA with its headquarters at Tema is the only authority responsible for hydrographic surveys in Tema and Takoradi harbours. The Hydrographic Section under this authority has nothing to do with the coastal surveys including the EEZ. Its functions include dredging to maintain depths, laying and maintenance of all buoys, salvaging sunken craft, checking position and distance of mooring buoys, harbor soundings and compiling harbor charts. Since the establishment of the two harbours, there

Figure 7: A mahogany tree that was pulled from Volta Lake

has been to some extent the activity of hydrographic surveying taken place there.

Volta River Authority/Volta Lake Transport Company (VRA/VLTC)

The VRA was established in April, 1961 mandated to operate mainly as a power generation, transmission and distribution utility. It is also responsible for the visual tide gauge. Readings of the water levels are taken daily at an hour intervals, and later on a time-height graph is drawn. A graph of the annual maximum and minimum water levels is obtained from the analysis of the level readings.

The VLTC incorporated in 1970 operates river transportation for passengers, bulk haulage of petroleum products and cross-lake ferry services along the Volta Lake. They depend on the maximum and minimum water levels for their operations. Its activities play an important role in Ghana's economic development. The VLTC depends on the statements made by the ferry crew and some fishermen about the local changes. Since 1988 that echo sounders were used to carry out hydrographic surveys at some ferry stations along the Volta Lake, no surveys have been conducted again.

Ghana Maritime Authority (GMA)

The Technical Services Division of the authority is responsible for the effective coordination of the technical services. Its activities in the field of hydrography and navigation are as follows:

- Provide navigation services along the coast of Ghana including collation and dissemination of tidal, current and weather information
- Undertake survey and chart Ghana's waters, preparation of charts and dissemination of relevant information on drafts along the coast
- Install, inspect and maintain lighthouse, buoys and other aids to navigation
- Demarcate safe water channels and waterways
- Carry out and identify marking, notification and removal of wrecks and other hazards to navigation
- Review and authorize the location of underwater cables, pipelines, terminal points, rigs and other offshore installations
- Handle environmental issues in respect of coastal and offshore developments
- Undertakes preliminary investigation of maritime accidents and casualties in collaboration with other departments
- Assist in the collection and compilation of hydrographic data for navigational charts and publications and other applications to meet standards of international organizations
- Assist in the production and distribution of charts and publications
- Assist in directing operations to find, position and chart new dangers to navigation
- Provide navigation services along the coast of Ghana including collation and dissemination of tidal, current and weather information
- Install, inspect and maintain lighthouse, buoys and other aids to navigation
- Conduct preliminary investigations of maritime accidents and casualties in collaboration with other department

Figure 8: A motorist canoe carrying passengers, food etc navigating around tree stumps

The importance of hydrographic surveying and its benefits to the economy of Ghana

Due to the increase of population living in the coastal region and along the banks of rivers, there is increase of activities that discharge different elements into the sea and other water bodies. In view of this situation, society must be keen to consider, with sufficient priority, the need to have reliable hydrographic information to adopt the most efficient and effective preventive and remedial measures to ensure clean seas. These water bodies, both natural and artificial have been considered as natural features and have brought about interconnectivity between different human groups mainly to exchange their goods and create movement from one place to another. In order to make movement from one place to the other very safe, the best medium of transportation is the use of the water body for that purpose. Therefore, hydrography and the representation of its results in a nautical chart have always been part of life and have contributed to mankind's development as well. In view of this, hydrographic surveying need to be conducted to measure the depth and

bottom configuration of water bodies to produce the nation's nautical charts to ensure Safe Navigation on the water bodies. The activity will "look" into the waterbody to see what the floor looks like and also identify floor materials (important for anchoring, dredging, pipelines and cable routing) dredging areas, cables, pipelines, wire pipelines, wrecks and obstructions and fish habitats.

The Volta Lake which is the largest man-made lake in the world and span from the south to the north even into neighbouring Burkina Faso could serve as the most convenient means of transport of goods and services from the south to the north. The Transport service on the Volta Lake is hampered by the perennial low water level as well as the presence of tree stumps and sand banks that impede the smooth movement of vessels and boats. Recent developments include a large-scale enterprise to harvest submerged timber from the flooded forests under Lake Volta [8]. This project harvests high-value tropical hardwood without requiring additional logging or destruction of existing forest and, according to Wayne Dunn, "could generate the largest source of environmentally sustainable natural tropical hardwood in the world [4]. This underwater forest activity will make the lake more navigable and safe and could generate the largest source of environmentally sustainable natural tropical hardwood in the world.

This project if successfully conducted would clear a transportation path for boats and water body users, provide social improvements in the form of jobs for some residents and greater boating safety for others; and reducing the threat to forest environments by satisfying demand for ebony, mahogany, and other hardwoods without removing living trees. The success of this project will depend on the conduction of a hydrographic survey because this activity would answer the following questions:

- How many trees or tree stumps are beneath the lake and their specific locations;
- The sizes of the trees and their depths beneath the surface of the water body.

Answers to the following questions will determine the method and technology to apply to operate under the water for the successful removal of the trees.

With reference to Ghana Government's objectives on transport and growth as indicated in the Ghana Poverty Reduction Strategy (GPRS) II, that involved the following:

- Ensure the provision, expansion and maintenance of transport infrastructure of all kinds
- Ensure the provision of affordable, safe and accessible transportation system that recognizes the needs of people and business enterprises including farmers
- Develop and strengthen the appropriate legal, institutional and regulatory framework to regulate all modes of transportation to ensure an efficient transportation system.

The objective above defines a clear indication that developing the water bodies to be used for transportation would bring about a vast improvement in the transportation system of the country.

Again, the Government through the Eastern Corridor Project has selected some settlement areas for the construction of landing stages or Inland Ports and the achievements of these projects cannot be achieved without the assistance of hydrographers and other allied professionals. The project when completed would be of great benefits to the economy of the country, and these would include;

- Transportation of cargo from the south to the north and neighbouring Burkina Faso.
- Transportation of food staffs from the north to the south.
- Reduction in loss of lives through accidents on the lake due to bad weather and presence of tree stumps.
- Ease of pressure on roads resulting in long life span of road network in the country.
- Create business opportunities and jobs for the youth and people of Ghana.

The conduct of hydrographic surveying would again adequately address areas [3] such as:

- Safe and efficient operation of maritime traffic control;
- Coastal Zone Management;
- Exploration and Exploitation of Marine Resources;
- Environmental Protection and Management;
- Maritime Boundary Delimitation.
- Maritime Defense
- Maritime Transport
- Tourism and Recreational Boating

Challenges in hydrographic affairs

- Non-existence of a Ghana National Hydrographic Service.
- Lack of Hydrographic surveying and Ocean Observation equipments, i.e. Research Vessels to conduct the surveys.
- Non-membership of International Hydrographic Organization (IHO)
- Unavailable capacity to process the measured data
- Non-existence body to control the activities of the various institutions
- Absence of Human Resource development training

Future plans

- The need to establish the Ghana National Hydrographic Service [2] to run it under the Ministry of Lands and Natural Resources.
- Strengthen the various institutions that are into the field of oceanography and hydrography. This will greatly involve the training of personnel in the departments and students in the following institutions:
  - Kwame Nkrumah University of Science and Technology (KNUST) that offers hydrographic surveying as a subject.
  - Department of Oceanography and Fisheries, at the University of Ghana, Legon offering degree course in Oceanography and Fisheries.
- Consult the International Hydrographic Society for advice, guidance and financial assistance.
- Develop Inland Ports within the country at strategic Site Locations
- Rehabilitate the existing harbours into higher international standards to be able to handle any oceanic and hydrographic activity.
- Apply for membership into IHO.

Conclusion

This paper attempts to create awareness to the fact that Transportation means in Ghana can be improved by the use of water bodies within the country. Again, there is the need to conduct hydrographic surveys on our water bodies to determine its safety for transportation. This work is of high significant to National Development of a country in the area of transportation. The use of the water body for transportation will reduce the over dependence on road transportation by creating another alternative thereby creating job for the people. If hydrographic surveying is conducted on our water bodies, the results would be used to determine the level of safety in its use for the development of a Water Transportation System. It would also create the awareness in the importance of hydrographic surveying to determine the safety in the use of the water body. This write-up concludes that the Water Transportation System can be one of the cost effective and safest modes of transportation in Ghana and the development of the system can be made possible to the highest level of safety with the conduction of a hydrographic survey to determine the topography of the Volta Lake.

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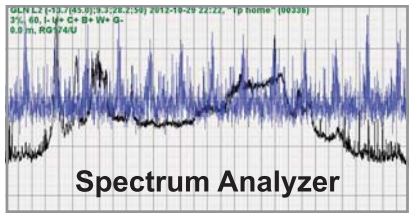
Verify, Monitor, record, and defend the accuracy of your shots with our six different RTK engines and verification systems. Export results in PDF and HTML formats.

5 Hz BEAST MODE RTK resolves ambiguities 5 times faster. This is not extrapolating the 1 Hz base data. Base transmits correction data 5 times per second.



Interference in the GNSS spectrum exists in many places. Monitor and avoid it with the TRIUMPH-LS.

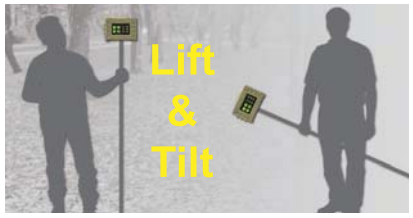
Multipath acts like a “ghost” signal and degrades the accuracy of your shots. We isolate multipath effects in both code and carrier phase measurements and remove them.

Mount your base on top of your car; park it near your job site and perform RTK survey. Then DPOS-It or Reverse-Shift-it.

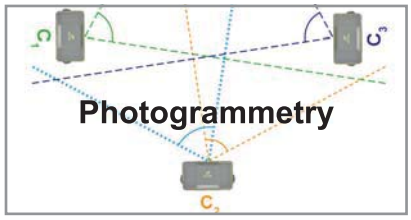
Don’t break out the Total Station! Complete the job with the TRI-UMPH-LS only.

Highly rugged. Gorilla Tested, 180 pounds of surveyor driving it into the pavement. Also, check out our concrete drop test on www.javad.com

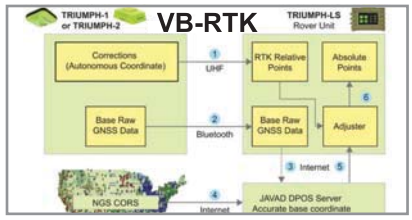
Bottom camera shows Double Bubble on the screen and documents it. Also, you can use these physical bubbles to calibrate the built-in electronic tilt sensors.



Survey starts with you lift the pole. You don’t need to level the rod, tilt sensors and compass automatically compensate for tilts.

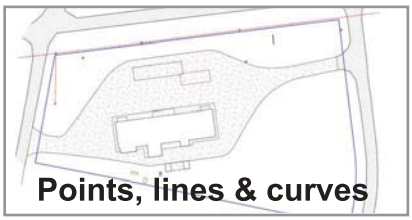


You can survey points that you or GNSS signals can’t reach. Camera Offset Survey (Photogrammetry in the box) with the internal forward facing camera.

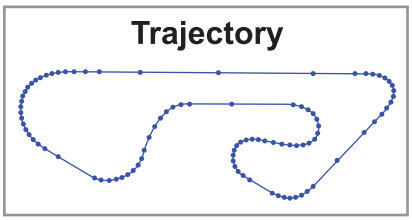


Process data collected at the base with OPUS or DPOS and automatically verify your shots. It basically ties your shots to the well-established NGS/IGS base stations.

The most comprehensive worldwide Coordinate Systems, transformation and localization, including “time dependent” coordinate systems.



Survey Points, Lines and curves automatically. No need to codes like BOC, MOC, and EOC, or others.



The deeper the curve, the faster points will be recorded automatically for accurate representation of trajectories.

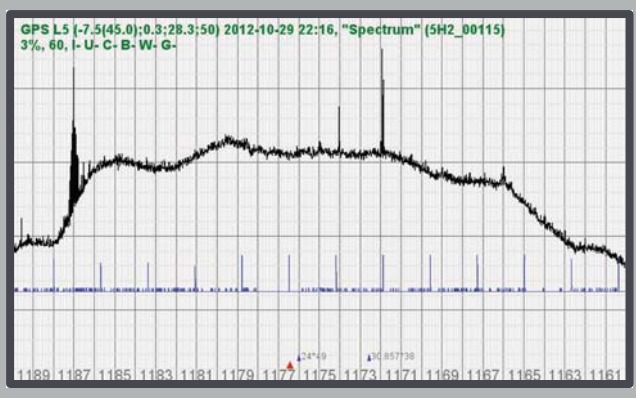
Append your shots with audio, photo and other technical and meta files automatically.

Monitor and avoid Interference with the TRIUMPH-LS

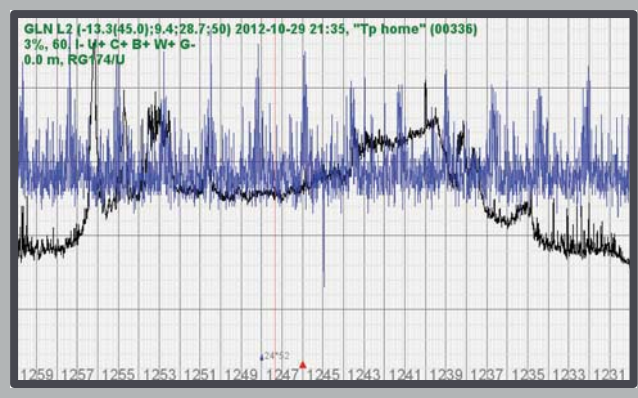
Radios
TV's
Radars
Harmonics
GSM
LTE
&
intentional
Jammers

Have you noticed in some places on some days that your receiver does not operate as it should? Intentional and unintentional interference appears almost everywhere. The Triumph-LS has the best available interference protection. It is the only receiver that monitors and reports interference graphically and numerically. Over 100 channels are dedicated to continuous interference monitoring.

