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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Saving Australian Height Datum

Geopotential models and their application in local geoid modelling

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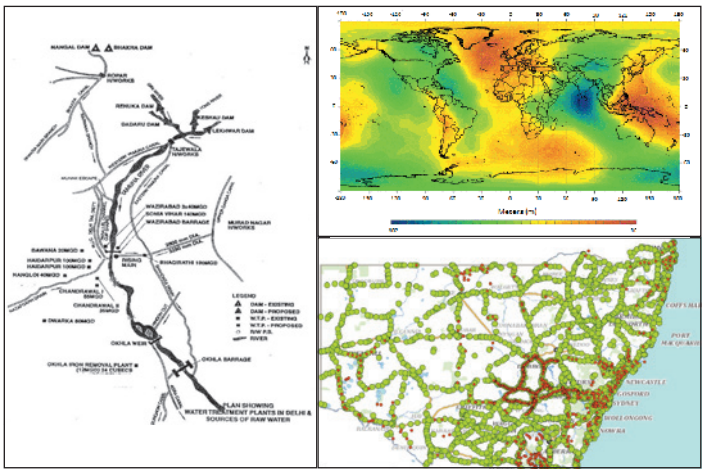

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Articles

Columns

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Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)

This issue of Coordinates is of 40 pages, including cover.

Drone defence

For the civilian use of drones, India has the guidelines in place.

In March 2021, the Ministry of Civil Aviation notified the Unmanned Aircraft System Rules.

Recently, the government has invited bids to use drones for the delivery of Covid-19 vaccines and other medicines for remote areas.

Telangana state government in India engages with Flipkart for drone delivery of medical supplies.

Many such positive developments indicate the vibrations of positive trends of Indian UAV ecosystem.

However, the recent drone attack at the airbase at the border areas is quite worrisome.

This has already alerted the concerned authorities and talks of drone detection systems are already in the air.

There is an urgent need of the installation of drone defence systems from such drone attacks,

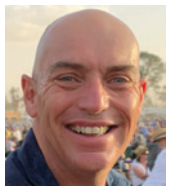
Will it also trigger a rethink of Drone policy in India?

Bal Krishna, Editor
bal@mycoordinates.org

Australian Height Datum: Saving AHD in New South Wales

The Australian Height Datum (AHD) celebrates its 50th anniversary this year. This paper outlines the datum maintenance and modernisation efforts undertaken in New South Wales (NSW) to not only preserve but improve access to AHD

Volker Janssen
Senior Technical Surveyor in the Geodetic Operations team at DCS Spatial Services, NSW Department of Customer Service, in Bathurst, Australia



Simon McElroy
Senior Surveyor, leading the Geodetic Operations team at DCS Spatial Services, NSW Department of Customer Service, in Bathurst, Australia

The Australian Height Datum (AHD) is Australia's first and only legal vertical datum, celebrating its 50th anniversary this year. The adjustment of the Australian National Levelling Network (ANLN) in May 1971 provided, for the first time, a nationwide network of physical AHD heights (Roelse et al., 1975). For most spatial professionals, AHD has been ubiquitous for the entire duration of their careers, being the vertical datum of choice because it was the only one. In a previous paper published in May 2021 issue of Coordinates magazine, we celebrated the achievements and longevity of AHD, outlined its shortcomings and looked ahead to a new era of vertical datum determination, culminating in the Australian Vertical Working Surface (AVWS, see ICSM, 2020a) as an alternative for those who need it.

DCS Spatial Services, a business unit of the NSW Department of Customer Service (DCS), is responsible for the maintenance of the NSW survey control network. Relevant information is made available via the Survey Control Information Management System (SCIMS), the state's database containing about 250,000 survey marks on public record (Janssen et al., 2019). This paper describes the datum maintenance and modernisation efforts undertaken by DCS Spatial Services through its ongoing Saving AHD projects. As AHD is showing its age and slowly deteriorating, these projects aim to not only preserve but improve access to AHD.

Present challenges

One important issue affecting the availability of AHD is mark destruction. Despite the best efforts in the Preservation of Survey Infrastructure (POSI, see DCS Spatial Services, 2020), entire sections of original ANLN spirit-levelled AHD have been destroyed. Mark destruction is far higher in eastern NSW, with some level runs completely lost in city regions or along highways. In rural and remote areas, marks often still exist but can be difficult to find due to the removal of all physical connections listed on locality sketch plans (e.g. road mile posts, telegraph lines and relocated fences or gates) and road realignments, which alter chainages or deviate far from the original road corridors.

Fortunately, many ANLN marks previously identified as destroyed or not found in SCIMS are being successfully recovered in good condition, maintained and upgraded using Geoscience Australia's free online GPS processing service, AUSPOS (see Janssen and McElroy, 2020; GA, 2021). On some level runs, DCS Spatial Services field crews report a recovery rate of 20% or better for lost marks. Finding marks that had reference blazes cut on trees is even more successful.

Another challenge is mark movement. How well has the mark been able to hold its initial AHD height over 50 years? Thankfully, Australia enjoys

One important issue affecting the availability of AHD is mark destruction. Despite the best efforts in the Preservation of Survey Infrastructure (POSI, see DCS Spatial Services, 2020), entire sections of original ANLN spirit-levelled AHD have been destroyed. Mark destruction is far higher in eastern NSW, with some level runs completely lost in city regions or along highways

rather stable tectonics, where vertical movements are generally infrequent and not substantial. However, there are exceptions, most notably in subsidence areas caused by mining, major construction activities or reactive soils.

While AHD has been lost in regions of reactive black soil and any new value would soon be invalid following the next wet or drought season, problems also occur in less obvious regions. A recent investigation into a height anomaly of about 0.14 m at the NSW-Victoria border revealed that issues arise with constraining ANLN junction points when new levelling observations are taken between them. Allowing for apparent mark instability at one junction point and using the new levelling data resulted in the discrepancy to be reduced by more than 50% (Watkins et al., 2017). Such mark movement supports the notion that, after several years, first-order levelling surveys may deteriorate to much the same order of accuracy as third-order levelling, which becomes apparent when runs are re-levelled (Lambert and Leppert, 1976).

The next challenge for AHD is technology itself. The era of Global Navigation Satellite System (GNSS) technology led to the development of geoid or quasigeoid models to convert GNSS-derived ellipsoidal heights to physical heights, including the current AUSGeoid2020 for Australia (e.g. Brown et al., 2018; Janssen and Watson, 2018; Featherstone et al., 2019). Particularly over longer distances, this has made height determination and transfer more efficient than with the traditional techniques employed in the 1970s and 1980s.

While the role of DCS Spatial Services is to maintain NSW's survey control network, in the last 10 years it has taken on a more active role in both POSI and its effort towards saving AHD. To this end, several projects have been undertaken.

Tide gauge monitoring

AHD was constrained by 30 tide gauges. Over the years, DCS Spatial Services has continued to monitor the stability of tide gauges via precise optical levelling, then digital levelling and recently precise EDM height traversing. Generally conducted every two to five years, these surveys monitor the stability of the tide gauge compared to a near array of stable survey marks. Port Kembla tide gauge has been regularly monitored for over 20 years, while Fort Denison tide gauge has been resurveyed across 600 m of water from the island in Sydney Harbour to Mrs Macquarie's Point (and then back to the survey plug installed in 1882 on the external wall of the former Department of Lands building). More recently, Eden tide gauge has been similarly connected.

Five GNSS Continuously Operating Reference Stations (CORS) were either specifically built or adopted to augment long-term monitoring of tide gauges located along the NSW coast in order to support sea-level studies: Fort Denison, Port Botany, Newcastle East, Port Kembla and Eden (Janssen et al., 2013). This helps answer the question "Is the sea level rising or the land falling, or both?"

Sampling ANLN level runs with AUSPOS

AHD is not homogenous. While multiple ANLN level runs may meet at a junction point, each has its own characteristics. Level runs may include (positive or negative) systematic errors, one-foot blunders, and may have been subject to mark movement over the last 50 years. Transferring or linking AHD heights from different ANLN runs can lead to serious complications. Sampling can model these issues.

In a dedicated large-scale effort, AHD marks were sampled across NSW, as quickly as possible, for improvement of the national AUSGeoid model. This was conducted in a series of Saving AHD AUSPOS survey campaigns, starting in 2015.

In the first pass, every level run was investigated and sampled, generally during a single field day with five to six GNSS receivers deployed over the length of the level run. Each mark was maintained (i.e. cleared, painted, and protected using generally three painted star pickets), photographed, observed by an overnight AUSPOS session, and SCIMS was updated with current metadata.

As part of NSW's contribution to the development of AUSGeoid2020, DCS Spatial Services collected more than 2,500 extended GNSS datasets (at least 6 hours but generally 12-24 hours duration) on levelled benchmarks for AUSPOS processing. These GNSS datasets informed the geometric component of AUSGeoid2020, helping to provide a much better connection to AHD (Janssen and Watson, 2018). For many of these old benchmarks, GNSS also improved their horizontal position, which was initially obtained by scaling off a map, often resulting in positioning errors of several

hundred metres. This not only improved user access, but also allowed preservation efforts to be undertaken (you can only protect a mark if you know where it is).

Observing FBMs and GBMs with AUSPOS

Meanwhile, a dedicated campaign is underway to find, maintain and collect AUSPOS datasets on Fundamental Bench Marks (FBMs) and Geodetic Bench Marks (GBMs), which were installed in the 1970s. These high-stability marks were specifically designed to maintain height, whether it be AHD, ellipsoidal or even AVWS height.

Recovering lost levelling

DCS Spatial Services has invested significant resources over the last few years in trying to recover lost levelling, e.g. first-order levelling from the Snowy Mountains Hydro-Electric Authority (SMA). This included approximately 1,000 marks over 1,000 km from Cooma to Tumut and on to the Victorian border, surveyed in the days of the Snowy Mountains Hydro-Electric Scheme (construction from 1949 to 1974). To date, nearly 15% of these marks have been recovered, maintained and observed. This is a great result, considering that SCIMS basically held no levelled heights in Kosciuszko National Park and these marks are now 70 years old.

Similarly, we continue to recover, on an ad-hoc basis, 1950s National Mapping Division levelling. This data is predominately located in remote regions, with level runs reaching out to a graticule of 1° map corners that are often located in the middle of an outback paddock.

DCS Spatial Services was also planning to recover Rural Bench Marks (RBMs), installed by the Australian Capital Territory (ACT) at the same time AHD was being observed. While about 450 of the 1,200 RBMs are located in NSW, only a handful are included in SCIMS. A planned joint project with the ACT Office of the Surveyor-General to recover these RBMs was cancelled in 2020 due to the COVID-19 pandemic. It has now been pencilled in for the 2021/22 financial year.

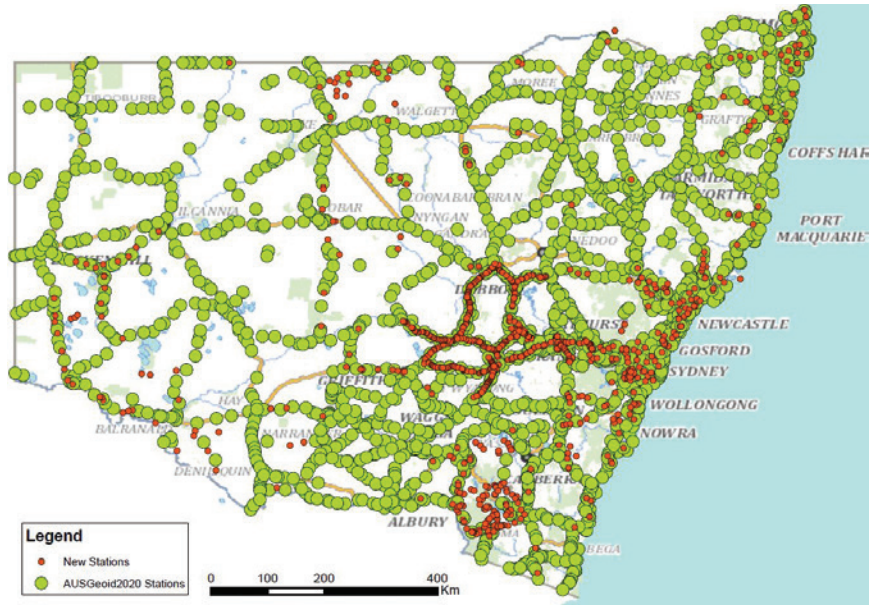


Figure 1: GNSS datasets of at least 6 hours duration on levelled marks observed by DCS Spatial Services, including those contributing to AUSGeoid2020

High fidelity (HiFi) saving AHD

In the Central West, DCS Spatial Services is nearing completion of its HiFi Saving AHD project. In this area, every rural ANLN mark has been searched for, then maintained and upgraded. To date, approximately 1,200 km of levelling has been audited and surveyed, while another 400 km is planned. The number of recovered ANLN marks has exceeded expectations, with evidence that some have been used by other surveyors. While it is fortunate to recover these marks, it is disappointing that surveyors have not reported these finds, so they can be shared for everyone's benefit. This project may be expanded to other parts of the state.