Interference awareness is a must when performing GNSS work. It allows safe GNSS operation in a city, airport and military environment.

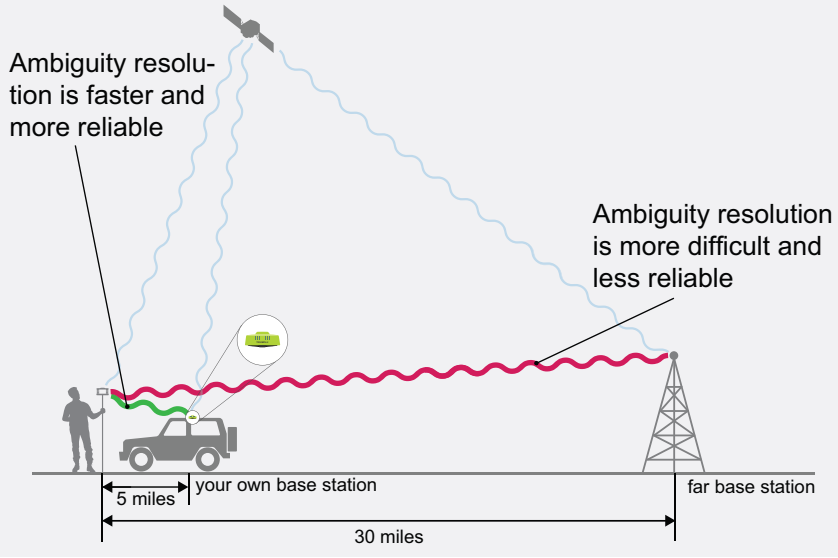


Some interference



Big interference

Advantages of your own base station and short baselines



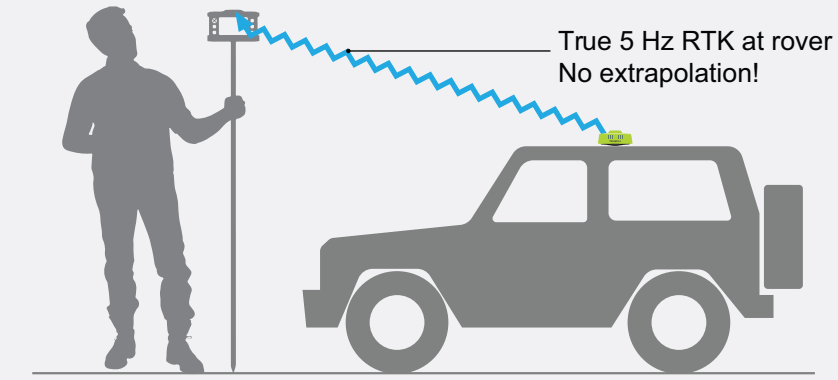
1. Shorter baselines provide significantly better **reliability** because the ambiguities are much easier to resolve and the correct ambiguity solution has an obvious contrast.

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

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

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

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



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

contact **sales@javad.com** for details.

1 Equip your car

Mount the TRIUMPH-2 and radio on top of your car or truck. You can use either **UHF or FHSS** (Frequency Hopping Spread Spectrum) radios. You may want to bolt them down in your car for everyday use. FHSS does not need a license but its range is limited to a couple of miles. UHF has a longer range (up to 50 miles with a 35 Watt amplifier) but it needs a license. FHSS is particularly helpful in connection with our Beast Mode RTK which provides corrections from a TRIUMPH-2 near your job site. Use an appropriate long whip UHF/FHSS for longer range transmission.

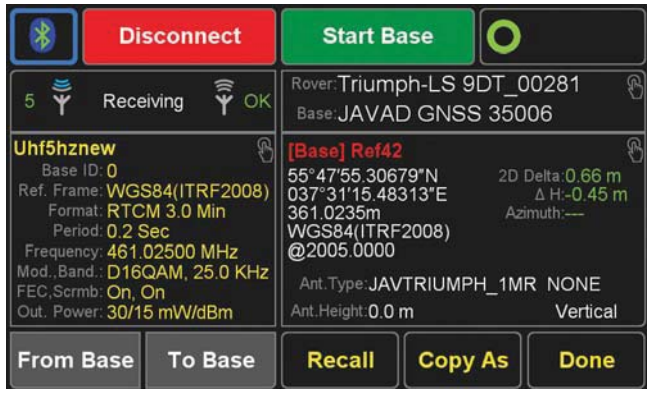
HPT401BT
1W UHF Radio

TRIUMPH-2
GPS+GLONASS
L1/L2

2 Park your car, Start Base

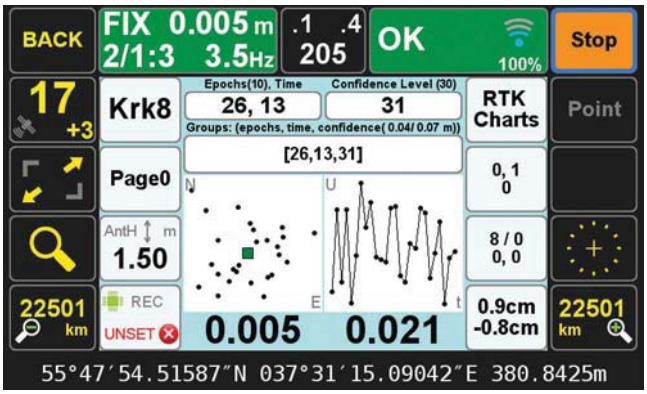
Park your car in an open area near your job site. It may be even in the middle of your site job. Engage all the brakes and ensure the car will not move. The Base/

Rover Setup screen makes it easy to configure the base and rover with the same parameters.
Use "**Auto**" for the base coordinate. "Auto" will use an autonomous solution as the base coordinates which may be off by several meters (this will be corrected later). Then click **Start Base**.

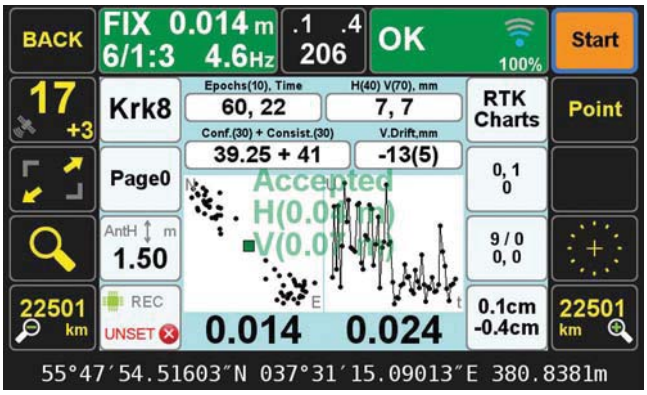


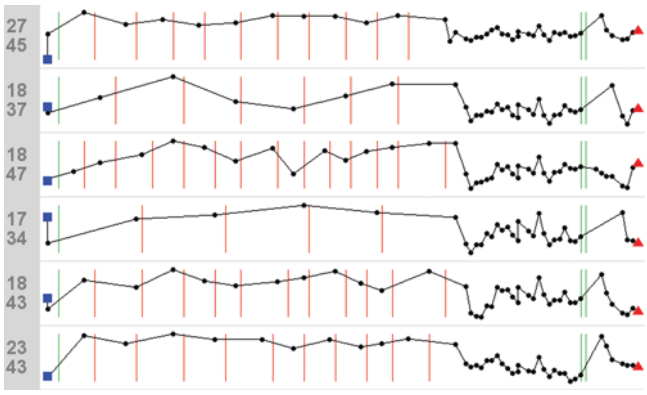
3 RTK Survey

Use your rover to perform your tasks. We have combined UHF and Spread Spectrum Frequency Hopping (FHSS) in the same module in TRIUMPH-LS as an option. The automatic "**Verify**" feature (Phase-1 and Phase-2) ensures that you will never get a wrong solution.



Since your RTK baselines are short, you benefit from all advantages that we discussed earlier BUT all your rover shots are shifted by the offset error of the autonomous base coordinates (up to several meters). "DPOS-It" or "Reverse-Shift-It" to correct for the error from the autonomous position.

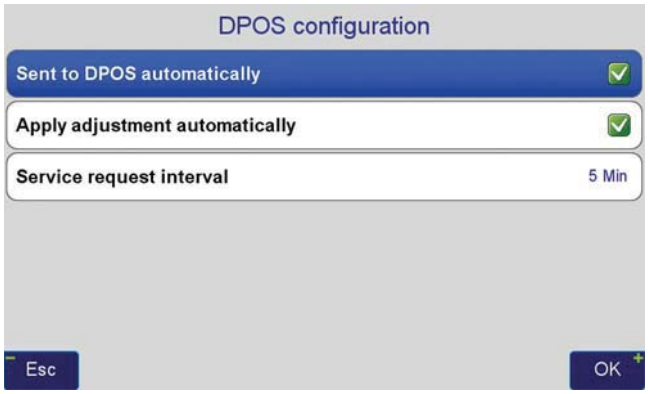


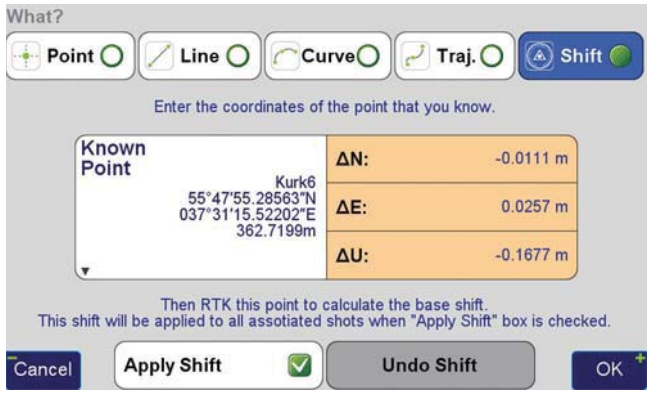


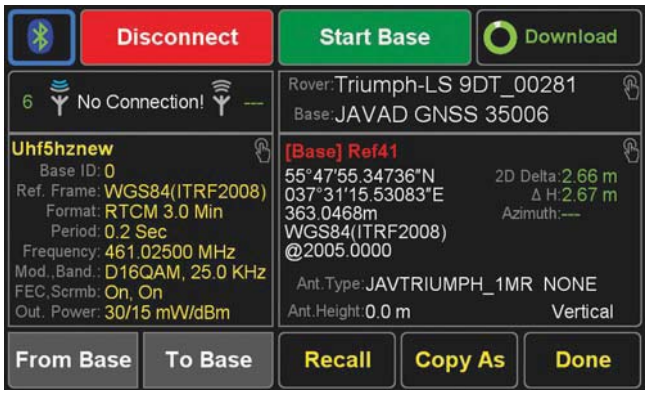
4 DPOS-it or Reverse-Shift-it

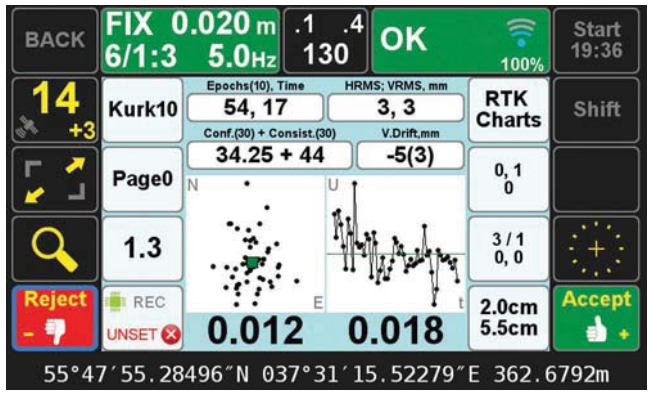
DPOS-it:
Press Stop Base and this will automatically **download** the raw GNSS base data to TRIUMPH-LS and send it to **DPOS** for processing with data from nearby CORS receivers. The TRIUMPH-LS then receives the **correct coordinates** of the base and **shifts** all the rover points accordingly. DPOS, CORS data and J-Field's RTK Verification guarantee your rover solutions.

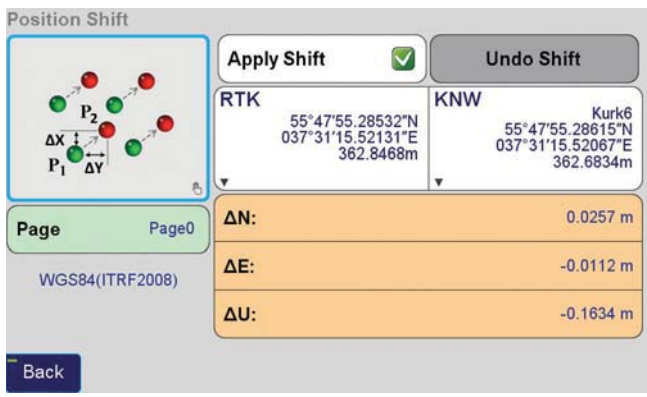
Reverse-Shift-it:
1) Take the TRIUMPH-LS to a **known point** and select the "**Shift**" function in the Setup Advanced screen. 2) Enter the **known coordinates** of that point. 3) Take a **shot** at that point and a base station shift will be **calculated and applied** to all previous and subsequent points surveyed in this session. You can then also use the newly surveyed points as known point for leap frogging during the project.