Overall, the ongoing Saving AHD campaigns have to date yielded 900 additional extended GNSS datasets on levelled benchmarks since the computation of AUSGeoid2020 (Figure 1). While the Intergovernmental Committee on Surveying and Mapping (ICSM) currently does not plan to update AUSGeoid2020 into the future, these datasets will be very valuable for the continuing improvement of AVWS.

Digitising historical levelling records

In NSW, AHD is simply a set of numbers printed on some 3,600 cardboard sheets,

Similarly, we continue to recover, on an ad-hoc basis, 1950s National Mapping Division levelling. This data is predominately located in remote regions, with level runs reaching out to a graticule of 1° map corners that are often located in the middle of an outback paddock

There can be only one legal vertical datum, and currently there is no planned push to replace AHD. DCS Spatial Services has yet to implement AVWS but continues to investigate and contribute towards it. Our ongoing Saving AHD projects ensure that users have access to their vertical datum of choice. These efforts may also help AHD celebrate more milestones in the future

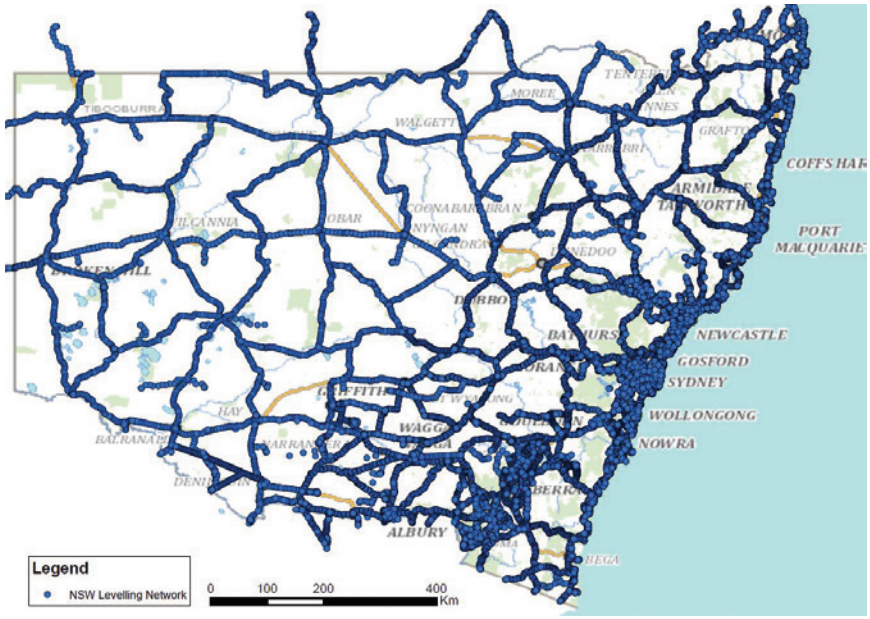


Figure 2: Location of benchmarks included in the NSW levelling adjustment

which are now safely stored in State Archives. These levelling cards summarise each level run and are abstracts of the original field notes, detailing the measured and adjusted height differences between benchmarks and junction points. At some stage, these AHD values were manually typed into SCIMS (naturally including unknown typos associated with all manual data entries), and an electronic master version does not exist. Despite the efforts by academics and federal agencies over the years, the original AHD values cannot be reproduced. The value on the card is AHD, for better or worse.

These historical levelling cards are progressively being preserved and digitised. First, they were scanned and safely archived in a digital environment. Optical Character Recognition (OCR) failed to convert these files to smart digital files, so each card was then manually converted to Excel files (one per level run). Quality assurance of this laborious manual data entry process is currently underway. Once complete, the values in SCIMS can themselves be checked to remove any typos that have lain dormant for decades.

Building the NSW levelling adjustment

Together with the results of data-mining existing levelling files in the DCS Spatial Services archive, the digitised historical levelling data is being used to generate a single, state-wide levelling adjustment for NSW. Currently, it comprises about 132,000 measurements and 98,000 stations (Figure 2). While still underway, the enormity of this task and its benefits to the profession should not be underestimated. Victoria has already completed a state-wide levelling adjustment, and other jurisdictions are now also starting similar projects.

It should be emphasised that there are no plans to readjust (or re-realise) AHD. Under the original rules, jurisdictions cannot modify the height of junction points without federal approval. The height of intermediate marks can be updated if a blunder or mark movement is detected and proven, which is part of the day-to-day maintenance.

Ongoing datum modernisation in NSW

DCS Spatial Services is responsible for the maintenance of the NSW survey control network. Datum modernisation and further improvement of survey infrastructure is required to accommodate the increasing accuracy and improved spatial and temporal resolution available from modern positioning technologies to an ever-broadening user base.

This has led to the establishment of CORSnet-NSW, Australia's largest state-owned and operated GNSS CORS network (e.g. Janssen et al., 2016; DCS Spatial Services, 2021). CORSnet-NSW is not only the backbone of the Geocentric Datum of Australia 2020 (GDA2020, see ICSM, 2020b) across the state but also provides fundamental positioning infrastructure that is authoritative, accurate, reliable and easy-to-use for a wide range of applications. Furthermore, with all sites contributing to AUSPOS, it comprises a fundamental, high-density and long-term component of AUSPOS infrastructure within NSW (Janssen and McElroy, 2020).

Consequently, the use of AUSPOS campaigns has developed into a capable and reliable alternative to conducting traditional static GNSS baseline surveys, simplifying field work logistics and reducing processing times. This has substantially accelerated the process of including additional survey marks into the GDA2020 state adjustment to improve user access to GDA2020 coordinates and uncertainties on public record through SCIMS (e.g. Gowans et al., 2015; Janssen and McElroy, 2020). AUSPOS has become the primary survey technique used by DCS Spatial Services to preserve AHD.

DCS Spatial Services is currently building an updated passive survey control network (in the Eastern and Central Divisions) with a minimum of one fundamental survey mark observed by 6+ hour AUSPOS every 10 km. Its vision is to ensure that any future user is no further than 5 km (and often much less) from such a fundamental mark providing direct connection to datum. Similarly, levelled AHD marks are observed by 6+ hour AUSPOS every 10 km, often at a far greater density. This will allow users to achieve DCS Spatial Services' vision of a Positional Uncertainty of 20 mm in the horizontal and 50 mm in the vertical (ellipsoidal height) component anywhere in the state and easily apply transformation tools to move between current, future and various historical datums and local working surfaces.

Conclusion

As AHD celebrates its 50th anniversary this year, this paper has outlined the datum maintenance and modernisation efforts undertaken in NSW to not only preserve but improve user access to AHD. Through its Saving AHD projects, DCS Spatial Services helps ensure that users have continued and easy access to AHD, while also providing a solid foundation for the continuing improvement of AVWS as an alternative for those requiring higher-quality physical heights.

There can be only one legal vertical datum, and currently there is no planned push to replace AHD. DCS Spatial Services has yet to implement AVWS but continues to investigate and contribute towards it. Our ongoing Saving AHD projects ensure that users have access to their vertical datum of choice. These efforts may also help AHD celebrate more milestones in the future.

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In Coordinates

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Cost effective GNSS positioning techniques

Neil D Weston
Chief of the Spatial Reference System Division, National Geodetic Survey, NOAA

Volker Schwieger
Professor and Director, Institute of Engineering Geodesy, University of Stuttgart (IIGS), Germany

There are two possibilities to economize resources. The first pertains to a reference site or a network of reference stations and the second primarily concentrates on the rover or users side. For the first, we initially focus on Continuously Operating References Station (CORS) networks that provide the reference site(s) data and metadata to the users. For the second, the report proposes to use low- cost (under €150) GNSS receivers instead of high-end geodetic quality receivers. After giving an overview on GNSS and geodetic positioning, both approaches and their opportunities are presented.

Road lane recognition

Wooyong Kang, Eunsung Lee, Jae-Ik Park, MoonBeom Heo and Giwook Nam
Satellite Navigation Department, Korea Aerospace Research Institute, Republic of Korea

This study analyzed the performance requirements of precise digital maps using the above mentioned characteristics in additionto the GNSS position error for vehicles on the road. To verify the possibility of lane recognition using GNSS and a precise digital map, a car driving test was conducted on an actual real road.

Implementation of semi dynamic datum in New Zealand

Graeme Blick
Chief Geodesist in the National Geodetic Office, New Zealand.

Don Grant
Surveyor-General New Zealand

NZGD2000 has now operated in New Zealand for over 10 years. The useof a semi dynamic datum has been well accepted and its implementation and use have been relatively straight forward from a technical and geodetic perspective.

Geodesic based trajectories in navigation

Adam Weintrit and Piotr Kopacz
Gdynia Maritime University, Gdynia, Poland

The paper presents the current and uniform approaches to sailing calculations highlighting recent developments

GNSS measurements in Uzbekistan for hydrology

To organize continuous monitoring of the river level using GNSS, the geodetic support system is proposed to start with the following procedures: reconnaissance, development of measurement techniques, testing GNSS at hydrological posts, processing and post-processing of satellite observations

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TOSHONOV Bekhzod
- master Department of geodesy and geoinformatics National University of Uzbekistan

The paper describes a method for improving the coordinates of hydrological stations using the GNSS. Traditional methods of determining the coordinates of level posts are analyzed in this work. The requirements for the accuracy and installation of geodetic points of level posts are given. A scheme of the GNSS network of the coastal zone with reference to the satellite geodetic network (SGN) of Uzbekistan has been developed. The results of measurements of six level posts using GNSS TRIMBLE R4 and a mobile navigator are given here. The accuracy of the coordinates and the covariance matrix are presented graphically depending on the measurement interval. It is proposed to perform GNSS measurements of the entire coastal zone of the main rivers of Uzbekistan.

Introduction

Recently, attention has been increased to determining the level of rivers using GNSS in connection with the change in the water balance. The water management complex of the river basin supports the rational use of water resources and is represented by hydraulic structures. A complex system has been created with a significant number of canals, pumping stations, and collectors. The irrigation network covers those places where settlements are concentrated and the control of water consumption by special recording devices becomes obvious. The replacement of classic recorders with modern mobile devices has led to an increase in the accuracy of fixing the level rail mark. The introduction of a precision coordinate system requires a more detailed check using modern information technologies. For this purpose, the most important is the improvement of the classical coordinates of hydrological stations, obtained in different years by various geodetic instruments, as well as the development of the GNSS network of the coastal zone.

Measurements and calculations

Geographic latitudes and longitudes of points of hydrological stations were obtained in the SK42 based on classical measurements. Since the main task of the hydrological stations is to determine the change in the water level, the rectangular coordinates were calculated approximately from topographic maps (Fig.1).