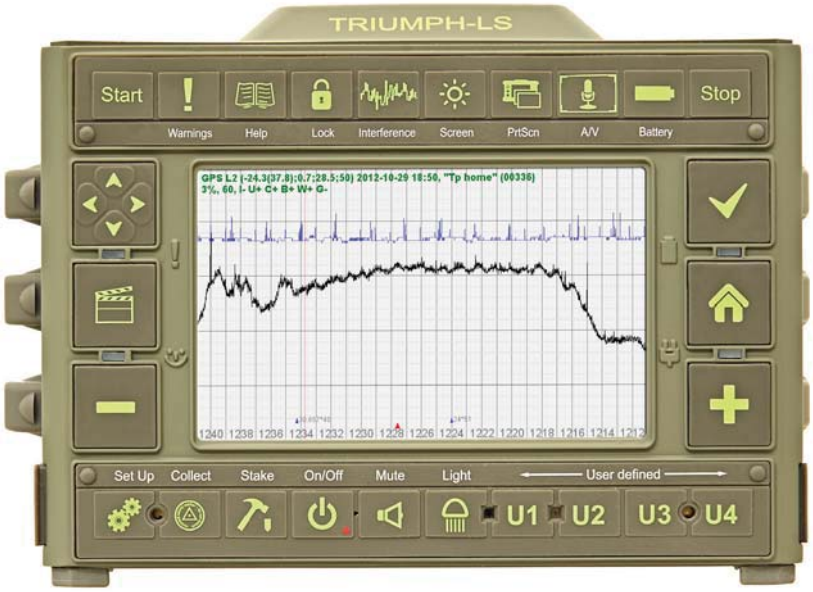




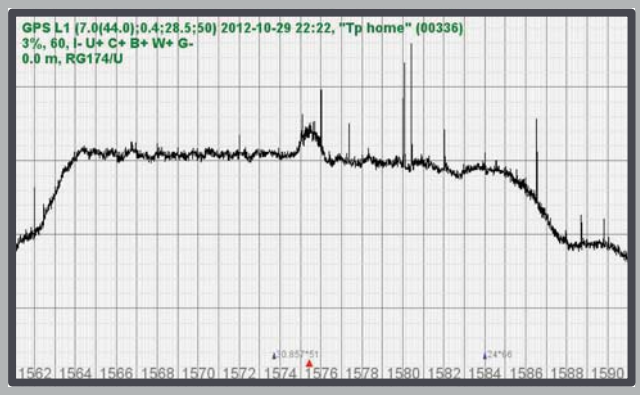


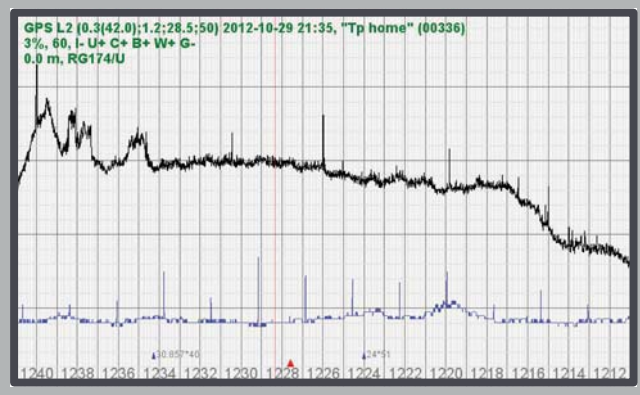


See who jams your GNSS

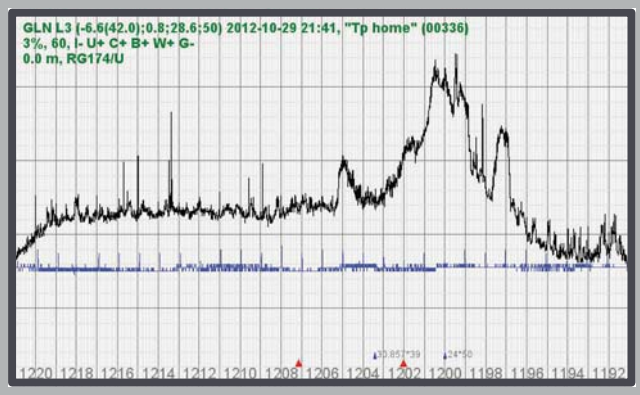


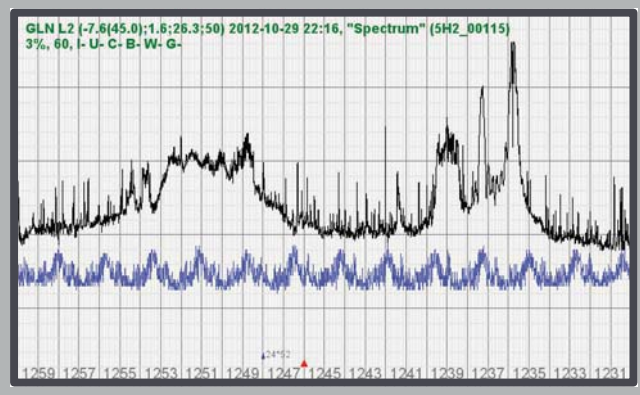
Now you can "view" interferences in your environment before starting your job and see if RTK is degraded.





Actual examples of somewhat clean GNSS environment.





Actual examples of noisy GNSS environments. People could not use some signals and did not know why.

REVERSE SHIFT<<it

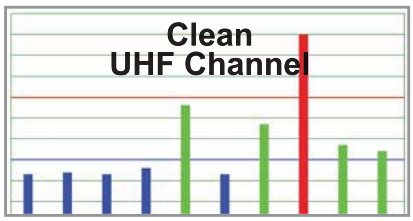
Setup base anywhere. Put the rover on a known point and click reverse “SHIFT”. The base correction will be applied to all past and future points in that session.

the most advanced GNSS chip with 864 GNSS channels, 24 digital filters and 24 anti-jam filters to protect against out-of-band and in-band jammers.

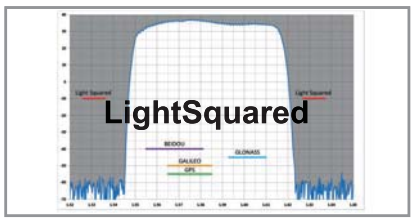
RAMS

Remote Assistance & Monitoring Services

Monitor and control the activities of your field crews from the comfort of your office via a PC, iOS/Android device. It is also a great tool for training and receiving support.

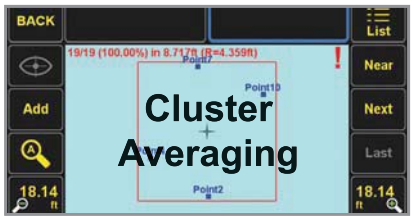


Similar to monitoring the GNSS bands, monitors and scans all UHF bands and shows interferences in all channels. It assists you to select the cleanest channel.



We told you so! LSQ issue was political and financial. Some editors, professors and generals must now eat what they wrote and testified. We do have J-Shield filter.

Fully integrated, all antennas, radios, controller, high resolution sunlight readable display, over 20-hours of internal batteries 2.5 Kg (5.5 lb) including monopod.



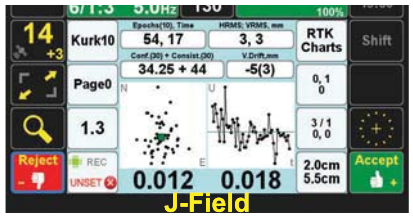
If you are required to repeat your shots we find clusters and average them automatically. You don’t need to make any attempt to manually tie shots together.

DPOS

Data Processing Online Service

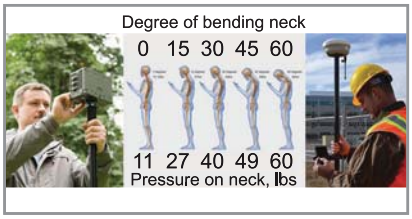
DPOS is similar to OPUS but processes GLONASS when available. It also applies corrections to the base coordinate and all RTK solution as mentioned in VB-RTK.

Visual Stakeout overlays stake points on top of the camera image to easily guide you to the stake point. A nice virtual reality.



Horizontal and vertical graphs of every epoch along with statistical data can automatically be recorded with each point for documentation and protection.

TRIUMPH-LS has the most comprehensive COGO functions (grid, ground and geodetic surfaces) and Time Dependent Transformations (US, HTDP)



They all break your necks! TRIUMPH-LS does not. Looking down puts 60 lbs of pressure on your neck. Look straight!

Six RTK engines plus one support engine provide robust RTK performance, even in challenging environments.

Send your survey results to Dropbox and Google Drive automatically.

You can quickly measure angles with the internal forward facing camera of the TRIUMPH-LS.

See detailed descriptions and more at www.javad.com

All these unique features at price of $12,990

Cadastre as a crucial component of SDI ensuring sustainable development

The correct spatial planning should lead to the rational and sustainable utilisation of the space, with consideration of the important social interest

Dr Ludmila Pietrzak
Vice President of Association of Polish Surveyors, Warsaw, Poland

Prof Elzbieta Bielecka
Professor of Military University of Technology, Faculty of Civil Engineering and Geodesy, Warsaw, Poland

The modern cadastre cannot be considered without mentioning issues related to the SDI (Spatial Data Infrastructure) and SES (Spatially Enabled Society). The SDI allows the network of spatial web services and data to be utilised by the Spatially Enabled Society in order to make correct and reasonable decisions with the use of spatial data, including cadastral data. The SDI combines and integrates not only spatial data, but also the information society. The well organised and administered cadastre is the basis and the most important platform for the development of the future, spatially active society, the modern land management system and the sustainable development (Steudler, Rajabifard 2012).

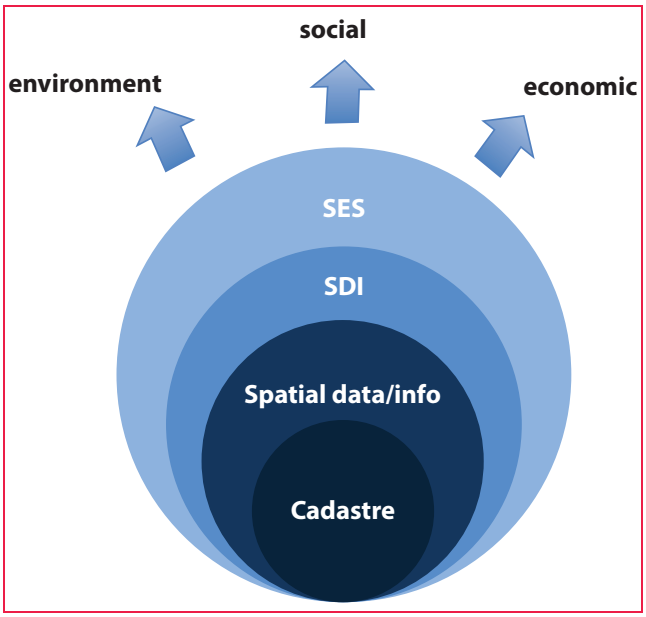


Figure 1: Sustainable development versus cadastre Relation between cadastre, SDI and SES – Abbas Rajabifard, Australia

Considering the importance of the cadastre, particular countries place the cadastral parcel as the basic, spatial reference object for different, thematic public registers. At the same time they establish the obligation to publish public registers in Internet. That happenned in the European Union countries after implementation of the INSPIRE directive (Directive 2007/2/EC). Spatial data infrastructure, authorised in Poland by the INSPIRE directive through implementation of the act on spatial information infrastructure in 2010, assigned the full powers to the Surveyor General of Poland, not only as the leading body for 15 spatial data themes, but also as the body, responsible for coordination of data harmonisation for all spatial data themes (Pietrzak et al. 2014; Bielecka, Zirowicz-Rutkowska 2013).

In order to apply good practices in the field of the cadastre and to develop international standards, works of the International Federation of Surveyors were initiated in this field. One of the documents was developed in 1998 and it is called *Cadastre 2014 – A Vision for the future cadastral system* (Kaufmann, Steudler 1998); the second one was completed in 2014, *Cadastre 2014 and Beyond* (Steudler 2014). At the same time, considering the correctly organised and administered cadastre, the international ISO 19152 Standard - Geographic information — Land Administration Domain Model (LADM), was developed. The spatial data infrastructure, the spatially enabled society and the sustainable development are inseparably related; it is illustrated in Figure 1.