As for the altitude, it was obtained by barometric or technical leveling. It should be noted the importance of the height value in determining the water level. With the help of optical levels, geometric leveling is performed with respect to the known benchmarks of the leveling network, the heights of which are reduced to the Baltic system of heights. Altitude accuracy will depend on instrument errors, calculations, and the reliability of the reference coordinates. Therefore, the accuracy of the altitude component of the point is also intended for determining the differences in sea levels and studying the vertical movements of the investigated surfaces. Coordinates of the benchmarks were calculated by the methods of triangulation and leveling. The reduction of the heights to the state leveling network is carried out by leveling the III and IV orders.

Naturally, the existing network requires complete modernization and reconstruction using digital devices. The only way out of this situation is to develop a method for increasing the accuracy of coordinates. It should include measures to create a system of permanent satellite observations of the dynamics of the river level and forecasting its state, which will allow solving applied problems in the design and construction of various hydraulic structures.

In connection with the introduction of satellite and information technologies into geodetic practice, the problem arises of reducing the coordinates of level posts. It is advisable to simultaneously perform the binding of benchmarks to points of the SGN located near the coastline (Fig.2).

In 2003, 19 reference stations were installed on the territory of the Republic of Uzbekistan, but over time their number

Figure 1. Topographic map and benchmark

Figure 2. Scheme of GNSS network for hydrology

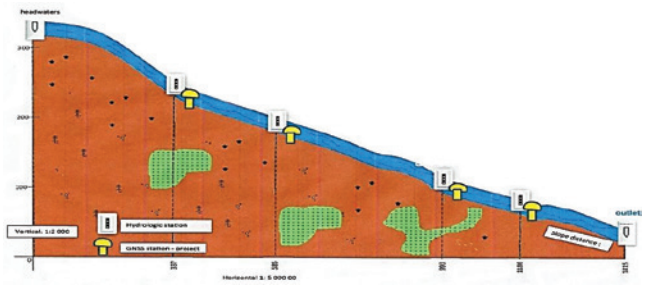

Figure 3. River level profile with GNSS points and level benchmarks

increased to 50. However, with such an increased number of ground satellite stations, the territory of the coastal zone was not covered by a GPS network, which indicates the need to create a SGN, including the benchmark of hydrological stations. For this, it is advisable to develop a project of a geodetic network, which should include triangulation, leveling and level posts, as well as new GPS stations near the main benchmarks.

The last time geodetic works of level posts were carried out in 1960-70 by technical leveling by a geodetic enterprise of the main department of geodesy and cartography. Since GNSS works were never carried out at these points, the first task was to test the navigation receiver for the presence of signals from satellites and to assess the effect of DOP on the accuracy of coordinates. Several posts of the level were selected for testing, where the infrastructure of the road network is developed (Fig.3). The selected stations are optimal for experiment, since the Syrdarya and Amu Darya rivers pass through the territory of Kyrgyzstan, Tajikistan, Uzbekistan, Kazakhstan and Turkmenistan. The study of the materials of the previous hydrological works showed that the clarification and updating of the coordinates of the points of the level posts of the coastal zone was not carried out due to insufficient funding and the organization was reorganized. In the process of GPS data at level points, the receiver is centered to the center of the benchmark, thereby minimizing the deviation of the plumb line from the normal.

At these sites, all the necessary organizational work was prepared to determine the coordinates of 6 points using the GNSS Trimble R4. More detailed studies were carried out at the "Chinaz" hydrological station, which is located in the Tashkent region. There is a triangulation point for the geodetic organization of Uzbekistan near this station.The rectangular coordinates of the point were calculated in the transverse-cylindrical projection of the Gauss-Kruger. The Krasovsky reference ellipsoid was used as the reference system, and the normal heights are given relative to the Baltic system of heights. The average values of hydrological stations coordinates are calculated using the method of transformation.

$$x = S + \frac{l^2}{2} r\, SinB + \frac{l^4}{24} r\, Cos^2 B\; SinB(5 - t^2 + 9\eta^2 + 4\eta^4);$$

$$y = lr + \frac{l^3}{6} r\, Cos^2 B(1 - t^2 + \eta^2) + \frac{l^5}{120} r\, Cos^4 B(5 - 18t^2 + t^4 - 14\eta^2 - 58\eta^2 t^2); \quad (1)$$

$$m = n = 1 + 0{,}000152 l^2 Cos^2 B; \quad p = m^2; \quad w = 0; \quad t = tgB; \quad \eta^2 = e'^2 Cos^2 B,$$

In practice, rectangular coordinates of the Gauss-Kruger projection are used, but in this case, pay attention to the location of the benchmarks relative to the axial meridian. On the axial meridian, the distortions along the ***y*** coordinate are equal to zero, and with distance from it, the distortions increase. For example, for a 6-degree zone at the edges of the meridian,

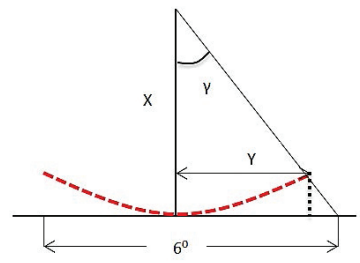

Figure 4. Distortions increase

The last time geodetic works of level posts were carried out in 1960-70 by technical leveling by a geodetic enterprise of the main department of geodesy and cartography. Since GNSS works were never carried out at these points, the first task was to test the navigation receiver for the presence of signals from satellites and to assess the effect of DOP on the accuracy of coordinates

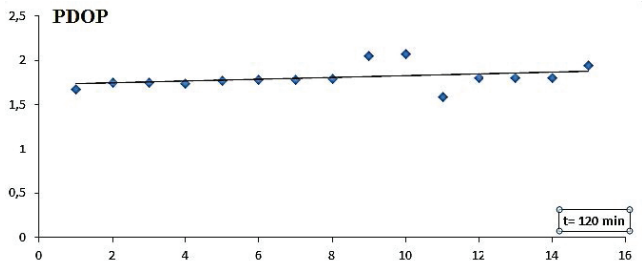

Figure 5. PDOP for Chinaz post

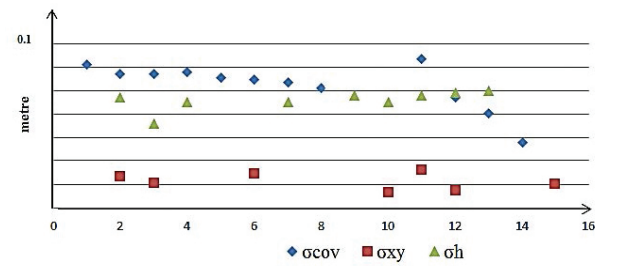

Figure 6.Change in coordinate accuracy over time

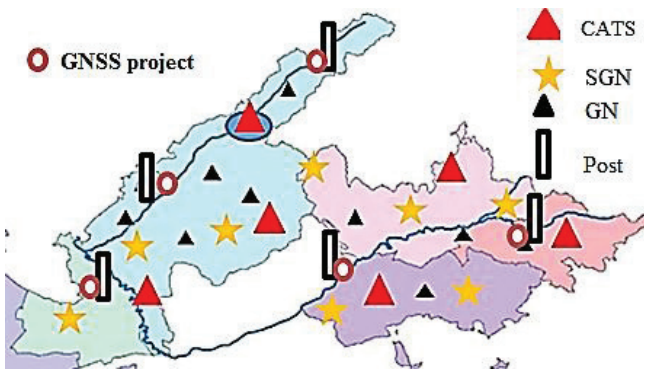

Figure 7. Fragment of the GNSS network

it reaches 1: 3200, which is too large for accurate measurements (Fig.4). In order for the distortions to be minimal or not to affect the rectangular coordinates, it is necessary to go to spherical coordinates, i.e. to latitude and longitude. In modern receivers, there are special geodetic formulas for the transition from one coordinate system. The disadvantage of joint adjustment of the SGN and traditional geodetic networks is the unequal accuracy. This leads to an incorrect solution of the system of equations. The solution of an incorrect system of conditional equations requires the involvement of a more correct and accurate method for processing geodetic works. The main stage of adjustment is to obtain the estimated values of the geocentric coordinates of the points.

On the basis of the least squares method, mean square errors of coordinates were calculated. Assuming that the measurements were performed under the same conditions, the unit weight error can be considered equal to 1.0. There were cases of non-uniformity of signal reception from the satellite. Consequently, the results obtained can be considered preliminary or accurate in the first approximation (Tab.1).

Table1. Coordinates of level posts

№	L	B	H (m)	σ_m	Posts
1	59°31' 07.59"	42°29' 23.33"	43.49	0.36	Samanbay
2	59 36 48.25	42 22 11.13	50.26	0.53	Kizketken
3	59 39 50.57	42 20 53.74	48.04	0.29	Niyatbay
4	61 20 04.49	41 13 18.75	86.03	0.50	Tuyamuyin
5	68 40 52.21	40 55 14.96	210.32	0.09	Chinaz
6	71 26 36.48	40 53 00.97	334.00	0.40	Djumashuy

The average values of the coordinates of the main point of the "Chinaz" level post are obtained on the basis of an array of measurements: x = 4531887.621, y= 12473205.639, H= 248.865. The main DOP ranged from 0.9 to 3.0, which is a natural result for points located near technical objects, as they affect the signal path (Fig.5). The PDOP results show that satellite signal reception is good, although buildings and structures have been built near the site.

Analyses

Based on the analysis of variance, graphs of changes in the coordinates of the "Chinaz" point depending on the number of observations were built. Since our task was to determine the preliminary coordinates, the signal reception interval was reduced to 10 minutes. The maximum height of satellites was set to 15 degree to exclude reflected signals from the surface layer and built structures. The quantitative characteristic of the accuracy of the measured and determined values is the root-mean-square error of these values. From the sequential processing of baselines for each session, coordinates with a covariance matrix are obtained COV_{xyz}.

$$Cov_{xyz} = \begin{pmatrix} 0.000000864 & 0.000000781 & 0.000001863 \\ 0.000000781 & 0.000000706 & 0.000001684 \\ 0.000001863 & 0.000001684 & 0.000004018 \end{pmatrix} \quad (2)$$

The analysis of the elements of the posterior covariance

The use of GNSS will make it possible to increase the accuracy of the coordinates of hydrological stations. This will result in the transfer of daily coordinates to the database and monitoring of changes in the river level in real time. In the future, it is advisable to carry out geophysical studies of the coastal zone in order to interpret the dynamics of changes in the relief of hydrological stations

matrix shows that the off-diagonal elements represent the covariance between the coordinates and have the same values, and the diagonal elements are the variances of the precision of the *x, y, z*. The resulting covariance matrix is symmetric and can easily be reduced to triangular form.

In the figure 6 shows the changes in the accuracy of the coordinates of the "Chinaz" post. The average values for the components *cov,* σ_{xy}, σ_h have an insignificant trend, which indicates an equal measurement accuracy over a short time interval. In order to obtain the exact coordinates of the benchmarks, it is necessary to perform as many GNSS observations as possible over a long time interval under various signal reception modes. Such investigations should be performed at all hydrological posts of the main rivers with the binding of these posts to the SGN.

Conclusion

To organize continuous monitoring of the river level using GNSS, the geodetic support system is proposed to start with the following procedures: reconnaissance, development of measurement techniques, testing GNSS at hydrological posts, processing and post-processing of satellite observations. After carrying out the above works, an adjustment of the SGN of the coastal zone should be performed. The final equalization of the height of hydrological stations should be implemented in the WGS84.

$$Hwgs84 = Hsk42 + T_X \cos B \cos L + T_Y \cos B \sin L + T_Z \sin B - \frac{a_E \Delta\alpha_E}{N} + \frac{\Delta e_E^2 N \sin^2 B}{2} + \\ + e_E^2 N \sin B \cos B \left(\frac{\omega_X}{\rho''} \sin L - \frac{\omega_Y}{\rho''} \cos L \right) + \mu(N + H - e_E^2 \sin^2 B). \quad (3)$$

The duration of continuous observations should be performed with GPS equipment, which allows high-precision referencing of the network of benchmarks to remote points of the SGN. Points of the Central Asian Tectonic Science and classical geodetic network with known coordinates should be used as control points when adjusting the SGN of the coastal zone (Fig.7).