Cadastral data in INSPIRE

The importance of cadastral data was reflected in INSPIRE. A cadastral parcel is one of the themes of the first annex to the INSPIRE directive. The INSPIRE

Table 1: Mapping of INSPIRE cadastral parcels application schema to Polish EGB model

No	INSPIRE Model for *cadastral parcels*		Polish EGIB model
	Object type/attribute	**<voidable>**	
1	CadastralParcel		EGB_DzialkaEwidencyjna
	geometry: GM_Surface		geometria: GM_Surface
	inspiredID	No	idIIP
	beginLivespanVersion	Yes	startWejsciaObiekt
	endLivespanVersion	Yes	koniecWersjaObiekt
	nationalCadastralReference	No	idDzialki
	areaValue	Yes	powierzchniaEwidencyja
	validFrom	Yes	waznoscOd
	vallidTo	Yes	waznoscDo
2	CadastralZoning		EGB_ObrebEwidencyjny
	geometry: GM_MultiSurface		geometria: GM_Surface
	inspiredID	No	idIIP
	beginLivespanVersion	Yes	startWejsciaObiekt
	endLivespanVersion	Yes	koniecWersjaObiekt
	nationalCadastralReferences	Yes	idObrebu
	estimatedAccuracy	Yes	
	level	Yes	
	levelName	Yes	
	originalMapScaleDenominator	Yes	
	referencePoint	Yes	
	validFrom	Yes	waznoscOd
	vallidTo	Yes	waznoscDo
3	CadastralBoundary		EGB_PunktGraniczny[1]
	geometry: GM_Curve		
	inspiredID	No	
	beginLivespanVersion	Yes	
	endLivespanVersion	Yes	
	estimatedAccuracy	Yes	
	level	Yes	
	levelName	Yes	
4	BasicPropertyUnit		EGB_ JednostkaRejestrowaGruntow
	inspiredID	No	idIIP
	nationalCadastralReference	No	idJednostka RejestrowaGruntow
	areaValue	Yes	powierzchniaEwidencyja
	validFrom	Yes	waznoscOd
	vallidTo	Yes	waznoscDo
	areaValue	Yes	

[1] cadastral Boundary object will be computed on the basis of EGB_PunktGraniczny

directive focuses only on geographical part of cadastral data, so the parcel is defined as "areas defined by cadastral registers or equivalent" (Data specification, 2010). INSPIRE does not aim at harmonising the concepts of ownership and rights related to the parcels. It was assumed that cadastral parcel should be used as "locators for geo-information in general, including environmental data".

The cadastral parcel is described by some mandatory attributes e.g. geometry, identifier, cadastral reference, and the label of the parcels that supports their identification on printed maps. "In case of availability Member States are also requested to supply information on the area of the parcel, when the parcel has been created/changed/retired, and the reference point, which is especially useful for visualization". Moreover, the reference to the national registers as a property (attribute) of the INSPIRE parcels national data sources can be reached. Using this approach other information, like rights and owners can be accessed fully respecting the national legislation on data protection. The data model for INSPIRE cadastral parcels is harmonised with ISO 19 152 Land Administration Domain Model. The INSPIRE Cadastral parcels model is very simple but flexible that allows data providers to publish their existing data in the efficient way.

Cadastral parcels are reference data for the following themes listed in Annex III: buildings, soil, land use, utility and governmental services, area management/restriction/regulation zones and reporting units.

Like others INSPIRE thematic data cadastral parcels should be described by metadata, including data quality information. The minimum DQ elements are: omissions and positional accuracy - Absolute external accuracy, expressed by absolute external accuracy.

Harmonisation of Polish cadastral data with INSPIRE application schema

The new approach to data acquisition

On July 12, 2014 the amendments to the Law of Geodesy and Cartography, being the basic law in the field of geodesy and cartography in Poland, came into force. Besides many rules, such as professional responsibility of surveyors, this law settled issues concerning fees for materials and databases of the state geodetic and cartographic resources, and, therefore, it settled fees for the use of the SDI databases, financed by public funds. Previous amendments, approved in 2010, introduced the necessity to disseminate geodetic data (including cadastral data) by means of web services. And, following the INSPIRE directive, the obligation to review and search them, free of charge, using view and discovery services, was also introduced.

INSPIRE does not aim at harmonising the concepts of ownership and rights related to the parcels. It was assumed that cadastral parcel should be used as "locators for geo-information in general, including environmental data

issued as amendment to the Law of Geodesy and Cartography; however, they settled the issues of acquisition, storing, updating and dissemination of the SDI data. In most regulations, attention was paid to conditions, when the surveyor, who implements geodetic and cartographic works and, thus, enriches the databases of the state geodetic and cartographic resources, pays lower costs for the use of the data, than other, external users. It was also assumed that public entities would be allowed to use the data from the resource free of charge.

Cadastral data is characterised by the high variability in time; unfortunately this is delays. However, amendments to the Law of Geodesy and Cartography, which came into force on July 12,2014, introduced positive changes in this field.

They forced the bodies, which maintain the cadastre, to disclose introduced changes within 30 days since the date of registration; the bodies and institutions where such changes occurred, were forced to send documentation (e.g. a notary - a notarial act) within 14 days since the date the legal effects of this documentation comes into force. This is a kind of a substitute of the multidimensional (including 4D) cadastre, desired in Poland. Although the introduced solutions are not the 4D cadastre, but it is an important step forward. We are sorely lacking the multidimensional, or at least the 3D cadastre. Only partial details are disclosed in the 3D cadastre, by disclosing information on premises in its the descriptive part. As for now, complete legal regulations are missing, which would allow for creation of the multidimensional and multitask cadastre. Cadastral data should be urgently integrated with data from other registers and legal and organisational procedures should be established to avoid data disintegration and to meet the AAA (Accurate, Assured, Authoritative) requirements.

Conceptual model of cadastral data in Poland was described in the Ordinance of the Minister of Regional Development and Building Industry of March 29,200 on the lands and buildings register. The important amendments to this act came into force on December 31, 2013 (Ordinance 2013). This model utilises the international

LADM Standard, includes packages responsible for parties (people and organizations); basic administrative units, rights, responsibilities, and restrictions (ownership rights); spatial objects (parcels, and the legal space of buildings). The possibility to harmonise Polish cadastral data with INSPIRE data specification for the themes *cadastral parcels* and *buildings* was also considered during the process of preparation of this Ordinance.

Table 1 presents the types of objects and their attributes in the INSPIRE schema, as well as corresponding types of objects in the Polish EGB application schema. As it turns out from this table, in case of the theme "cadastral parcels" and the Polish model of lands and buildings register data, the types of spatial objects and their attributes, required by INSPIRE, may be automatically generated basing on the register data, acquired according to the conceptual model, included in the ordinance on the lands and buildings register (Ordinance, 2013).

The cadastral data structure (EBG model) is much more developed than the INSPIRE model for the theme "cadastral parcels". The INSPIRE data model considers specific features of public registers, which are maintained in particular member states of the European Union. Therefore, only basic types of spatial data are determined, which will be made available by all member states. In Poland, due to organisational, legal and economic aspects, creation of INSPIRE data files for the theme "cadastral parcels" should be based on the resources of the central repository of copies of cadastral data file, which will be created within the development of the integrated real estate information system.

Final remarks

The importance of the cadastre obliges the country to perform the following activities in this field:

- modernisation of the cadastral system with the assurance of AAA (Accurate, Assured, Authoritative).
- development of the multi-task and multi-dimensional cadastre. The developed cadastre should ensure the to law and space, where the extension of property rights is reflected.
- introduction of the ISO 19152 standard, in order to adapt to requirements which must be met by the contemporary, integrated, multi-dimensional and interoperational cadastre.
- integration of cadastral data with other public registers - repeated data means repeated funds. Such data integration is forced by legal regulations, which are obligatory in Poland, force such data integration.
- introduction of the 4D cadastre, in which registration of data and objects would be performed in real time.

In Poland, due to organisational, legal and economic aspects, creation of INSPIRE data files for the theme "cadastral parcels" should be based on the resources of the central repository of copies of cadastral data file, which will be created within the development of the integrated real estate information system

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Planning MSW landfill site using GIS based multi-criteria evaluation

The current paper endeavors to identify suitable landfill sites for municipal solid waste (MSW) in seven surrounding *tehsils* of Shimla and Solan Districts of Himachal Pradesh (India) using Geographic Information System (GIS) based Multi Criteria Evaluation (MSE)

Shashi Shekhar
Scientific Officer,
Himachal Pradesh
Pollution Control Board

Background

With the commencement of cleanliness drive across the country initiated by Hon'ble Prime Minister of India, identification of proper landfill sites for wastes assumes special significance. Solid waste dumping is a serious problem in the urban areas because most solid wastes are not dumped in the suitable areas. Therefore identification of environmentally appropriate dumping site has to be planned objectively considering important thematic areas/limiting factors prevailing in mountainous region like Himachal Pradesh. It is with this objective, the current paper demonstrates the capabilities/usefulness of the GIS/RS tools, which can play a significant role in planning and identification of such sites. As the MC Shimla has already identified their landfill site near Bharyal at Tutu Shimla, the methodologies/tools adopted in the paper may be useful in identifying suitable sites for other ULBs.

Identifying suitable landfill site for municipal wastes has been a key concern for urban local bodies (ULBs). Due to several physiographic and natural limiting factors prevailing in mountainous regions, identifying suitable landfill site has been a contentious issue for Shimla MC in the past. The paper shall make an attempt to identify environmentally compatible and suitable sites in seven surrounding tehsils of Shimla and Solan Districts of Himachal Pradesh. While assessing suitable lands, different thematic layers were taken into account for GIS based multi-criteria evaluation (MCE) such as slope, elevation, distance from rail-line, road/infrastructure of national and state significance, wildlife sanctuaries, land use/cover, distance from educational & health facilities, monuments/heritage, geomorphology, soil texture, lineaments, drainage network, and geology. Though, there is an every scope to enhance the accuracy of findings by increasing the spatial resolution of satellite imagery and other input data, some of them are available on cost-basis.

The final suitability map is prepared by weighted overlay analysis of numerous thematic maps through the use of GIS and Image-processing software such as ArcGIS, Quantum GIS & Erdas Imagine. For this analysis, some of the medium resolution satellite data/sensors such as Landsat 7/8 based ETM+, OLI-TIR, IRS based LISS-III and other datasets procured from open source, have been taken into as primary inputs.

Problems

Waste is a material discharged and discarded from each stage of daily human life activities, which, if not disposed properly, often leads to adverse impacts on human health and the environment

Table 1 – Tehsils in study area

Sr. No.	Tehsils	District	Population as per Census of India 2011	Population density (calculated from map)
1	Shimla (R)	Shimla	84,382	257
2	Shimla (U)	Shimla	1,69,578	2828
3	Theog	Shimla	84,684	180
4	Junga	Shimla	13,398	129
5	Kandaghat	Solan	40,529	176
6	Arki	Solan	56,908	151
7	Sunni	Shimla	35,379	132
Total population			**4,84,858**	**264**

(Source: Census of India, 2011 and density calculated from Tehsil map)

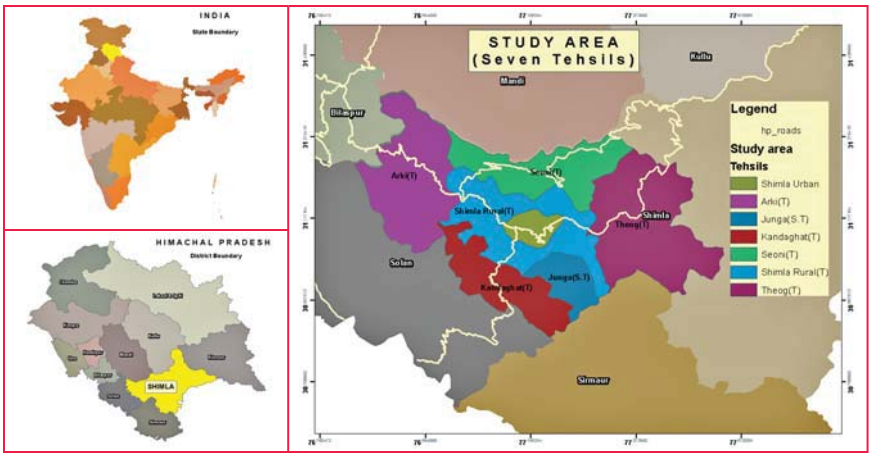

Figure 1: The study area

(Bringi, 2007). Therefore, identification of environmentally compatible dumping site is the key concern and important step in effective waste management. It has been observed that most solid waste disposal sites are found on the outskirts of the urban areas where there are water bodies, crop field, settlement, along road, etc. These are suitable sites for the incubation and proliferation of flies, mosquitoes and rodents. They transfer diseases that affect human health (Abul, 2010). Inappropriate disposal of solid waste can be manifested by contamination of surface and ground water through leachate, soil contamination through direct waste contact, air pollution by burning of wastes, spreading of diseases by different vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste (Visvanathan and Glawe, 2006). Solid wastes indiscriminately thrown also results in aesthetic problems, nuisance, and pollution of land and water bodies of an area (Hammer, 2003).

Waste generation

Municipal solid waste has also been recognized as one of the major problems confronting governments and city/ environmental planners the world over. India, one of the most populous countries in the world generates between 500-700 gm of waste/head/day. However, the average waste generation in Shimla Planning area is estimated to be about 93 tonnes per day at an average waste generation of 350 grams/capita/day. The waste generation is characterized by high seasonal variations with a 30% increase in MSW due to tourist inflow to the town (Shimla MC Report).

In accordance with the MSW Rules, 2000 and JNNuRM requirements, only inert waste and rejects from processing facility can be diverted to landfill. In view of the same, landfill may be designed and planned for the waste of about 30 MT/day and hence, landfill plot size of more than 10ha has been selected/planned through this study.

Environment and economic viability

Locating suitable dumping sites for wastes attracted lots of studies and research from scientists. Distance has been primary criteria for such analysis. Several studies suggested that the solid waste dumping site should be located within one km buffer from the roads. Some argued solid waste disposal sites should not be placed too far from the roads to decrease the cost of transportations. Also solid waste disposal site should not be placed too close to settlement areas, and recreation centers and monuments of national importance etc. Therefore, maintaining balance in environment factors and economic concerns is of utmost importance. One can't afford to compromise on environment and health concerns at the same time increasing transportation cost shall also lead to rise in vehicular pollution, which shall defeat the very purpose of environment protection.