Thus, the use of GNSS will make it possible to increase the accuracy of the coordinates of hydrological stations. This will result in the transfer of daily coordinates to the database and monitoring of changes in the river level in real time. In the future, it is advisable to carry out geophysical studies of the coastal zone in order to interpret the dynamics of changes in the relief of hydrological stations.

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Geopotential models and their application in local geoid modelling

The objective of this article is to share the knowledge of alternative way of geoid determination with incorporating a high resolution GGM, terrain and GPS/levelling data

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Development of GGMs

With the advent of new gravity dedicated satellite missions (CHAMP, GRACE and GOCE), the long wavelength gravity field modeling of the Earth is possible with remarkable accuracy. Numerous global geopotential models (GGMs) have been developed to date with these improved satellite gravity information, enhanced land gravity and satellite altimeter data. These GGMs can be categorized into: CHAMP-only *(TEG4 (Tapley et al., 2001), , EIGEN-2 (Reigber et al., 2003))*, GRACE-only *(ITG-Grace03 (Mayer-Gürr etal., 2007), EGM2008 (Pavlis et al., 2012))*, GOCE-only *(GO_CONS_GCF_2_SPW_R2 (Migliaccio et al., 2010))*, and their combinations with terrestrial gravity and altimeter data *(EIGEN-6C (EIGEN-6C4 (Foerste et al. 2014), GECO (Gilardoni et al. 2016); SGG-UGM-1(Weiet al. 2018), SGG-UGM-2(Weiet al. 2020))*. All developed GGMs to date are available at http://icgem.gfz-potsdam.de/ICGEM/ICGEM.html.

High resolution GGMs and EGM2008

The EGM2008 represents the first state-of-the-art global high resolution model publicly released by the U.S. National Geospatial-Intelligence Agency (NGA) EGM Development Team in April 2008 (Pavlis et al., 2012: http://earth-info.nga.mil/GandG/wgs84/ gravitymod/egm2008/index.html).The development of this model is a major achievement in global gravity field modeling. It completes spherical harmonic degree and order 2160, and provides some additional coefficients up to degree 2190. These represent gravity field quantities with wavelength approximately 10 arc minutes ($\lambda = 360 / n_{\max}^{EGM} \approx 10$ arc minutes), which equate to spatial resolution of 5 arc minutes ($\Delta x = 180 / n_{\max}^{EGM} \approx 5$ arc minutes), depending on the latitude. Hence, any gravity field quantities with spatial scale larger than 5 arc minutes are supposed to be represented by this model. Since then, there are many high resolution GGMs that have been published to date and available at ICGEM: http://icgem.gfz-potsdam.de/ICGEM/ICGEM.html. Figure 1 shows the global variation of geoid heights generated by EGM2008 model.

With the advent of new gravity dedicated satellite missions, the long wavelength gravity field modeling of the Earth is possible with remarkable accuracy. Numerous global geopotential models (GGMs) have been developed to date with these improved satellite gravity information, enhanced land gravity and satellite altimeter data

The Earth's gravitational potential in terms of fully-normalized, unit-less spherical harmonic coefficients $\overline{C}_{nm}$, $\overline{S}_{nm}$ can be expressed as

$$V(r,\theta,\lambda)=\frac{GM}{r}\left[1+\sum_{n=2}^{N\max}\left(\frac{a}{r}\right)^{n}\sum_{m=0}^{n}(\bar{C}_{nm}\cos m\lambda+\bar{S}_{nm}\sin m\lambda)\bar{P}_{nm}(\cos\theta)\right],$$

where n and m denote the degree and order of the harmonic coefficients, Nmax indicates the maximum degree of the series expansion (e.g. 2190) and $\bar{P}_{nm}(\cos\theta)$ are fully normalized associated Legendre polynomials. The geocentric polar coordinates for each computation point represent (r,θ,λ). GM and a are scaling parameters associated with this model, which have the numerical values of $GM = 3986004.415X10^{8} m^{3}s^{-2}$ and $a = 6378136.3m$.

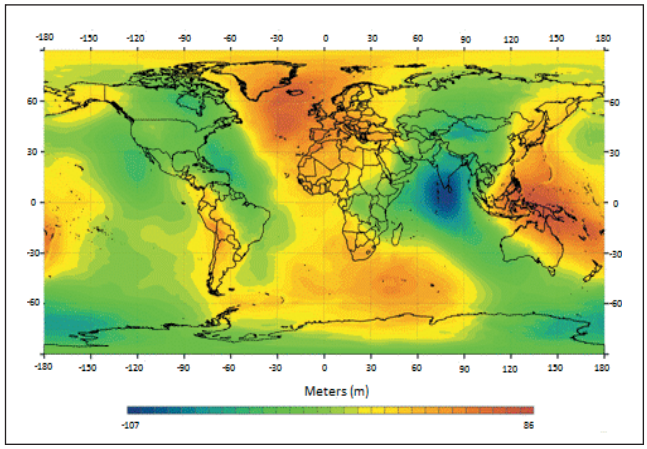

Figure 1: EGM2008 geoid heights interpolation on 2.5x2.5 minutes grid. (Source: *http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/egm08_wgs84.html)*

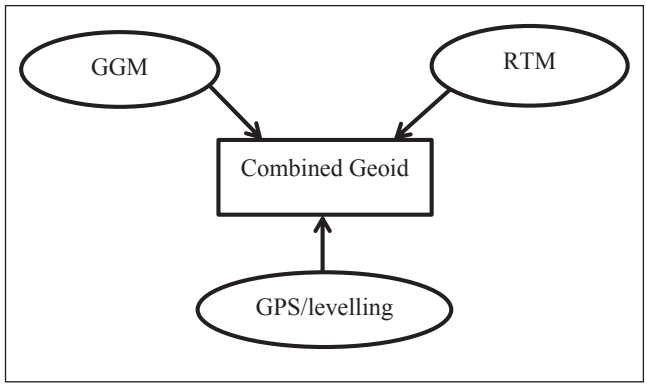

Figure 2: Data sources required for combined geoid

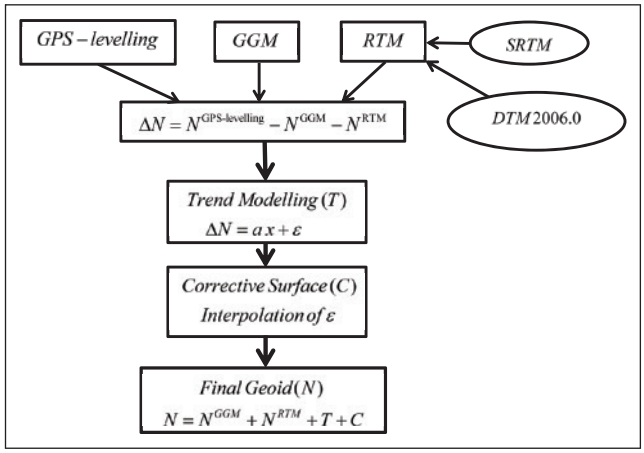

Figure 3: Computation scheme of geoid modelling procedure

Geoid modelling using high resolution GGM and terrain data

In remove-restore approach of gravimetric geoid determination, the geoid undulations due to long wavelength gravity field variations are estimated by a GGM and the high frequency components are obtained through a regional topographic model. The remaining medium to short wavelength features of geoid undulations are estimated by Stokes or Molodensky-based approaches using gravity measurements. With the availability of high resolution GGM, separate estimation of medium level components became unnecessary since medium and even part of the short wavelength components are already embedded in high resolution GGM. Therefore, as an alternative methodology, combined geoid determination using heterogeneous data can be used for local geoid modelling.

The truncation of GGM model at its maximum degree and order leads to omission (truncation) errors, and can contribute to the fact that the model is unable to resolve all gravity field features, from the long to the short wavelength. This error is more evident in mountainous regions where the topography is the dominant source of the short wavelength features of the gravitational field. If it is possible to estimate the effect of the omission errors on geoid heights, then the effect can be added to GGM derived geoid heights to obtain improved geoid heights, especially in mountainous areas (Hirt et al. 2010, Prasanna et al. 2021). The available GPS-levelling data can then be used to constrain long wavelength geoid errors. In practical geoid determination schemes, a GGM is used as a reference field, which includes the effect of global topography. The RTM reduction method (Forsberg 1984) accounts for the topographic irregularities relative to smooth reference surface. The advantage of RTM method is that it only accounts for the topographic effect that has not been included in the spherical harmonic model of the gravity field of the Earth.

RTM geoid heights

RTM data can be obtained from two freely available data sources: DTM2006.0 (Pavlis et al., 2007) and Shuttle Radar Topography Mission (SRTM) elevations (Farr et al., 2007). DTM2006.0 is a spherical harmonic model of global Earth's topography which comprises 2.4 million pairs of fully normalized height coefficients $\overline{HC}_{nm}$, $\overline{HS}_{nm}$ (Pavlis et al., 2007). The elevations of this model are given by

$$H(\theta,\lambda)=\sum_{n=0}^{N\max}\sum_{m=0}^{n}(\overline{HC}_{nm}\cos m\lambda+\overline{HS}_{nm}\sin m\lambda)\bar{P}_{nm}(\cos\theta)\cdot$$

Since DTM2006.0 has the same spatial resolution as high resolution GGM (degree & order 2190), it can be considered as a low-pass filter which removes long wavelength topographic components associated to GGM from high resolution (30 m resolution) SRTM data. RTM elevation can be computed by $H^{RTM} = H^{SRTM} = H^{DTM\,2006.0}$.

RTM elevations can be converted to the corresponding geoid heights N^{RTM} using the rectangular prism forward modelling method (Nagy et al. 2000).

The available GPS-levelling data can then be used to constrain long wavelength geoid errors (ΔN) that can be estimated through a low order trend function.

$\Delta N = N^{\text{GPS-levelling}} \Delta N^{\text{GGM}} \Delta N^{\text{RTM}} = ax+\varepsilon$, where x is the vector of unknown parameters and a is the vector of coefficients and ε denotes the residual vector. The residuals can finally be interpolated as the corrective surface. The whole computation procedure can be depicted as below flow chart.

Numerical results

Geoid modelling in Canadian Rockies (Prasanna & Chen, 2012):

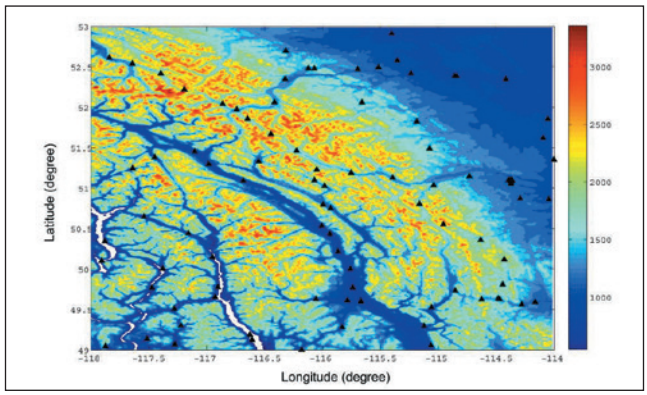

Figure 4: The topography map of the test area in Canadian Rokies. Elevations are supplied from SRTM3 database. Figures are given in meters. Triangles show GPS-levelling points.

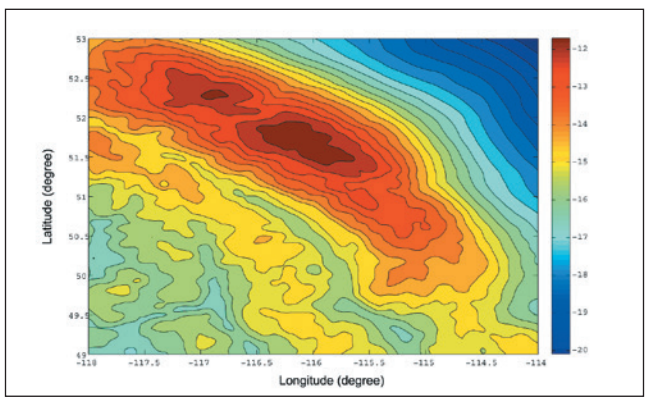

Figure 5: Combined Geoid over the test area. Values given in meters.