Description of Study Area

While identifying suitable lands for dumping of urban wastes, it is desired that suitable lands should not be far away from the current city, at the same time, it has to maintain certain minimum buffer to keep it away from the sensitive locations. Therefore, all the tehsils surrounding the city have been selected for the study and of them, five tehsils are from Shimla District and two from neighbouring Solan District (Figure 1). Demographic profile of seven surrounding tehsils such as population and their population density as per Census of India 2011 is given in Table 1.

Data Used and Methodology

The study used spatial multi-criteria evaluation (SMCE) technique to identify the most suitable solid waste dumping site. Spatial multi-criteria approaches have the potential to reduce the costs

Table 2: Different Data Layers / Maps and Sources

S. No.	Data Layer / Maps	Source	
1.	Base Map	Topographical Maps of Survey of India (1:50,000) and ArcGIS 10 base map, Bhuvan portal and OpenStreetMap.	
2.	Elevation Map	ASTER –DEM (30 m)	Version 2 released (October 17, 2011).
	Slope Map	Derived from DEM	
3.	Land use/Land cover Map	Land use and land cover map has been prepared digitally by using Supervised Classification method in ERDAS IMAGINE based on LANDSAT 8-OLI-TIR (30m) pan sharpened with PAN (15m) verified with limited field check and Google Earth maps.	
4.	Geological Map	Geological Map has been obtained from Department of Industries, Himachal Pradesh, which is also available in various reports.	
5.	Geomorphological Map	Lithology & geomorphological map have been prepared using Survey of India Toposheets (1:50,000) and remote sensing imagery and SoER Himachal Pradesh.	
6.	Demographic Map & Tehsil map	Census of India 2011.	
7.	Forest Resource Map	Forest Survey of India, Department of Forests Himachal Pradesh and Landsat 8 satellite data.	
8.	Road Network/Airport	OpenStreetMap, Google Earth & Public Works Department GoHP.	
9.	Soil texture	National Bureau of Soil Survey and Land Use Planning, Nagpur prepared Atlas in collaboration with Department of Agriculture, GoHP.	
10.	Settlement location map	OpenStreetMap	
11.	Town Map	Census of India 2011	
12.	Rivers & drainage map	Survey of India toposheets (scale 1:50,000)	
13.	Educational, Health facilities and Monuments	Census of India 2001 & 2011, Google Map & Department of Education and Department of Health, GoHP	

and time involved in siting facilities by narrowing down the potential choices based on predefined criteria & weights and permitting sensitivity analysis of the results from these procedures (Higgs, 2006). The solid waste disposal site selection mapping was done using multi-criteria evaluation and creating layers to yield a single output map. The regular procedures of digitization, georeferencing, supervised classification, weighted overlays and other mandatory corrections were applied/ conducted in GIS/RS environment.

There are some useful geospatial data/ image of moderate resolution of multi-spectral bands (MS) of 30 meters and 24 meters in public domain, which are available from Landsat and IRS respectively. The two important sources of such optical imagery of high temporal resolution, as on today, are available from the Landsat-8 and Sentinel-2. While the Landsat program is the longest-running enterprise for acquisition of satellite imagery of Earth, operated since July 23, 1972 by USA and the current satellite being Landsat-8, however, recently launched Sentinel-2 is an Earth observation mission developed by ESA (European Space Agency) as part of the Copernicus Programme, which is equally useful in performing terrestrial observations in support of services such as forest monitoring, land cover change detection, and natural disaster management. The current study uses Landsat data for land use/cover mapping.

Other thematic data have been collected from numerous sources such as Survey of India, toposheets, Bhuvan India, Census of India, Department of Forests, GoHP and from other open sources (Table-2). Though, some old data have also been updated through the help of Google Earth and OpenStreetMap as well.

GIS based Multi Criteria Evaluation (MCE)

Suitability analysis in GIS environment is a GIS-based process used to determine the appropriateness of a given area for a particular use. The basic premise of GIS suitability analysis is that each aspect of the landscape has intrinsic characteristics that are to some degree either suitable, partly suitable or unsuitable for the activities being planned. Suitability is determined through systematic, multi-factor analysis of the different aspects of the terrain. The present study is based on land/human resource data collected from various sources (Table-2), which have been weighted overlaid together using a common measurement scale and weights were provided according to its importance.

Modelling of criteria

Different thematic layers, which were taken into account for multi-criteria evaluation using Weighted Overlay tool by incorporating thematic areas are soil texture, slope, elevation, educational and health facilities, monuments of national and state significance, land use/cover, geomorphology, lithology, drainage network, road network and geology. The Weighted Overlay tool applies one of the most used approaches for overlay analysis to solve multi-criteria problems such as site selection and suitability models. As with all overlay analysis, in weighted overlay analysis, one must define the problem, break the model into sub-models, and identify the input layers. Since the input criteria layers were in different numbering systems with different ranges, to combine them in a single analysis, each cell for each criterion has been reclassified into a common preference scale such as 0 to 5, with 5 being the most favorable (0=

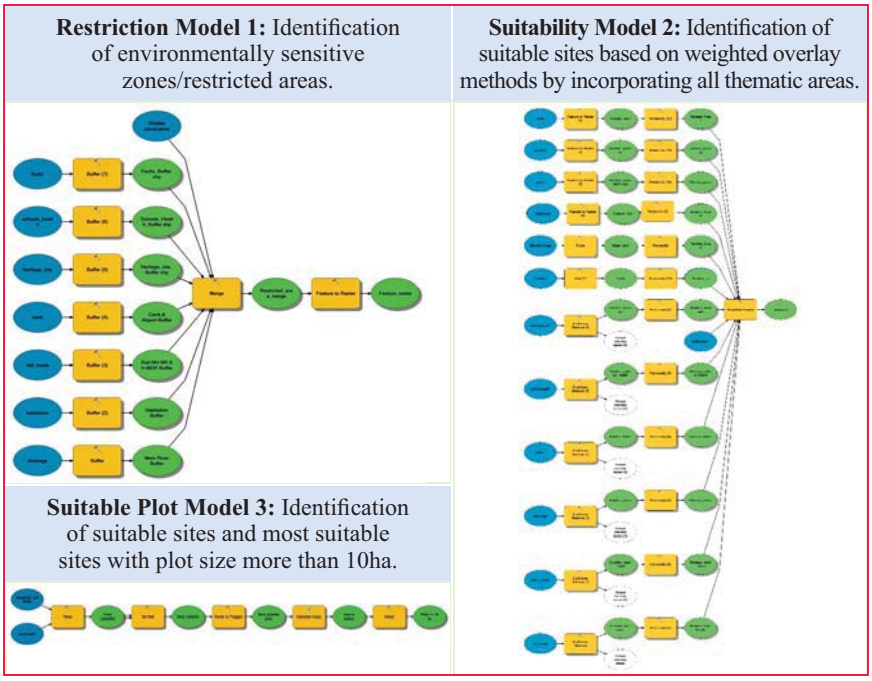

Figure 2: Modelling workflows

Table 3: Environmentally Sensitive Zones or Restricted Area

Sr. No.	Restricted areas	Buffer (m)
1	Wildlife sanctuaries	Restricted
2	Habitation	500
3	Railway and Important roads	500
4	Airport	5000*
5	Cantonment	500
6	Archaeological sites	500
7	Schools/Health facilities	500
8	Third order rivers/water-bodies	200
9	Lithology faults and upstream watershed of drinking water sources	500

* Though 20km distance to be maintained by CPCB Guidelines, but being hill and having different surface area, an aerial distance of 5kms is used for this study.

Table 4: Assigned Weights to Thematic Layers

Sr. No.	Criteria	Weight
1	Land use/cover	15
2	Distance from UNESCO Rail/National Highways, Border Roads, State Highways, MDR	10
3	Slope	10
4	Archaeological sites	10
5	Distance from educational and health facilities	10
6	Distance from Habitation	10
7	Distance from main rivers and its tributaries	10
8	Nearness to small roads	8
9	Elevation	5
10	Distance from Faults	5
11	Geomorphology	3
12	Geology	2
13	Soil texture	2
	Total	100

not suitable, 1 = very less suitable, 2 = less suitable, 3 = moderate suitable, 4 = high suitable and 5 = very high suitable). An assigned preference on the common scale implies the phenomenon's preference for the criterion.

Produced suitability map is based on the criteria and weights as mentioned in Annexure 1. Land use/cover being the central criteria had maximum weight allocated followed by slope, which is important in the case of hill town like Shimla. Nearness to small road shall give additional advantage of accessibility to dumping sites.

Modelling workflows of thematic layers

ModelBuilder application of ArcGIS has been used to create, edit, and manage models for the current study. Models are basically workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another as input. ModelBuilder can also be thought of as a visual programming language for building workflows. Three models were applied to reach the final identification of suitable plot (Figure 2).

Identifiation of Environmentally sensitive zones/restricted areas

In such assessment, it is also imperative to consider the natural limiting factor, ecologically sensitive factor, ecological protection factor for the safeguard of our fragile natural and man-made resources. The Table 3 indicates such buffer areas, which have been identified as the restricted zone due to non-suitability of such lands for landfill sites.

Thematic mapping

The thematic layers (Figure 3) were prepared based on data and maps collected from multiple sources as mentioned earlier and reclassified as per the weights assigned in the weighted overlay matrix compiled at Annexure 1. Most of the reclassified thematic layers (Figure 3) were used as input layers for weighted overlay analysis.

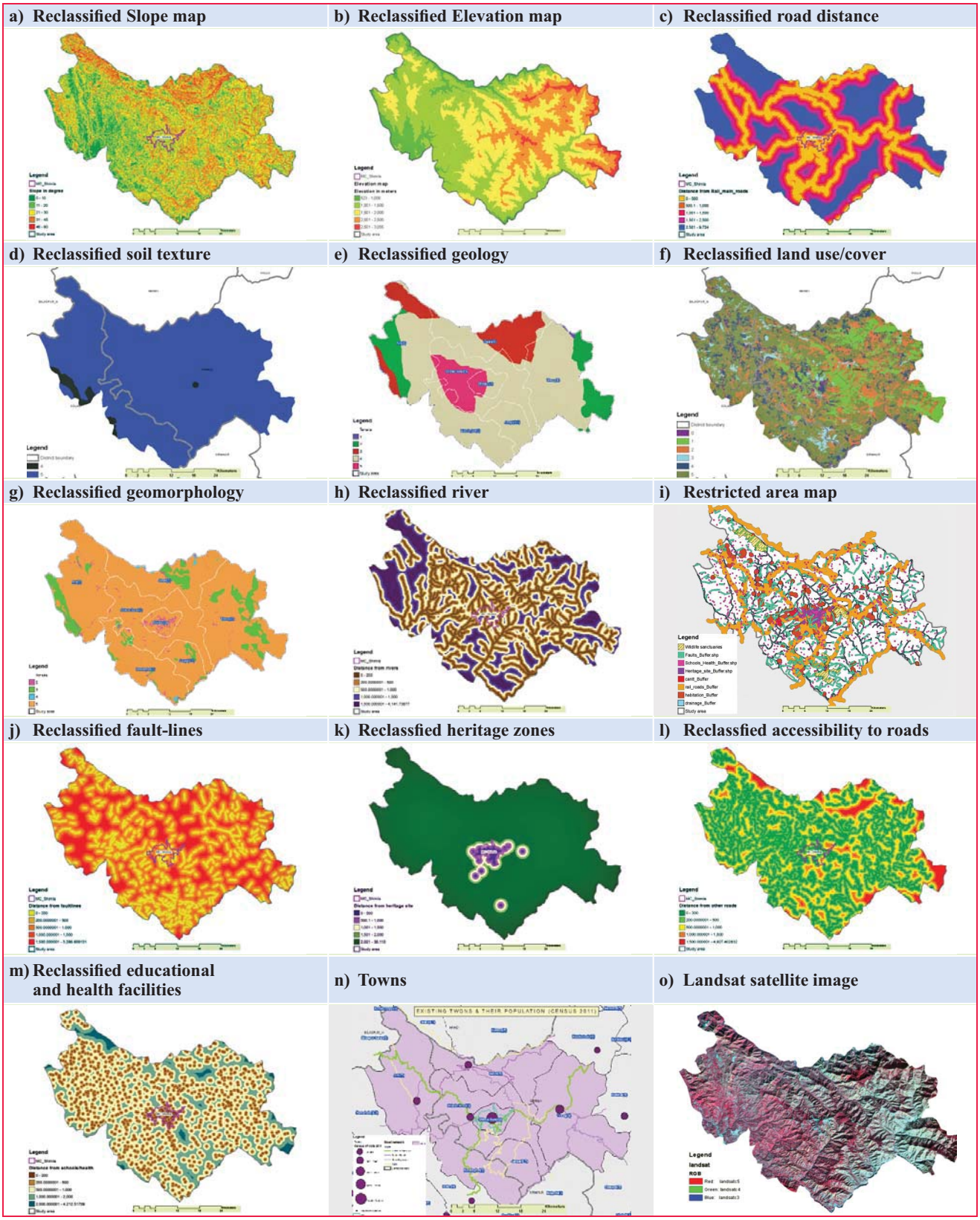

Figure 3: Reclassified thematic layers used as inputs for Final Map

Suitability assessment analysis

The following criteria have been identified and their thematic maps prepared for the current study along with their assigned weights for suitability analysis as per the breakup indicated at Table 4. Criteria and relative weights have been adjusted to the distinct local conditions prevailing in mountainous region. Higher weights have been assigned to dominating

Table 5: Suitable lands

Suitability types	Area in ha	Percent of TGA
Not suitable	88972.2	48.46
Very less suitable	391.5	0.21
Less suitable	26801.01	14.60
Moderately suitable	57401.64	31.27
High suitable	10019.25	5.46
Total Geographical Area (TGA)	1,83,585.6	100.00

criteria such as land use/cover, slope, distance from rail-line, main roads and main rivers, nearness to small road as they are very important in selection of suitable landfill sites.