A part of the Canadian Rockies (latitude 49°-53° -N and longitude 118°-114° W, 300x450km^2) was selected as the test area. It comprises rough mountains with elevation variation from 400m to 3500m and reasonable numbers of GPS-levelling points are available for computation (Figure 4).

EGM2008 geoid model was used as the high resolution GGM. There are significant omission errors in EGM2008 in this mountainous area. The RTM corrections were estimated as the difference between high resolution SRTM3 and the low resolution DTM2006.0 models. As DTM2006.0 is the topography model incorporated in EGM2008, the RTM corrections represent the fine geoid features which are not included in the EGM2008 model. Table 1 shows the RTM corrections as the as a function of spherical harmonic degree of the DTM2006.0.

Table 1: Descriptive statistics of RTM geoid undulations at 97 GPS-levelling points as a function of spherical harmonic degree of the DTM2006.0.

Degrees	Min (m)	Max (m)	Mean (m)	STD (m)
2160	-0.169	0.041	-0.052	± 0.048
1800	-0.184	0.017	-0.059	± 0.052
1440	-0.218	0.021	-0.068	± 0.059
1080	-0.271	0.079	-0.086	± 0.084
720	-0.435	0.169	-0.106	± 0.121
360	-0.810	0.223	-0.207	± 0.276

In order to obtain the optimum RTM correction, different spectral combinations of EGM2008 and DTM2006.0 were used (Table 2).

Table 2: Descriptive statistics of RTM reductions using different EGM2008/RTM solutions as a function of different maximum spherical degrees. Linear bias is removed, i.e. the mean value is 0.000 m. N= GPS/levelling geoid height

Comparison	$n_{\max}^{\text{EGM}}$	$n_{\max}^{\text{DTM}}$	Min (m)	Max (m)	Range (m)	STD (m)
N – EGM2008 only	2190	-	-0.254	0.264	0.518	± 0.082
N – (EGM2008+RTM)	2190	2160	-0.221	0.245	0.466	± 0.076
N – (EGM2008+RTM)	2160	2160	-0.240	0.257	0.497	± 0.078
N – (EGM2008+RTM)	1800	1800	-0.252	0.290	0.542	± 0.088
N – (EGM2008+RTM)	1440	1440	-0.283	0.314	0.597	± 0.093
N – (EGM2008+RTM)	1080	1080	-0.332	0.301	0.633	± 0.094
N – (EGM2008+RTM)	720	720	-0.321	0.284	0.605	± 0.107
N – (EGM2008+RTM)	360	360	-0.324	0.378	0.702	± 0.130

According to the Table 2, RTM correction with respect to the maximum spherical harmonic degree 2190 of EGM2008 and 2160 of DTM2006.0 reference surfaces seems optimum in terms of the residual range and the standard deviation.

A parametric model was used to compute the trend which comprises systematic part of ΔN. Table 3 shows the results after the trend modeling and the cubic function gives slightly better results.

Table 3: Statistics of trend modelling

Model	Number of coefficients	Min (m)	Max (m)	Mean (m)	STD (m)
Linear	3	-0.226	0.247	0	± 0.078
4-parameter	4	-0.232	0.247	0	± 0.079
5-parameter	5	-0.231	0.245	0	± 0.080
Quadratic	6	-0.230	0.246	0	± 0.080
Cubic	10	-0.164	0.226	0	± 0.070
5th order polynomial	21	-0.163	0.256	0.002	± 0.075

The detrended residuals obtained from the cubic model are interpolated using various interpolation techniques. Among those techniques, the kriging and minimum curvature interpolation methods shows good results.

The final combined geoid is obtained by adding corrective surface, cubic trend and RTM effect to the EGM2008 geoid heights. Figure 5 shows the combined EGM2008 geoid over the test area. Table 4 shows the validation of the combined geoid and comparison with the Canadian CGG2005 geoid.

Table 4: Validation of combined geoid using 97 GPS-levelling points.

Model	Min (m)	Max (m)	Mean (m)	STD (m)
EGM2008	-0.854	-0.365	-0.583	± 0.087
After adding trend and RTM effect	-0.183	0.209	0	± 0.072
Combined geoid by adding corrective surface using kriging interpolation	-0.175	0.142	-0.002	± 0.066
Combined geoid by adding corrective surface using minimum curvature interpolation	-0.173	0.148	-0.004	± 0.070
CGG2005	-0.681	-0.335	-0.485	± 0.067

Conclusions

The objective of this article is to share the knowledge of alternative way of geoid determination with incorporating a high resolution GGM, terrain and GPS/levelling data. This method would be useful for regions with sparse GPS-levelling and gravity data networks.

The test area selected was a well surveyed area with very large elevation variations (400 to 3500 m). The omission error of EGM2008 in the region was quite large and thus suitable for testing the proposed alternative method.

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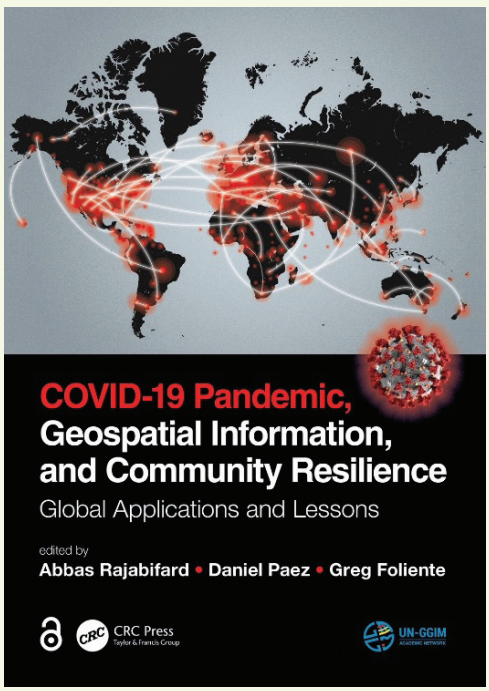
BOOK

Geospatial information and Pandemic: an Open Access Book

The Centre for SDIs and Land Administration at the University of Melbourne (CSDILA) has announced the latest publication, an open access text that can be freely downloaded as an e-book from this link: https://library.oapen.org/handle/20.500.12657/49450 Physical copies be ordered from the publisher – Routledge, Taylor & Francis Group – or on Amazon.

Title: COVID-19 Pandemic, Geospatial Information, and Community Resilience: Global Applications and Lessons

Editors: Professor Abbas Rajabifard, Dr Daniel Paez, Professor Greg Foliente



The focus of the book:

Geospatial information plays an important role in managing location dependent pandemic situations across different communities and domains. Geospatial information and technologies are particularly critical to strengthening urban and rural resilience, where economic, agricultural, and various social sectors all intersect. Examining the United Nations' SDGs from a geospatial lens will ensure that the challenges are addressed for all populations in different locations. This book, with worldwide contributions focused on COVID-19 pandemic, provides interdisciplinary analysis and multi-sectoral expertise on the use of geospatial information and location intelligence to support community resilience and authorities to manage pandemics.

Chapters in this publication cover many intersections between the pandemic and geospatial sciences, including different approaches to people management during an outbreak, the potential for new and existing technologies and data collection in managing large populations in isolation, use of social media to track community resilience, and the lessons to be learned from different country's approaches to using location data in managing their populations through the pandemic.

River Yamuna in Delhi- Pollution control, digital planning and management

A judicious integration of ecological scientific research, digital planning and management is necessary to keep the urban river clean and flowing. This requires committed participation of the local communities. The cultural and traditional connect with water, as reflected in traditional water structures, and purification customs, can be potential social tools to involve the masses to conserve water resources and to prevent pollution of river

A K Jain
worked as Commissioner (Planning), Delhi Development Authority. He was a member of the Committee of the Ministry of Housing and Urban Affairs on the DDA (2015), and UN Habitat (2007-12). A member of Editorial Board of International Journal of Environmental Studies (UK), and author of several books, he is visiting faculty in planning and architecture. He was awarded 2nd Urban Professional Award 2014 at World Urban Forum in Medellin, Colombia and IBC Lifetime Achievement Award (2016).

From times immemorial, the cities, agriculture and culture evolved along the rivers. Among various Delhi's, Shahjahanabad (17th Century), was built along the river Yamuna, a 1370 km long river emanating from the Himalayas and merging into the River Ganga at Prayag. However, with indiscriminate urbanisation River Yamuna in Delhi has become a dirty drain. The river zone covering 9700 Ha in the midst of Delhi has been encroached upon, used for power stations, sanitary landfill, bus depot and parking, construction of roads, grid sub-stations, samadhis, housing, offices, stadia, temples, cremation ground, an IT Park, metro depot and various other activities. More than 70 unauthorised colonies have come up in the area, which have altered the river regime and its water quality.

About 90 per cent of river water is diverted into drains and canals upstream and most of the remaining water is stored for urban use, leaving the river high and dry, especially during the summer. River without a continuous flow lacks oxidation and becomes stagnant and polluted. A significant problem is eutrophication which results from the excessive levels of nutrients in municipal, industrial, irrigation and drainage effluents. Nearly 75% of pollution of river is from municipal sewage with the balance coming from effluents generated from industries, run-off from agricultural fields, solid waste dumps, open defecation, etc. The analysis of the water quality data along the length of the river reveals the following:

i. The levels of Dissolved Oxygen (DO) above the threshold limit (5 mg/ litre)
ii. The levels of Biochemical Oxygen Demand (BOD) above the acceptable limit of 3 mg/ litre.
iii. The higher levels of coliform (faecal and total) count in the river water.

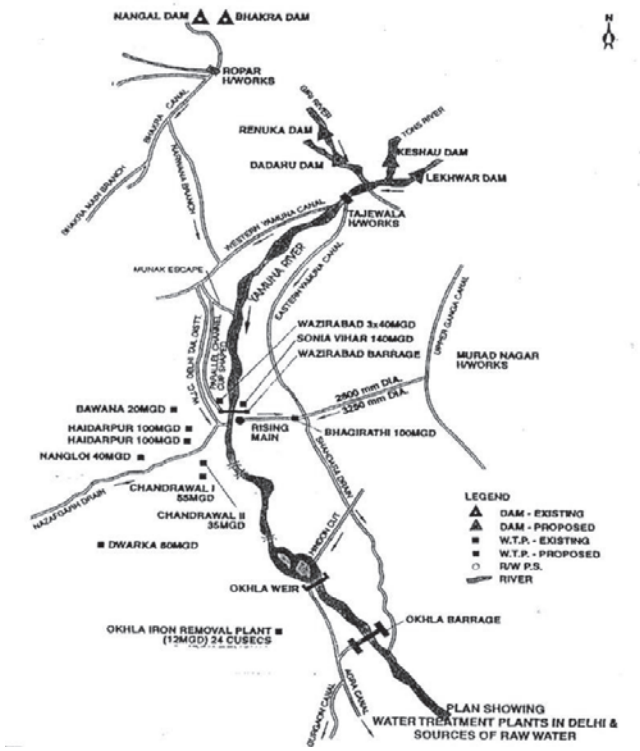
It is estimated that during last 50 years freshwater vertebrate in the river have declined by 83%, groundwater has depleted and there is a serious loss of biodiversity. The construction of embankments to bind the floodplain has constricted the water flow, resulting into frequent flooding, construction of unauthorised colonies, real estate projects, roads and flyovers in the river flood zone.

Biodiversity, land form and the river

There is a close relationship between the landform and the river. Its maze-like structure reflects and celebrates a kinesthetic and topographic abstraction of space. As such, river can't be separated from the network of canals and drains. These are valuable hydrological and ecological resources, which with the indiscriminate urbanization have

Shahjahanabad on the bank of river Yamuna (1850)

River Yamuna in Delhi (1850)



Sources of Water Supply in Delhi: River Yamuna in Delhi flows in a length of 45 km and 9700 Ha of area is designated as river flood zone. Delhi has a 350 km long network of canals and major drains and 600 water bodies

River Yamuna in Delhi is now a dirty drain

become the corridors of filth, garbage, squatting, insanitation and beds of mosquitoes, stray and dead animals. These canals and drains can be developed as green corridors with jogging tracks, pedestrian and cycle pathways. Historical water system and structures, baoli, embankments, sluice gates, lakes, catchment areas, canals, etc. can be protected by green portals and kept alive by the public activities.

Keeping the river flowing

A major problem which affects the overall health of the river relates to non-availability of adequate water flow. The river Yamuna cannot be made pollution free unless the adequate flow is maintained. The Supreme Court of India in 1999 directed that a minimum10 cumecs of water be ensured in the river Yamuna throughout, together with pollution abatement and up-gradation of water quality. The availability of water in the river throughout the year is not only important for making it lively and pollution free, but also to meet the burgeoning demand of water supply by capacity augmentation of the existing reservoirs and local collection of the monsoon water.

Huge quantities of human, industrial, tanneries and solid and liquid wastes are carried by 22 major drains falling into the river Yamuna in Delhi. These drains dump solid wastes, sewage and wastewater in the river. These violate the Water (Prevention and Control of Pollution) Act, 1974, and Environment Protection Act 1986. The installation of treatment facilities (STPs and ETPs) by polluting units and surrounding urban areas, and their efficient and effective functioning are essential.

While curative actions, such as installation of treatment facilities are necessary, more important is preventive action. This involves removal of non-compatible and pollution generating land uses from the river zone and also cleaning of major drains and controlling the dumping of solid waste and untreated sewage into rivers and drains.

Reducing river pollution

Causes of contamination of river water are indiscriminate use of fertilisers and chemicals, poor hygienic environment of the water sources, improper disposal of sewage and solid waste, pollution from untreated industrial effluents, and over-exploitation leading to quality degradation. Of all the pollutants, urban sewage may be the worst offender in near-urban waters, although industrial pollutants can be a major source. In addition, up to half of the contaminants reaching urban waters come from non-point sources, such as urban runoff.

Thus, the supply of additional quantity of water by itself does not ensure good health; proper handling of water and prevention of contamination are also equally important.

Among the most important elements of the public health package are:

- Safe drinking water
- Disposal and recycling of wastewater
- Safe disposal of human excreta which is associated with more than 50 per cent diseases
- Safe solid waste disposal
- Sanitation and hygiene
- Personal hygiene, cleanliness and use of toilets
- Community Sanitation.

By reducing river pollution, cities can reap the double benefit of effectively increasing the water supply while lessening the deterioration of the aquatic environment. As the "pollution shadow" spreads, cities go further to find water, which significantly increases the costs of water supply.

Controlling urban runoff, although difficult, is essential if cities are to mitigate their impacts on nearby water bodies.

Regional water resources can only be properly managed at the river basin level. It is therefore necessary to have planning and control for the whole river basin. Groundwater, for which various government departments share responsibility, should be managed as a unified regional management framework.

Because of the urbanisation and demand for groundwater, aquifers are vital water resource management.

Urbanisation, removal of forest cover and the addition of impervious surfaces have increased frequency of flooding and changed stream characteristics. By adopting, the natural drainage system, water-table recharges and increases lag time for run-off. Protection of flood plain and drainage are imperative for flood control, for regulating stream control and for maintaining water quality.

Innovative and economical solutions like primary treatment, bio-remediation, oxidation ponds, aeration, etc. can be employed to treat waste water. For treatment of pesticide traces, capping the existing sand bed with bituminous charcoal or coconut shells can be an easy and inexpensive solution. Increasing flocculants by adding powered activated carbon (PAC) or bentonite clay with doses varying from 25-30 mg/l and the use of granular activated carbon can be effective, subject to its cost. Raw water tanks and rainwater storage can be protected by clay beds, which should be secured from getting washed away during the monsoons. The best way to get rid of the pesticides (non-point) and industrial toxins is through "source protection measures", i.e. protect the catchments through methods such as organic or biological farming.

The soft landscape and vegetation along the river banks can allow rain to be absorbed rather than running off. Natural in-stream elements, e.g. root wads provide slow-water habitat for fish and insects that regenerate native wetlands.

Interceptor sewers along the major drains can help in checking the sewage flowing into the river. This also needs putting up Sewage Treatment Plants (STPs) and to augment the capacity of existing STPs and recycling the effluents and wastewater. It is necessary to lay interceptor sewer along the three major drains (i.e. Najafgarh, Supplementary and Shahdara) to intercept sewage flowing from subsidiary small drains. It also involves augmenting the existing capacity of STPs at Delhi Gate and Dr. Sen Nursing Home drains from the existing 2.2 to 15 million gallons daily at each point. Subsequently to interceptor sewers for 13 small drains falling into Bela Road and Ring Road trunk sewers, and additional STPs may be taken up and to recycle effluent wastes and wastewater.

As river cleaning is connected with the water, drainage, solid waste management and transport networks, all these need to be planned together with appropriate technology and participation of the people, infrastructure agencies and other stakeholders. An important aspect is to incentivise wastewater recycling and enhance the reuse of treated wastewater.

The covering of the drains and canals for construction of roads, parking, markets, etc. should be avoided. The South Greenways along Barapulla Nalla in New Delhi has proposed converting dirty and filthy drain into a beautiful, lively area by primary water treatment, bio-remediation, desilting sewerage in micro-STPs and wastewater recycling, along with creating balancing ponds for slow surface run off to recharge the water table. The organic reed beds and aerators can clean the sewage entering the drains help replenish aquifers. An improved drainage integrated with rejuvenation and beautification of lakes, canal and riverfront will also help to prevent flooding of urban areas, damage to roads and buildings and reduce risk of water-borne diseases.

The Delhi Jal Board has initiated the work on the rejuvenation and beautification of 155 water bodies; Jahangirpuri marshes, Najafgarh Lake, Mayur Vihar, Shahdara Lake, Neela Hauz, Hauz Khas and Hauz Rani. The Yamuna Bio-diversity Park (457 acres) has been developed by the DDA. An integrated rejuvenation and beautification of Najafgarh lake and Najafgarh drain (from Delhi-Gurgaon border to Wazirabad/river Yamuna-45

km) can be taken up as a pilot in collaboration with I & F Department and DTTDC. The water bodies fall under the jurisdiction of 10 agencies and local bodies. It is necessary to develop an integrated and coordinated system of management.

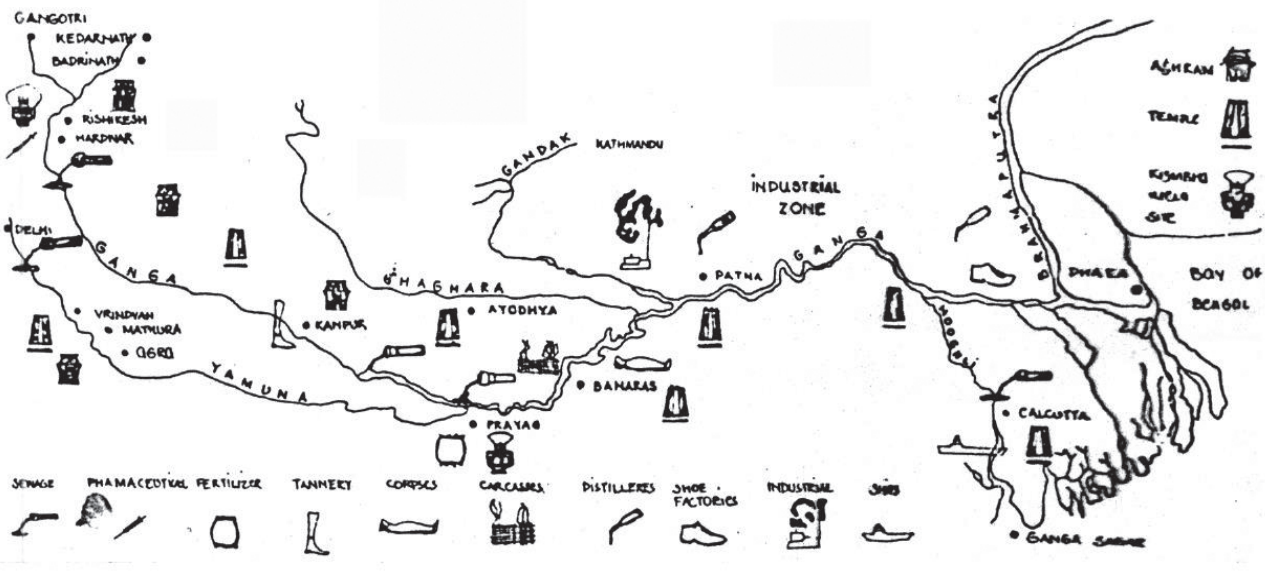
The riverfront can be activated by sports, picnic spots, fairs, bathing ghats, etc. Incongruous and people-repelling uses such as sanitary landfill sites, flyash dumps, STPs. parking lots, power plants, security lines, industries, tanneries, dairies, waste dumps and brick plants located in river zone should be closed. Infiltration beds and buffer strips along the river can quickly absorb and filter contaminants and sediments in runoff and vegetation can stabilize river banks from erosion. Trees provide ambient growth environment for fish, migratory birds and wildlife. Wildlife observation areas, theme parks and interpretive nature/ historical trails, boating and walkways can be planned in the riverfront which would highlight the river ecology and its significance.

Step well (baoli) at Red Fort is an important feature of traditional water system

The strategic phasing of the river project should start with the preparation of an overall watershed development plan by participation of all concerned agencies, government departments and the people. This requires an effective and empowered institutional structure, bringing various agencies on a common platform with a legal backup and a clear delineation and definition of various terms, such as water course, embankment, flood plain, riverfront and river zone.

For the conservation of the eco-sensitive nature of the river zone, the agencies dealing with the river, land, water, power, irrigation, transport, drainage and sewerage should work together on water supply-sewerage-drainage, flood control, mobility/public transit and environment management plans. The regularization of encroachments, religious structures, industries, commercial activities and unauthorized colonies in River Zone should be avoided and carefully dealt with, keeping in view its eco-sensitive nature and within an overall policy framework. The rejuvenation of the river involves the preservation of water quality and pollution control.

The unsewered areas, viz. slums, unauthorized colonies, resettlement colonies, villages, etc. need to be provided with alternative, decentralized sewage systems. Under the Yamuna and the Ganga Action Plans, various schemes have been undertaken, such as Up-flow Anaerobic Sludge Blanket (UASB), sewage treatment through afforestation (Karnal Technology) and Constructed Wetland. Resource recovery options like methane generation and aquaculture. Biodegradation of the open drains carrying sewage are being used for oxidation of organic constituents and reduction of pollution load. Other options include oxidation pond, wetlands and sewage farming.



Sources of Water Pollution in River Yamuna and Ganga
Source: World Watch, 1995

Water quality

Water quality is typically characterized on the basis of conditions such as:

- water clarity or transparency (greater water clarity usually indicates better water quality).
- concentration of nutrients (lower concentrations indicate better water quality).
- quantity of algae (lower levels indicate better water quality).
- oxygen concentration (higher concentrations are preferred for fisheries).
- concentration of dissolved minerals (lower values indicate better water quality).
- acidity (a neutral pH of 7 is preferred).