Result and discussion

It is observed from the Table 5 that about half of geographical area is falling under non-suitable zone of the study area. While there is not a single site having very high land suitability, there is observance of some high and moderate suitable lands in different parts of the study area. The final suitability map thus indicates that about 31 percent of total geographical area (TGA) of the study area is moderately suitable for waste dumping while only 5 percent lands falling under high suitable zone (Figure 5).

The spatial pattern of the land suitability also indicates that suitable plots are more concentrated in Arki and Kandaghat tehsils of Solan District scoring more on wastelands and lower topography/slope. Nonetheless, patches of scattered suitable sites are observed across the region.

The final suitability map also depicts that about half of the area is not suitable for planning landfill site on account of observance of numerous sites of ecological and historical significance. It is also observed that there is acute shortage of such lands inside the Shimla MC however there is small chunk of partially and moderately suitable sites near the periphery of Shimla Planning Area (Refer Figure 5). Furthermore, it would also be appropriate to develop small dumping sites at other locations for smaller towns located in other parts of the study area. Some dumping site may be located near to some large rural settlements by making their viable clusters for dumping their non-biodegradable wastes.

It is worthwhile to note that earlier during 1999, Shimla MC had identified a landfill and waste processing site near Darni Ka Bagicha, which was found to be inadequate and gradually became ill managed, leading to environmental degradation and public nuisance. After Public Interest Litigations were filed in the Hon'ble High Court, the H.P. Government shifted the plant to its new location in Bharial located near Tutu.

Conclusion

The above findings have demonstrated the ability of GIS and remote sensing as a veritable tool for analyzing the criteria for decision support. The paper has taken land use/cover, slope, water sources, settlement, faults, geomorphology, geology, elevation, slope, soil texture, archaeological sites, educational & health facilities, airport, cantonment boards and transport facilities as determining factor in order to find appropriate site for solid waste dumping site. The results have shown that few suitable sites are present in the study area, however, there is no very high suitable zone owing to several restricting factors prevailing in the region. But there is high/moderate suitable zone around. These sites are easily accessible by the small roads but they are away from rail/roads of high significance. These places are also far away from any water sources and other environmentally sensitive variables put into analysis. They are also located in north-eastern and north-western parts of the study area on barren and waste lands with moderate slope. Hence, the capacity to use GIS and remote sensing technology for the effective identification of suitable solid waste dumping site will minimize the environmental risk and human health problems. While there is always a scope for improvisation with respect to tool and techniques of GIS and Remote Sensing, use of high resolution satellite data coupled with primary/field surveys and further use of knowledge in

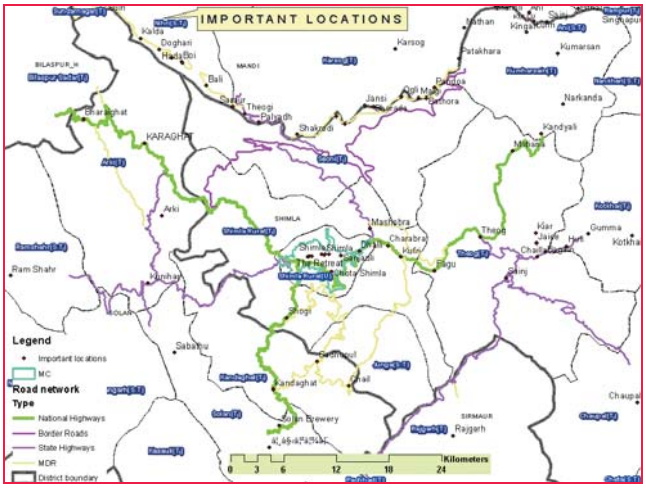

Figure 4: Important Locations

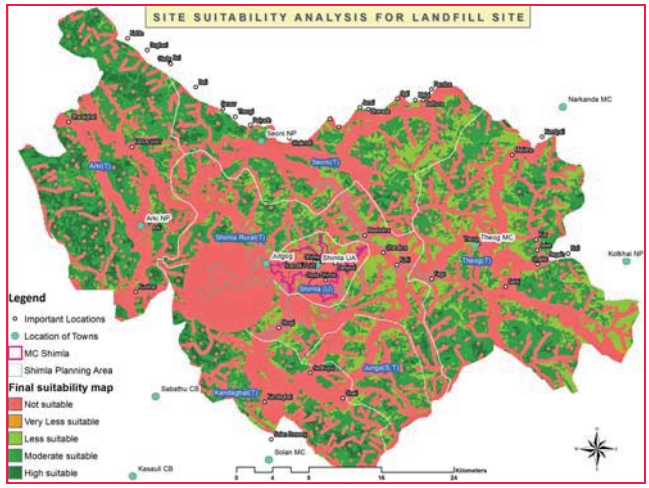

Figure 5: Final suitability map

Annexure 1: Criteria and their weights

Sr. No	Land use and Land cover	Weight	Sr. No.	Slope in degree	Weight
1	Barren Rocky/Stony waste	4	1	0^0-10^0	5
2	Crop Land in Forest	3	2	10^0-20^0	4
3	Degraded wastelands	5	3	20^0-30^0	3
4	Dense forest	1	4	30^0-40^0	2
5	Gullied/Ravenouse Land	3	5	More than 40^0	1
6	Kharif+Rabi	3	**Sr. No.**	**Distance from settlements (m)**	**Weight**
7	Land with scrub	4	1	0-500	0
8	Land without scrub	5	2	500-1000	1
9	Mixed Built-up land	0	3	1000-1500	2
10	Open forest	3	4	1500-2000	3
11	Perennial rivers	0	5	2000-2500	4
12	Sandy Area	2	6	above 2500	5
13	Scrub Forest	4	**Sr. No.**	**Nearness to small roads (m)**	**Weight**
14	Habitation	0	1	0-200	0
15	Water body	0	2	200-500	5
Sr. No.	**Away from NH/BR/SH/Rails (m)**	**Weight**	3	500-1000	4
1	0-500	0	4	1000-1500	3
2	500-1000	1	5	1500-2000	2
3	1000-1500	2	6	Above 2000	1
4	1500-2000	3	**Sr. No**	**Geomorphology**	**Weight**
5	2000-2500	4	1	Alluvial fan Younger	3
6	above 2500	5	2	Denudational Hills (Large)	5
Sr. No.	**Elevation in meters**	**Weight**	3	Habitation areas	0
1	Above 2500	0	4	Ridge type Structural Hills (Large)	1
2	2000-2500	1	5	Shallow alluvial plain (Younger/ Lower)	3
3	1500-2000	2	6	Structural Hills (Large)	5
4	1000-1500	4	7	Terraces – Older	4
5	500-1000	5	8	Terraces – Younger	3
Sr. No.	**2. Geology**	**Weight**	9	Water Body	0
1	Balini Group	2	**Sr. No.**	**Soil Texture**	**Weight**
2	Dalhausie-Mandi-Karsog Granitoid	3	1	Loamy	5
3	Jutogh Group	5	2	Sandy	2
4	Krol Group	4	**Sr. No.**	**Distance from Main River (m)**	**Weight**
5	Kullu Group	3	1	0-200	0
6	Shali & Largi Group	2	2	200-500	1
7	Shimla & Jaunsur Group	3	3	500-700	2
8	Sirmur Group	3	4	700-1000	3
9	Siwalik Group	2	5	1000-1500	4
10	Sundarnagar & Rampur Group	2	6	Above 1500	5
Sr. No.	**Archaeological/touristic sites/ cantonment board (m)/**	**Weight**	**Sr. No.**	**Schools/health facilities (m)**	**Weight**
1	0-500	0	1	0-500	0
2	500-1000	1	2	500-1000	2
3	1000-1500	2	3	1000-1500	3
4	1500-2000	3	4	1500-2000	4
5	2000-2500	4	5	Above 2000	5
6	above 2500	5			
Sr. No.	**Fault-line and upstream watershed of drinking water sources (m)**	**Weight**			
1	0-500	0			
2	500-1000	2			
3	1000-1500	3			
4	1500-2000	4			
5	Above 2000	5			

assigning weights to criteria, using them for our environmental management is of utmost importance. In addition, some of the distance criteria by CPCB seems to be plain-centric such as distance from airport is 20kms. While, this may need some re-look in hills and surface distance or other realistic distance need to be developed for mountainous region. The present paper is only a modest attempt to explore the broad opportunities that these geospatial tools offer us, to plan for a better landfill site in mountainous region.

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GPS error caused '12 hours of problems' for companies

Several companies were hit by hours of system warnings after 15 GPS satellites broadcast the wrong time, according to time-monitoring company Chronos. The company observed problems last week, after noticing some GPS time signals were 13 microseconds out. Such a discrepancy is considered severe and several Chronos telecoms clients faced "12 hours" of system errors.

Previously, the GPS errors had also been blamed for disturbances with BBC radio broadcasts. According to the US Air Force (USAF), which manages the GPS satellite network, problems began when a satellite named SVN 23 was decommissioned. A USAF spokeswoman confirmed that the error had been pushed to the satellites by "ground system software". *www.bbc.com*

CASA updates aerial GNSS requirements

Australia's governing body for aviation, CASA, is implementing new regulations and aircraft equipment mandates to align Australian operations with global standards set by the International Civil Aviation Organization (ICAO).

Under CASA's guidelines, Australia will adopt GNSS-based Performance- Based Navigation (PBN) in accordance with the ICAO Global Air Navigation Plan. PBN uses area navigation and will provide more direct and efficient routes compared to those based on conventional ground-based navigation aids. The new rules also contain a number of equipment mandates between 12 December 2013 and 2 February 2017 and affect all Instrument Flight Rules (IFR) pilots and aircraft operating in Australia. GNSS is the enabling technology for both PBN and automatic dependent surveillance-broadcast (ADS-B) in Australia and will affect all IFR aircraft.

Singapore partners Chinese association to develop satnav tech

Singapore Space and Technology Association (SSTA) and GNSS&LBS

Association of China (GLAC) recently signed MoU to formalise their partnership for industry development. The partnership aims to advance the development of integrated space capabilities in the area of navigational satellite technology. The partnership will include co-building a common platform for navigational satellite experts from both associations for knowledge sharing, conducting joint research projects and to identify opportunities to commercialise such projects together. *www.channelnewsasia.com*

New Global Positioning Spacecraft for Glonass

Russia continues to develop new generation spacecraft for its Glonass, Russian Deputy Prime Minister Dmitry Rogozin said. "Work continues on creating and testing new generation spacecraft, which will allow to significantly increase the [Glonass] system's accuracy characteristics by 2020" *http://sputniknews.com*

U.S. could still cancel Raytheon GPS ground system

The Pentagon and the U.S. Air Force could still cancel the ground control system Raytheon Co is developing to operate new GPS satellites, if the company does not improve its performance on the troubled system, a top U.S. general said.

Lieutenant General Samuel Greaves, who heads the Air Force's Space and Missile Systems Center, said officials were keeping close tabs on Raytheon's GPS Operational Control System, or OCX, which he described as the Air Force's "No. 1 troubled program."

Officials have stopped short of cancelling the OCX program, which has seen costs double due to increased cyber requirements and poor contractor performance, citing the importance of the system. OCX will be the first satellite control system designed after the advent of significant jamming and other cyber threats. Raytheon spokesman Mike Doble said the company was committed to delivering "without compromise" the modernized ground system and meeting all program requirements as specified by the Air Force. Greaves said the Air Force has alternatives in case it did have to cancel the Raytheon program. *www.reuters.com*

New Air Force satellites launched to improve GPS

The United Launch Alliance (ULA) successfully launched a Boeing-built satellite into orbit as part of the U.S. GPS, last month. This $131 million satellite was the final addition to the Air Force's most recent 12-satellite GPS series, known as the Block IIF satellites. We can all access GPS from our phones because of this very constellation. *http://techcrunch.com*

New MEO BeiDou Satellite launched

China successfully completed its first BeiDou launch of the year, lifting a new-generation satellite into orbit on February 1, 2016 and adding to its 17 operational spacecraft in the nation's GNSS constellation. The fifth of the new series, the middle-Earth-orbiting (MEO) satellite will join its four predecessors in testing inter-satellite crosslinks and a new navigation payload that will set the framework and technical standards for global coverage, according to the Xinhua state news agency. By the end of 2018, another 18 satellites will be put into orbit for Beidou's navigation service, said Chengqi Ran, director of the China Satellite Navigation Office.