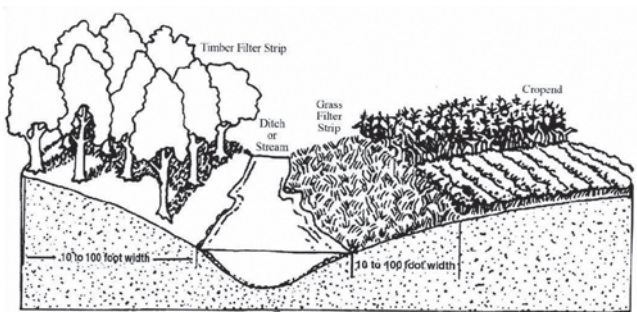
Many waste chemical compounds from industry, some with toxic or deleterious effects on humans and/or other water-dependent organisms and products, are discharged into lakes and reservoirs. Some can kill aquatic organisms and damage irrigated crops. Inadequate water purification resulting in the discharge of bacteria, viruses and other organisms into natural waters can be a primary cause of waterborne diseases.

The water quality standards as prescribed by the Bureau of Indian Standard are tabulated below:

Table : Organoleptic and Physical Parameters of Drinking Water

Sr. No.	Characteristics	Requirement (Acceptable limit)	Permissible limit in the absence of alternate source	Method of Test, ref. part of IS 3025	Remarks
1.	Colour, Hazen units, Max	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate source.
2.	Odour	Agreeable	Agreeable	Part 5	Test cold and when heated Test at several dilutions
3.	pH Value	6.5-8.5	No relaxation	Part II	-
4.	Taste	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
5.	Turbidity, NTU, Max	1	5	Part 10	-
6.	Total dissolved solids, mg/L Max	500	2000	Part 16	-

Source: BIS IS 10500: 20



Green filter strip

Rainwater harvesting

The term rainwater harvesting refers to collection and storage of natural precipitation and also other activities, aimed at harvesting surface and groundwater, prevention of losses through evaporation and seepage, and all other hydrological studies and engineering interventions, aimed at conservation and efficient utilization of the limited water endowment of a physiographic unit, such as a watershed.

The options for water harvesting are the following:

- Construction of storage structures for "in situ" collection of rainwater.
- Farm ponds for collection of runoff, either for supplemental irrigation or for augmentation of groundwater.
- Check dams for storing runoff in first order (small) streams.
- Percolation tanks at appropriate sites for augmentation of groundwater.
- Construction of ponds and reclamation/revitalization of traditional water arresting structures.
- Artificial recharge through wells.
- Reduction of evaporation from surface water bodies and soils.
- Prevention of seepage losses in appropriate situations.
- Enhancement of runoff through mechanical arid chemical treatment in catchment areas.
- Sub-surface dams to arrest base flow of groundwater.
- Soil and water conservation practices comprising contour and terrace bunding.

Groundwater recharge

The 'Manual on Artificial Recharge of Groundwater', prepared by Ministry of Water Resources, Central Ground Water Board (CGWB) gives the following options for artificial groundwater recharge:

1. Ditch and Furrow Method
2. Lateral Ditch Pattern
3. Dendritic Pattern
4. Contour Pattern
5. Spreading Basin or Percolation Tanks
6. Gully Plug / Check Dam / Nala Bund / Gabion Structures
7. Dug Well Recharge
8. Recharge Shafts / Pits / Trenches
9. Artificial Recharge through Injection Well
10. Induced Recharge from Surface Water Sources
11. Subsurface Dykes / Underground Bandharas

Rainwater harvesting and groundwater recharge should be dovetailed with watershed development programmes. This involves several actions as outlined below:

- Arresting groundwater decline and improving its accessibility water quality
- Preventing surface water run-off during monsoons
- Reducing water wastage and recycling of wastewater

Watershed management

The watershed management aims to conserve the natural drainage and flow of water stream. This involves development, conservation and revival of the ponds, check dams, water, gully control structures, contour bunding, ridges and furrows, rainwater harvesting micro-irrigation, etc.

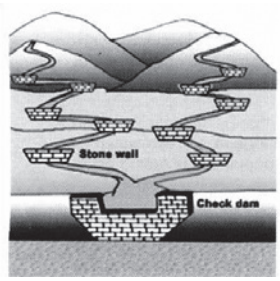
Various options can be adopted according to topography and water quality of a watershed:

a. **On-channel Storage and Recharge of Storm Water Channels:** Several seasonal streams become activated during the monsoons providing the outlet to flood waters as well as local area runoff. With careful planning these waters can be stored on the channel itself. The storage capacity of channels can be enhanced by deepening and can he enlarged to form on-channel lakes at locations conductive to recharge. These reservoirs offer the possibility of creating rich urban bio-diversity habitats.

b. **Off-channel Storage for Floodwaters:** As all storm water cannot be stored on channel, possibilities exist for the creation of off-channel reservoirs linked to the main channel. The creation of off-channel reservoirs, especially wherever a suitable recharge area, exists in the neighbourhood of a channel, is a useful device for storing water for the lean season. These reservoirs also offer the possibility of creating rich urban bio-diversity habitats.

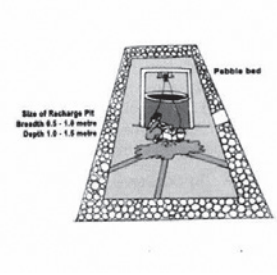
c. **Storage in Lakes and Depressions:** In urban areas, lakes have often been misused for dumping of solid waste and sewage disposal. The storage capacity of these can be increased by desilting and widening. The water quality would need to be improved by replicating the principles of wetlands by the systematic induction of aquatic plants and fish. This is a very low cost treatment and subsequently only clean water would enter the underlying aquifer.

d. **Floodplain Reservoirs for Conjunctive Extraction:** Very often the fresh water aquifers underline the floodplains. In urban areas, there is no place to store the monsoon discharge of the river due to lack of topographical relief. To overcome this difficulty simple reservoirs on the floodplain can be created by scooping out earth at appropriate locations and letting these reservoirs to be filled up by the expanded monsoon season flow of the river.

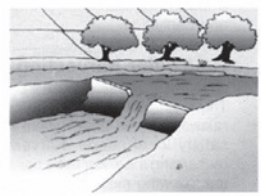


Rainwater harvesting through watershed management

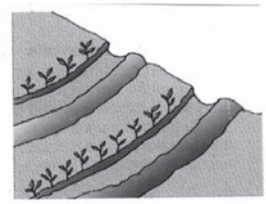
Traditional water harvesting through eris (lakes)



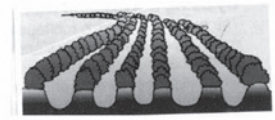
Recharge ground water by pebble beds



Check dam structure



Contour bunding.



Ridge sand furrows gully control and trenching

Watershed management

Urban ponds, water bodies and lakes are important part of the eco-system as they recharge groundwater, provide aesthetically pleasing space for recreational activities, prevent floods and allow sediment retention.

Based on natural topography, catchment zones should be identified. The parks and green strips can have bio-swales and recharging pits which receive water from all hard paved areas. The storm water flow into the de-silting chamber with grating, where the silt settles down and can be cleaned regularly. As the chamber has a grating over it, the other waste like leaves, etc. will not enter the drain. From the storm water drain, the water flows into a bio-swale (located in parks and green strips), and recharging pit.

Based on hydrology, geology, climate, ecological and socio-economic consideration, the watershed management strategy may be developed with the drainage and landscape. Fine-grained landscapes, with high drainage densities and high stream frequencies are necessary in areas with erodible soils and rocks and high rainfall.

River basin management

River basin management process entails the delineation of river basin, data, local knowledge, maps, land status, land management, land use, demographic, social, cultural, economic and environmental information. These are the basis of the diagnosis of the issues, problems and evolving the plans and strategies of river basin management. Comprehensive river basin planning involves sound economic analysis, environmental analysis and participation of the local people affected by the project.

River Zone (Zone O) in Delhi covers 9,700 Ha of land, most of which belongs to Delhi Development Authority/Government. However, it has been vulnerable to encroachments by 76 unauthorised colonies, besides development of IT Park/ DMRC Depot, temples, Commonwealth Games Village, DTC Depots, transport infrastructure projects, etc. The most of the properties in 76 unauthorised colonies, the land largely belongs to the government. The Government in 2019 issued NCTD (Regularisation of Property Rights in Unauthorised Colonies) Regulations. Although this zone is not covered by this notification, there are pressures to exclude these unauthorised colonies from this zone (O). There are also gaps in land records and services. According to NCAER (2020) the status of land record and services is given below:

- Records of Rights : Poor, Obsolete
- Spatial Records : Very Poor, Manual
- Digitised Cadastral Maps : 53% of Villages
- Digital Registration Process : Very Poor
- Quality of Land Records, Updation and Land Use : Very Poor

Lack of digital Land Information System and practice of power of attorney are the major hurdles in land management. This needs the adoption of information communication technologies (ICT) based digital ledgers for data management, Land Admin Domain Model (LADM), geographic information system (GIS), electronic data capture, web-based applications, satellite/Total Station/ Drone surveys, national spatial data infrastructure (NSDI) and e-governance.

For sustainable management of land in river basin in Delhi, the following initiatives are essential:

Digital Ledgers and Blockchain,
A digital ledger is a geographically distributed database that is shared and synchronized across a network of the participants. It has a blockchain structure where the data is stored in blocks, linked and secured by cryptography for handling identities, contracts and assets. The blockchain is an electronic transactions system. It is based on a hash algorithm that converts data into a block.

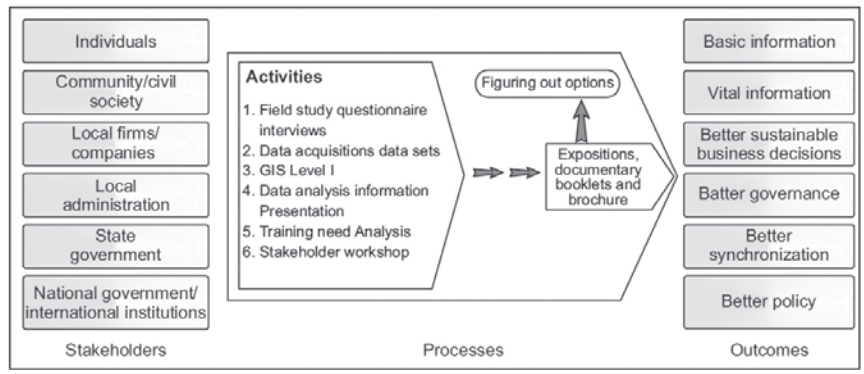
There are three types of blockchain: public, consortium and private blockchain. A public blockchain allows anyone in a network to be involved in the process of adding blocks. A consortium blockchain requires participants to be from an organization. A private blockchain is operated by a particular organization. Every user receives a unique public key and a unique private key. These two keys can be used for privacy and authentication. Thus, a blockchain is a chain of digital signatures that are joined together in clusters with a specific block.

> LADM is capable of depicting the and different forms of land grabbing. The LADM defines the Spatial Units and different forms of property. It contains the Rights, Restrictions and Responsibilities. For land pooling two specialised classes, one for public based regulation, and the other for a Land Registration, where the ownership rights and the publicly imposed restrictions are registered for each case

LADM framework

The Land Administration Domain Model (LADM) is an International Standard (IS) of the International Organisation for Standardization, as ISO 19152. It covers basic information related to components of land administration and includes agreements on administrative and spatial data, land rights and source documents (e.g. deeds or survey plans), and forms of tenures- customary tenure, government land, and privately held land.

As such, LADM is capable of depicting the Land Administration System and different forms of land grabbing. The



Reassessing the Needs by Information Intensity and Leveraging—the collection of information is directed towards identifying strengths, weaknesses, opportunities, and threats (SWOT) of a defined area in the river basin. The basic information covers air, water, waste and other relevant environmental or social concerns, which is done in a condensed yet simple format such that can be understood by all. Source: Styczynski, A.; Wold, J.; Tah, S.; Bose, A. (2014) When decision making processes fail: an argument for robust climate adaptation strategies for planning in the face of uncertainty, Environment Systems and Decision Journal, Springer.

It is necessary to map the socio-cultural activities, festivals and cultural resources which are dependent upon the river. It is also essential to assess dependency of riparian communities on riverine resources and their perception towards river biodiversity and conservation

LADM defines the Spatial Units and different forms of property (commonly held, public or private). It contains the Rights, Restrictions and Responsibilities. For land pooling two specialised classes, one for public based regulation (AL_ Infrastructure Reserve), and the other for a Land Registration, where the ownership rights and the publicly imposed restrictions are registered for each case.