GPS to keep check on mineral transport

The Orissa government in India will introduce by August a GPS-based vehicle tracking system for vehicles carrying minerals, according to a decision taken at meeting of the state-level task force on mining chaired by Chief Secretary AP Padhi here. "It was decided to make installation of GPS mandatory for all mineral-carrying vehicles by August. The Orissa Space Applications Centre (ORSAC) has prepared a proposal in this regard, which was approved by the government," mines director Deepak Mohanty said. *www.orissapost.com*

JPL demonstrates airborne water quality sensor

In a study published in the current issue of the journal Environmental Science & Technology, researchers combined water sample measurements collected by USGS scientists aboard a high-speed boat in northeastern San Francisco Bay with data collected by NASA's Jet Propulsion Laboratory (JPL) scientists at the same time onboard a specially instrumented Twin Otter aircraft flying overhead. The plane carried the JPL-developed Portable Remote Imaging Spectrometer (PRISM), which measures the amount and wavelength of visible light and near-infrared radiation reflected toward the instrument from the water below. The PRISM data allow researchers to detect the unique spectral signatures of several water constituents typically used as indicators of water quality. When the two data sets were later analyzed and compared in laboratories, the PRISM data closely matched the water quality information collected from the boat.

The benefit of PRISM is that it can greatly expand the spatial coverage of traditional boat- and fixed-monitoring, station-based approaches used for water quality monitoring. For example, a single PRISM airborne flight can assess the water quality of much of the San Francisco Bay-Delta Estuary; similar coverage using a boat would take weeks. New imaging spectrometers like PRISM can enable accurate detection of water quality indicators that were previously difficult to measure using existing satellite sensors. Scientists hope to apply the PRISM technology to sensors on future Earth-orbiting satellites that can provide continuous global monitoring. *http://prism.jpl.nasa.gov/*

ISRO to double missions to 12 per year

"We have already launched 55 missions during past five years and we are looking at doubling it during the next five years to 12 launches per annum. The new launches will be under both categories, including satellites and

Galileo update

Galileo satellites atop Soyuz

Another pair of Galileo navigation satellites is scheduled for launch by Soyuz rocket in May, ahead of a quartet on an Ariane 5 in the autumn, bringing the Galileo system a step closer to operational use.

The European Commission asked ESA to look into the feasibility of a Soyuz launch in the first half of the year to speed up the deployment of the constellation and to increase its robustness for delivering initial services.

One satellite is in storage at ESA's technical centre in the Netherlands, having completed all its testing to clear it for flight, with another due to join it very soon.

The satellite platforms are built by OHB in Bremen, Germany, with their navigation payloads coming from Surrey Satellite Technology Ltd in the UK, using a steady stream of high-technology equipment sourced from all across Europe.

The Galileo production line has attained a steady rhythm, as has the environmental testing, so six satellites are available for launch this year, more than were initially planned.

In the second half of the year, four satellites will be launched together for the very first time, on a customised "Ariane 5 ES Galileo".

In development since 2012, it is based on the Ariane 5 ES (Evolution Storable), previously used to place ESA's 20-tonne ATV vehicle into low orbit for resupplying the International Space Station.

This new variant will carry a lighter payload – four fuelled 738 kg Galileos plus their supporting dispenser – but will take it up to the much higher altitude around 23 222 km.

The target orbit is actually 300 km below the Galileo constellation's final working altitude. This leaves Ariane's upper stage in a stable 'graveyard orbit', while the four satellites manoeuvre themselves up to their operating position.

Following this first Ariane 5 flight, there should be 18 Galileo satellites in orbit. *www.esa.int*

Galileo sats 9 and 10 sending valid signals

The European Space Agency (ESA) has announced that the ninth and tenth satellites in the planned 30-bird fleet started sending "valid navigation signals" as of January 29th.

Galileo's eleventh and twelfth satellites are also aloft, but are undergoing testing. The ESA says the two satellites have reached their final orbits and that "payload activation is proceeding according to schedule." Another pair of satellites have completed pre-flight testing and are in storage ahead of launch.

The ESA's plans for Galileo call for a constellation of 30 satellites. Eight birds will be grouped in one of three orbits for a total of 24 operational satellites. Each orbit will also host a pair of backup satellites. Each satellite has an expected working life of a dozen years. *www.theregister.co.uk*

launch vehicles," Indian Space Research Organisation secretary (science) YVN Krishna Murthy said recently.

"We've already launched two missions this year and two more will be launched next month," he added.

The ISRO Satellite Centre has built over 70 satellites in the last 41 years and there is a huge demand for small launchers with carrying capacity of 500 kg. Talking about the ISRO's annual budget, he said it is likely to be around $1.1 billion this year, up from $0.9 billion last fiscal. *www.thestatesman.com*

Russia to Build 2 New Arctic Remote Sensing Centers

Two new Remote Sensing Centers will be built in Russia's Arctic to ensure adequate emergency monitoring in the region, the Russian Emergencies Ministry (EMERCOM) said. It also planned to create a net of 10 search-and-rescue centers in the Arctic. Four of them have already been launched. *http://sputniknews.com*

DigitalGlobe, Facebook team-up for mapping world's population

From the stage of Mobile World Congress, Facebook CEO, Mark Zuckerberg announced to develop the Telecom Infra Project under new technologies and approaches for connecting the 4.2 billion people that still remain offline. To enable this, the Facebook Connectivity Lab is leveraging DigitalGlobe's Geospatial Big Data initiative to determine population densities across vast rural areas in 20 developing nations.

Existing maps of populations in many parts of the world are too coarse, outdated, and inaccurate. To solve this problem, information from high-resolution satellites proves invaluable; it provides a consistent global information dataset for mapping population locations. This is where DigitalGlobe's content and platform become a critical part in achieving the vision. It will be completing an accurate mosaic of the globe at 50

cm resolution in the coming months and will be replenishing this basemap of the world on a frequent basis. *http://economictimes.indiatimes.com*

Teledyne upgrades Optech Lynx SG and Lynx SG-S mobile survey systems

Teledyne Optech has announced two critical performance upgrades of its Optech Lynx SG and Lynx SG-S mobile survey systems. The upgrade has increased the speed of both the device by 20%, and is pushing the Lynx SG platform to 600 lines per second.

In addition, all models in the Lynx mobile product line now output a real-time LAS file designed for in-field coverage checks and rapid access to the survey data. With support for up to 10 cameras, survey-grade LiDAR precision, continued industry-leading scanner performance, and a productivity-focused Optech LMS processing solution that provides for real-time calibration, boresight, trajectory optimization and control validation, the Lynx mobile survey system is the pre-eminent solution for transportation and civil engineering applications where accuracy matters.

South Africa uses drones to battle rhinos

In hills where Zulu royalty once hunted wildlife, South African conservationists now scan live video from a thermal-imaging camera attached to a drone, looking for heat signatures of poachers stalking through the bush to kill rhinos.

The unarmed drone, which resembles a model airplane, flies several miles from a van where an operator toggles a customized video-gaming control, zooming and swiveling the craft's camera. The nocturnal surveillance in Hluhluwe-iMfolozi Game Reserve comes amid international discussion about whether technology, particularly drones, will make a real difference in anti-poaching efforts that often rely on the "boots on the ground" of rangers on patrol.

Several years ago, drones were touted by some as a silver bullet for conservation, but some experiments have foundered. Even so, drone technology is developing quickly and the aircraft have been used around the world.

Tanzania introduces remote technology to monitor crops

The National Food Security Division in the Ministry of Agriculture Livestock and Fisheries in collaboration with the Sokoine University of Agriculture (SUA) and University of Maryland (USA) is implementing a project aiming at transforming agricultural sector through a technological breakthrough based on crop monitoring.

The project, Spurring Transformation for Agriculture through Remote Sensing (STARS) adapts and develops advanced remote sensing techniques and applications for monitoring crop conditions in collaboration with the end-user community. *www.ippmedia.com*

ISRO, Minstry of UD preparing GIS database

ISRO is working with Minstry of Urban Development for enabling preparation of large scale GIS database using satellite data for 500 towns under Atal Mission for Rejuvenation and Urban Transformation (AMRUT). These 500 towns include 100 towns under Smart city Programme announced by the Government of India. *www.newkerala.com*

NASA creates 3D map for Earth forests

US space agency, NASA is working on a new instrument for the International Space Station that will create a 3-D map of the Earth's forests, in order to measure the role of trees in scrubbing carbon from the atmosphere. The new instrument will use LiDAR, a laser system for measuring distance between the space-based instrument and the surface. Called the Global Ecosystem Dynamics Investigation (GEDI) LiDAR, the system will be put together at NASA's Goddard Space Flight Center in Greenbelt, Md.

Although it's well-known trees store carbon, NASA says it's not clear how much the forests contain. So we don't really know what the effects of deforestation are on climate change or how effectively we could slow global warming by planting more trees. The project is a joint venture of the University of Maryland and NASA.

Sentinel-3A launched

The third ESA-developed satellite carrying four Earth-observing instruments was launched, ready to provide a 'bigger picture' for Europe's Copernicus environment programme.

The 1150 kg Sentinel-3A satellite was carried into orbit on a Rockot launcher from Plesetsk, Russia, at 17:57 GMT (18:57 CET; 20:57 local time) on 16 February.

The mission is the third of six families of dedicated missions that make up the core of Europe's Copernicus environmental monitoring network. Copernicus relies on the Sentinels and contributing missions to provide data for monitoring the environment and supporting civil security activities. Sentinel-3 carries a series of cutting-edge sensors to do just that. *www.esa.int*

Airbus inks deal for satellite imagery with ST electronics

Airbus Defence and Space has signed a contract with Singapore Technologies as a channel partner for its satellite data and value-added products in Singapore. With privileged access to a unique satellite fleet comprising the TerraSAR-X and TanDEM-X radar satellites and the high and very-high optical satellite constellation SPOT and Pléiades, Airbus can offer daily coverage worldwide as well as weather-independent acquisitions, at a variety of resolutions.

Delhi Police join hands with ISRO to curb crime

"The Crime Mapping, Analytics and Predictive System (CMAPS) is being operationalised by Delhi Police in partnership with ISRO for effective use of space technology- based tools for ensuring internal security," a senior police official said.

He said the system would help in crime control and law and order and security management through analysis of relevant data and patterns, leading to the optimisation of available resources. The system will be complete with police officials being equipped with Personal Digital Assistant (PDA) devices connected to a central processor, which stores records of more than two hundred thousands of criminals.

The system will enable real time access to vital information at the crime scene itself so the officials do not have to go back to police stations for filing reports, the senior official said, adding the system will be capable of converting every distress call into a digital message with the location of the caller being flashed through GPS.

DHS puts 275 GIS-based datasets online

To better prepare for and respond to national emergencies, the Department of Homeland Security in the US needed to adopt new technologies that facilitated community collaboration -- while also continuing to secure the data needed to maintain homeland security.

To that end, DHS has opened 275 geospatial datasets from its Homeland Infrastructure Foundation-Level Data collection to support nationwide homeland security collaboration. The HIFLD Open website provides access to the datasets as well as up-to-date downloadable files and visualization tools. Location information is available on two dozen categories of assets, from border crossings to refrigerated warehouses. Developers can also use these datasets for web applications, while analysts can download data for modeling and predictive analysis. *https://gcn.com*

Rs 300 crore to map 1.5 lakh bridges, culverts

The Ministry of Road Transport and Highways has launched a project worth Rs 300 crore to map 1.5 lakh bridges and culverts across the country. The Integrated Bridge Management System (IBMS), when fully operational, will become the world's largest system, a top official from the Ministry of Road Transport and Highways said. So far, the IBMS has mapped 50,000 such bridges and culverts out of about 1.5 lakh in the country, the official said.

IDEC Engineers have been appointed as the project consultant for it and the system will have data like national identity number, longitude and latitude details, classifications and socio-economic details of the area among others. *www.dnaindia.com*

Flood Mapping in Odisha to Reduce Risk Factors

The coastal district of Kendrapara witnessed severe floods 12 times from 1994 to 2013. Loss of life and property

was enormous. To avert such huge losses like in 2011 when 473 villages under nine blocks were badly hit, the Odisha State Disaster Mitigation Authority (OSDMA) released a Flood Inundation Mapping (FIM) for Kendrapara. The survey teams referred to 15 years of flood history of Kendrapara district for the mapping which has been prepared under Government of India-UNDP project on Enhancing Institutional and Community Resilience to Disaster and Climate Change-2013-17 *www.newindianexpress.com*

GIS Cloud develops 'Fastest Map Engine' in the world

Croatia based GIS Cloud has announced of developing what the company is calling the 'fastest software for digital mapping in the world.' Assured with its performance, the company has also launched a global competition "The Fastest Map Engine Challenge". On their website, GIS Cloud has also posted a video, which shows how in just 31 seconds it managed to create a digital map of the American city of Fort Collins, with 86,100 addresses, 10,600 lines and 69,700 polygons, which uses as a base a digital satellite map from Microsoft's Bing Maps.

University of Twente starts capacity development projects in Africa

NUFFIC has awarded funding to two NICHE projects of the ITC Faculty of the University of Twente. The aim of the projects is to strengthen education and training capacity in developing countries, and they thus align seamlessly with the mission of the ITC Faculty. In the first project, the Tanzania-Netherlands Energy Project, ITC will collaborate with various other knowledge institutes to achieve a range of goals which include strengthening energy-related education in the field of geothermics as well as gas extraction in Tanzania and on Zanzibar. The second project involves, among other things, strengthening the Eastern Africa Land Administration Network (EALAN) and building capacity in land administration and land governance in eight East African countries. *www.itc.nl*

GIS mapping to link transport services

Kochi Metro Rail Ltd (KMRL) is planning a GIS mapping of the Greater Cochin area to develop traffic and transport infrastructure. KMRL has sought the state government's approval for the Rs 1.25 crore-project, which will be implemented by Keltron. The mapping process is a critical part of the integrated ticketing system being implemented by KMRL, where a common smart card will link all public transportation facilities. *http://timesofindia.indiatimes.com*

Forest guards to get digitized beat maps

The Kolhapur forest division is preparing digitized maps of every beat in a bid to improve the quality of vigilance as well as keeping a check on forest guards. Around 60 forest guards are being equipped with GPS and cameras to record their forest visits. The work is 80% complete and the first trial run will be conducted soon.

A geographical area is divided into beats, where the forest guards are expected to make routine visits as per the forest department's instructions and carry GPS-enabled devices to mark their digital track. *http://timesofindia.indiatimes.com*

Improvement of Jordon's real estate mapping

The EU and the Department of Lands and Survey (DLS) have launched a 1 million euro twinning project aimed at enhancing the technical and administrative capacities of the DLS in the fields of cadastre (mapping real estate ownership and values) and administration.

DLS is the main beneficiary of the project — dubbed "Reducing discrepancies between the physical reality and the graphical cadastral information in Jordan" — while co-beneficiaries and participants include the Greater Amman Municipality, the Ministry of Municipal Affairs, the Royal Jordanian Geographic Centre and the Association of Owners of Land Survey Offices, the minister noted. *www.jordantimes.com*

QantasLink Selects FreeFlight Systems 1203C SBAS/GNSS Sensor

NextGen avionics leader FreeFlight Systems has announced that QantasLink, Australia's largest regional airline, has selected the FreeFlight 1203C SBAS/GNSS sensor for retrofit into its DHC-8-200/300 series of aircraft.

QantasLink paired the 1203C with the Dash 8's TDR-94D Mode-S transponders.

As a certified ADS-B position source approved for all ICAO jurisdictions, the integrated 15-channel 1203C SBAS/GNSS sensor is part of a fully rule-compliant ADS-B Out system when paired with a compatible certified Mode S transponder like the TDR-94D. Providing reliable service to fleets worldwide, the 1203C also serves as the approved position source for CPDLC, TAWS/FMS, RNP and other NextGen applications. *www.freeflightsystems.com*

New data controller for surveying by Topcon

Topcon Positioning Group has added the FC-5000 to its line of data controllers for construction and surveying professionals. The 7-inch sunlight-readable display field controller is designed to provide operators a larger, more versatile and faster handheld computer for the modern construction site. The controller is compatible with all Topcon GNSS receivers and total stations — operating MAGNET Field, Site and Layout software. Additional features include an optional 4G LTE cellular modem, internal GPS navigation, Bluetooth and Wi-Fi, and a battery life of 10-plus hours.

u-blox Brings cm-level Precision GNSS Technology

u-blox has launched the NEO-M8P GNSS receiver modules delivering high performance down to centimeter-level accuracy. Measuring merely 12.2 x 16 x 2.4 mm, NEO-M8P is the smallest high precision GNSS RTK (real time kinematic) module available on the market based on GPS and GLONASS satellite-

based navigation systems. The rover with the u-blox NEO-M8P-0 receives corrections from the u-blox base receiver NEO-M8P-2 via a communication link that uses the RTCM (Radio Technical Commission for Maritime Services) protocol, enabling centimeter-level positioning accuracy. *www.u-blox.com*

Hexagon opens 1,200-seater office in Hyderabad

Research and development unit of Hexagon AB, Hexagon Capability Centre India (HCCI) has opened a 1,200-seater office in Hyderabad. Along with this, the IT firm also announced that the HCCI will relocate operations at its four offices in the city to the new facility in Hi-Tec city.

The facility houses Hexagon's Product R&D and services teams working on integrated technologies in the areas of aerospace, agriculture, automotive infrastructure, construction, mining, power, safety, surveying and security. It is one of the three major R&D facilities of Hexagon – Switzerland and the U.S. has one each.

Vice president and country manager Navaneet Mishra said that the headcount of the unit is 1,000 and there are plans to raise this by 200 in about two and a half years. Apart from those engaged in the R&D operation in the city, the company has a sales network of about 250 people spread across the country. *Hindu*

OriginGPS launches Multi Micro Spider

GNSS module maker OriginGPS has launched the new Multi Micro Spider, which has a fully integrated and highly sensitive multi-GNSS module, with support for GPS, Glonass, BeiDou and Galileo. The Multi Micro Spider is designed for applications that require quick movement, minimal power consumption and ultra-small form factors, such as wearables and drones.

Hexagon acquires SigmaSpace

Hexagon AB has announced the acquisition of SigmaSpace Corporation, a next-generation technologies provider. Headquartered near Washington, SigmaSpace offers a unique LiDAR technology that enables 3D data collection at much higher speeds and resolution than conventional systems.

Trimble News

Acutime 360 Multi-GNSS Timing Antenna

Trimble has introduced its latest smart antenna with an integrated multi-GNSS receiver for high accuracy and precise timing applications—the Acutime™ 360. The smart antenna provides a pulse-per-second (PPS) output synchronized to UTC within 15 nanoseconds (one sigma). It is built using the field-proven Trimble 360™ technology platform for multi-GNSS systems.

R9 GNSS receiver

The Trimble R9s GNSS receiver is scalable and flexible. Built on a sleek, modular GNSS platform, geospatial professionals can add functionality according to their workflow demands, such as being deployed as an RTK base station or an RTK rover mounted on a rod, in a backpack or on a vehicle. It provides access to multiple GNSS constellations, wide-band 450 MHz internal radio, Ethernet connectivity and is easily configurable via the front panel. The solution also offers scalability from an entry-level receiver for post-processing, to a full-featured triple-frequency GNSS base and rover.

Trimble acquires Sefaira Ltd

Trimble has acquired London/New York-based Sefaira Ltd., a developer of cloud-based software for the design of sustainable and high-performance buildings.

Sokkia releases SHC500 Field Controller

Sokkia has introduced an addition to its line of field controllers for construction and surveying applications — the SHC500. It is designed to provide operators a compact handheld option with numerous features and benefits, including a 4.3-inch touchscreen display and optional 5 MP camera with built-in LED flash.

It is designed for the professional operating MAGNET® Field, Site and Layout software. The data controller works with all Sokkia GNSS receivers and total stations, and meets or exceeds all field application requirements. *sokkia.com*

Harris Corporation to Offer Fully Digital GPS III Payload

Harris Corporation has announced that it will offer an all-digital navigation payload for GPS III Space Vehicles (SV) 11 and beyond. Harris' fully digital navigation payload will add value to the U.S. Air Force's GPS mission by offering enhanced performance and enabling on-orbit reprogramming. The all-digital payload expands on the advanced features of the current 70-percent digital solution Harris provides for Lockheed Martin's GPS III SV 1-8 satellites. The features provide greater flexibility, affordability and accuracy versus existing satellites and include an advanced modular design, atomic clock timing systems, radiation-hardened computers and powerful transmitters. *harris.com*

Fugro delivers surface current data

Fugro and remote sensing solutions provider Areté Associates have delivered near real-time, synoptic, surface current data to characterize loop current and loop current eddy conditions in the US Gulf of Mexico. The new Remote Ocean Current Imaging System (ROCIS) was deployed on its first operational project, in the US Gulf of Mexico. Over the course of the five-month program, Fugro surveyed currents over a distance of more than 125,000 km (77,671 mi). Fugro and Areté Associates developed a system that uses a combination of digital camera technology and

positioning systems, together with advanced algorithms, to derive surface currents from wave spectra measurements. It can be installed on a suitable survey aircraft together with an inertial navigation system augmented by Fugro's Starfix satellite positioning system. *www.offshore-mag.com*

Septentrio PolaRx5 GNSS Reference Station Receivers

Septentrio has announced the start of shipments to UNAVCO of its all new multi-frequency PolaRx5 reference receiver. This follows the 2015 announcement by UNAVCO that Septentrio had been selected at the Geodesy Advancing Geosciences EarthScope (GAGE) Facility Preferred Vendor for next-generation GNSS reference station products. UNAVCO is a non-profit university-governed consortium that facilitates geosciences research and education using geodesy. UNAVCO operates the GAGE Facility for the National Science Foundation with additional core support from NASA. *www.septentrio.com*

NEW RIEGL High-Speed Mobile Mapping Turnkey Systems Launched

RIEGL recently launched two new High-Speed Mobile Mapping Turnkey Systems featuring this high performance VUX-1HA kinematic LiDAR sensor!

The new VMQ-1HA High-Speed Single Scanner Mobile Mapping System, with one VUX-1HA scanner integrated, is an economically priced, lightweight system for the growing mobile mapping market. Fully integrated into the measuring head of the system, the sensor enables acquisition of dense point cloud patterns, even with single passes at typical traffic speeds. The optional integration of up to four cameras allows simultaneous acquisition of imagery to complement the captured LiDAR data. The new VMX-1HA High-Speed, High Performance Dual Scanner Mobile Mapping System, with two VUX-1HA scanners integrated, provides dense, accurate, and feature-rich data, even at high driving speeds. With up to 2 million measurements and 500 scan lines per second, the fully integrated turnkey solution is ideally suited for challenging projects and engineering-grade surveying applications.

'Similis' – a new SMD antenna by Antenova

Antenova Ltd, manufacturer of antennas and RF antenna modules for M2M and the Internet of Things, recently revealed a new SMD antenna called Similis, which offers an exceptionally low profile solution for 3G, LTE and MIMO applications. The Similis antenna measures just 40 x 10 x 1.6mm, making it half the height of the popular Lucida which Antenova introduced last year. Antenova has designed the Similis antenna for low profile M2M and IoT applications where space is tight and its size will be a real advantage - in particular, it offers a lower profile than leading wireless cellular modules which are usually more than 2mm in height. This new antenna is suitable for Femto/base stations, portable devices, remote monitoring, smart meters, network devices and wearable electronics. *www.antenova-m2m.com*

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MARK YOUR CALENDAR

April 2016

IGRSM 2016
13 - 14 April
Kuala Lumpur, Malaysia
http://www.igrsm.com/igrsm2016

International GIS Forum
13 - 15 April
Moscow, Russia
http://www.gisforum.ru/en/

Interexpo GEO-Siberia-2016
20 - 22 April
Novosibirsk, Russia
www.expo-geo.com

Geo-Tunis 2016
26 - 30 April
Tunis
www.geotunis.org

May 2016

XPONENTIAL 2016
2 – 5 May
New Orleans, USA
www.xponential.org/auvsi2016/public/enter.aspx

FIG Working Week 2016
2 - 6 May
Christchurch, New Zealand
www.Figure net/fig2016/call.htm

10th Annual RIN Baska GNSS Conference
8 - 10 May
Baska, Krk Island, Croatia
www.rin.org.uk

MundoGEO#Connect2016
10 - 12 May
Sao Paulo, Brazil
http://mundogeoconnect.com/2016/

NAVITECH 2016
10 - 13 May
Moscow, Russia
www.navitech-expo.ru/en/

GEO Business 2016
24 - 25 May
London, UK
http://geobusinessshow.com

European Navigation Conference
30 May - 02 June
Helsinki, Finland
www.enc2015.eu

June 2016

HxGN LIVE
13 - 16 June
Anaheim,USA
http://hxgnlive.com/anaheim

6th International Conference on Cartography & GIS
13-17 June
Albena, Bulgaria
www.iccgis2016.cartography-gis.com

2016 Esri International User Conference
27 June to 1 July
San Diego, USA
www.esri.com

July 2016

ISPRS – PRAGUE 2016
12 - 19 July
Prague, Czech Republic
http://www.isprs2016-prague.com/

September 2016

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

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

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

October 2016

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

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

3D Athens Conference
18-21 October 2016
Athens, Greece
http://3dathens2016.gr/site/

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

November 2016

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

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

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

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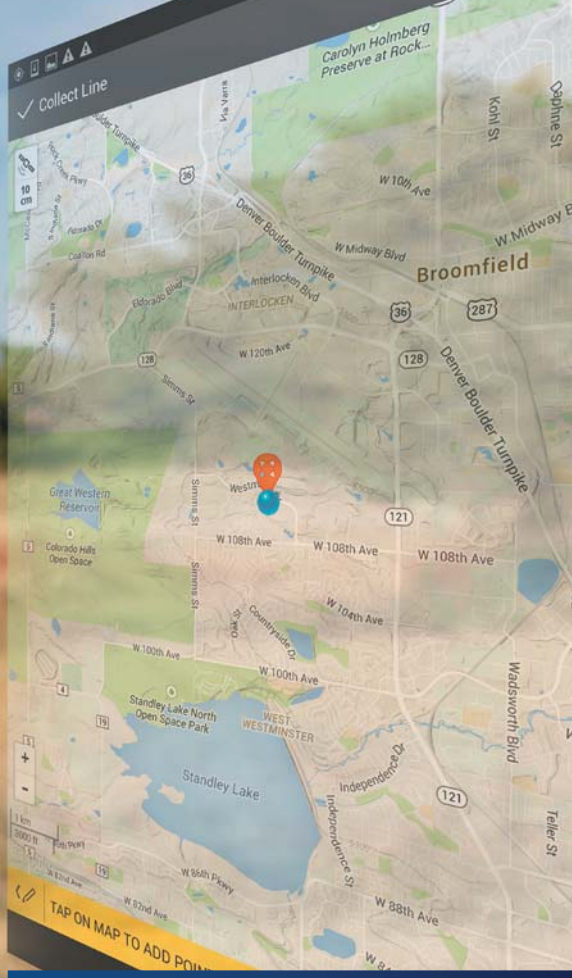

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