This involves allocation of institutional responsibilities, building around shared values and a cross-sectoral management involving the departments of environment, forests and climate change, industry, transport, power, health, rural development, finance, pollution control, irrigation and flood control, local urban bodies, water supply and sewerage, etc. This implies developing a comprehensive policy and blockchains, governance reforms, pricing, water demand management, land use zoning and capacity development for planning, implementation, monitoring and enforcement.

Community participation

Regardless of formal regulations, local informal regulations are usually stronger in eco sensitive river basin, particularly with respect to water use, storage, pollution control and social audits. This poses certain implications. First, strengthening central regulatory agencies, who should not impose uniform standards. Local variations in regulation are legitimate. Second, the regulatory agencies should facilitate negotiations between communities and development by supplying reliable information on water, energy, irrigation, emissions and effluents, and local environmental conditions, providing technical advice, and transferring experiences from other locations.

Rather than sticking to the conventional path all the time, some flexibility must be retained to learn lessons and build on from there. Pro-environment and pro-development objectives of a river basin have to be met in a dynamic situation where many things cannot be taken for granted and the process is transparent.

Sustainable water management

It is necessary to understand that 'sustainability' is primarily a process and then an objective. This involves:

- Better understanding of ecosystem, river basin management, digital surveys and planning
- Stronger local governance to address local issues, poverty and culture.
- Creating public-private partnerships and a financial/ business model at local levels.
- Moving away from goal oriented approach to process based approach.
- Increased capacity building, decentralization and better departmental co-ordination; decrease in top down methods.
- Increased stakeholder involvement across levels, disciplines and strata; decrease in experts only approach.

It is necessary to map the socio-cultural activities, festivals and cultural resources which are dependent upon the river. It is also essential to assess dependency of riparian communities on riverine resources and their perception towards river biodiversity and conservation. The local people should be helped to deter illegal construction, sand mining and fishing and learn about their river and its ecology.

Conclusions

Rivers have nurtured numerous civilizations through the ages and are part of India's history. The river is a vehicle for human emotions, elation and melancholy. This gives the river a symbolic motif in art or literature. The landscape of hills, cascading tributaries and rivers articulate a poetry of space and a celebration of the kinaesthetic and topographic abstraction of nature. A meandering river along the hills and forests manifests commonality and interdependence.

However, with the changing times, the rivers are seen more as the sources of economic growth and material needs. People are no more connected with the river. The river floodplain is becoming the ground for real estate development. This is inviting an ecological disaster. Indiscriminate damming of the river flow, water extraction and canalisation, dumping of solid and liquid wastes, sewage/wastewater and industrial effluent discharge in the rivers have seriously jeopardised their ecological sustainability.

Undeniably, a judicious integration of ecological, scientific research, digital planning and management is necessary to keep the urban rivers clean and flowing. This requires committed participation of the local communities. The cultural and traditional connect with water, as reflected in traditional water structures, and purification customs, can be potential social tools to involve the masses to conserve water resources and to prevent pollution of rivers.

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Rivers have nurtured numerous civilizations through the ages and are part of India's history. The river is a vehicle for human emotions, elation and melancholy

National security missions for the Australian DoD supported by Maxar

Maxar Technologies has delivered 3D data products and high-resolution satellite imagery to the Australian Department of Defence under recent multi-million-dollar contracts.

Maxar's 3D data suite enhances situational awareness and decision-making for military applications. The 3D data suite includes a 3D Surface Model, which provides a high-fidelity, positionally accurate and photorealistic view of terrain and surface features and textures. *www.maxar.com*

GIS-based portal to facilitate DDA's 2041 'master plan'

The Indian Institute of Technology, Roorkee (IIT-R) is preparing a 'web-available GIS large scale map' for the Delhi Development Authority (DDA). The map will help the DDA envisage their 2041 master plan for the national capital. The DDA has sanctioned a budget of Rs 7.5 crore for IIT-R to complete the project.

Earlier this month, the DDA gave its preliminary approval to the master plan draft for Delhi in 2041. *www.timesofindia.com*

Designing the future EU quantum internet

The European Commission has selected a consortium of companies and research institutes to study the design of the future European quantum communication network, EuroQCI (quantum communication infrastructure). It will enable ultra-secure communication between critical infrastructures and government institutions across the European Union.

The European consortium led by Airbus is composed of Leonardo, Orange, PwC France and Maghreb, Telespazio (a Leonardo and Thales 67/33 joint venture), the Consiglio Nazionale delle Ricerche (CNR) and the Istituto Nazionale di Ricerca Metrologica (INRiM).

The EuroQCI will integrate quantum technologies and systems into terrestrial fibre optic communication networks, and will include a space-based segment ensuring full coverage across the EU and other continents. Ultimately, this will enable secure Europe's encryption systems and critical infrastructures such as government institutions, air traffic control, healthcare facilities, banks and power grids against current and future cyber threats.

Since June 2019, 26 Member States have signed the EuroQCI Declaration, agreeing to work together with the Commission, supported by the European Space Agency, towards the development of a quantum communication infrastructure covering the whole EU.

The first service to make use of it will be quantum key distribution (QKD). The QKD service will transmit encryption keys through quantum communication channels on both terrestrial fibre optic and space laser links. Using quantum photon states makes key distribution immune to vulnerabilities unlike the current methods. *www.airbus.com*

Intermap and TATA Communications strategic agreement

Intermap has entered into a strategic agreement with TATA Communications. Intermap will initially support TATA's expansion of its 5G wireless telecommunications network in select Indian cities. Intermap's elevation data-as-a-service (EDaaS) solution for telecom network and real estate site planning increases the efficiency and reduces the cost of planning operations for companies that operate at country-wide or even global scale. *www.intermap.com*

Gauging survey and 'digital twin' of Scotland's Railway

Fugro has been awarded a contract to survey Scotland's entire rail network and provide Network Rail with a holistic gauging database that includes clearance data from the track to lineside structures, platforms, objects, and the train-to-train passing interface. The routewide gauging Geo-data will support the continued safe passage of trains operating on the network and facilitate the introduction of new rolling stock.

The project started at the end of April and will survey approximately 2750 route kilometres, spanning 93 different route sections and 638 station platforms. The use of Fugro's train-mounted RILA monitoring system will remove the need for surveyors to be on or near the track during data collection and thus deliver a clearly defined health and safety benefit. It will also afford unrivalled speed of survey data acquisition. *www.fugro.com*

Concept3D introduces new 360° Map

Concept3D have launched its latest product, 360° Map, which takes interactive mapping to the next level by creating true 3D models for significantly enhanced wayfinding, appearance and functionality. A major advancement from traditional 3D rendered maps which only allow the user to view a building or location from a single, fixed perspective, the structures, grounds, and even the trees in Concept3D's new 360° Map can be viewed from North, South, East and West, providing a realistic experience unlike any mapping system available. Concept3D launches 360° Map in collaboration with Indianapolis Motor Speedway, Hawaii Convention Center, and Baldwin Wallace University, demonstrating the potential of the new software for sporting arenas, major event and conference centers, higher education, and tourism. *www.concept3d.com*

Schneider Digital and DAT/EM Systems global partnership

DAT/EM Systems International and Schneider Digital have announced a global partnership agreement for the distribution of the latest 3D stereoscopic

vision technology from Schneider Digital to all DAT/EM customers around the globe. Under this cooperation from now on, DAT/EM partners worldwide can directly distribute to their clients the 3D PluraView stereo monitors and Schneider Digital Workstations as complete photogrammetric workplace solutions, for example in combination with the Summit Evolution Professional digital stereoplotter. *www.datem.com*

HERE and Bentley Systems partnership

HERE Technologies has announced the availability of a solution that makes it easier for US departments of transportation (DOTs) to conduct fixed asset management activities, plan capital investments, and deliver infrastructure performance assessments according to federal regulations.

HERE data sources, including HERE map, light detection and ranging (LiDAR) data, and street level imagery, are now accessible within Bentley Systems' Orbit, an on-premises application or cloud service for managing, analyzing and sharing reality meshes, extremely large point clouds, imagery, and traditional GIS data. Now, state and city DOTs can quickly build digital twins, which are highly accurate 3D representations of their physical realities, without the time and cost required to acquire the LiDAR and street-level imagery themselves. *www.bentley.com*

Secure on-orbit ethereum multisignature transaction services on the ISS

SpaceChain has announced that its blockchain-enabled payload has been launched into space from NASA's Kennedy Space Center aboard a SpaceX Falcon 9 rocket, and will be subsequently installed at the International Space Station (ISS). The mission, made possible by Nanoracks and its Space Act agreement with NASA, marks SpaceChain's fourth blockchain payload launch into space and the first demonstration of Ethereum technology integration into its hardware on ISS. Nexus Inc. (Nexus) will be the first SpaceChain customer to have direct access to this service.

The security and remoteness of space infrastructures ensures the independence of Ethereum contract operation from centralized terrestrial servers, hence providing more efficient smart contract operation and greater application scenarios. *www.spacechain.com*

Chooch AI integrates synthetic data generation

Chooch AI has announced artificial intelligence modelling using synthetic data generation. It generates synthetic data based both on CAD files and 2D images, and creates thousands of variations on annotated objects in images, changing angles, backgrounds, and obstructed views. With AI-augmented computer training, Chooch AI can create datasets and high accuracy AI models in minutes even with a limited number of images. *https://chooch.ai*

Point cloud modeling with BricsCAD

The software engineers at PointCab have introduced yet another Plugin to the market that facilitates point cloud modeling. Next to their existing Plugins for Revit and Archicad, PointCab has released their "4Brics Plugin" for the CAD Software BricsCAD. With the Plugin, users of PointCab's Origins software can now transfer all important 3D information from the point cloud to BricsCAD in real-time. *https://pointcab-software.com*

USGS releases nationwide marsh vulnerability maps

U.S. Geological Survey scientists have developed and made available a new mapping resource that can identify the most vulnerable marshes across the contiguous U.S. through a combination of remote-sensing and satellite technologies. These maps provide critical information to land managers and help inform marsh conservation and restoration strategies without costly site-specific or labor-intensive assessments.

The USGS has shown that marsh resilience can be evaluated by calculating the ratio of unvegetated area to vegetated area across an entire marsh system, covering marsh plains, channels, ponds and intertidal flats. The method, termed the UnVegetated-Vegetated marsh Ratio or UVVR. UVVR, uses data collected from 2014-2018 through remote sensing techniques, such as satellite imagery and aerial photography, to gauge how much of an individual marsh is open water and how much marsh plants cover it. By comparing the ratio of ponds, channels and tidal flats to marsh vegetation, land managers can determine which marshes stand the best chance of persisting in the face of changing conditions. *www.usgs.gov*

Scottish Forestry uses Bluesky aerial photomaps

Scottish Forestry is using specially commissioned aerial photography to help identify trees in distress. It awarded Bluesky a contract to capture almost 1,400 square kilometres of standard (RGB) aerial imagery together with colour infrared (CIR) photography following a competitive tender process. The data was captured during the summer of 2020 and delivered to Scottish Forestry ready for use in a range of desktop mapping and GIS software. *www.bluesky-world.com*

Australian Government establishes a freight data hub

Geoplex have developed a national interactive tool to help provide vital insights into Australia's freight system. The National Freight Data Hub (NFDH) will help industry, governments and researchers to better understand Australia's freight system, evaluate and plan for the future. The insights aim to help industry make more efficient decisions on movements, and even better understand the impact of traffic congestion on freight pricing. *www.novasystems.com*

IMCA publishes guidelines on the use of GNSS for tide calculations

The International Marine Contractors Association's (IMCA) newly published 'Guidelines on the use of GNSS for tide calculations' (IMCA S 027) provides an overview of how Global Navigation Satellite Systems (GNSS) can assist in more accurate real-time direct measurement of tidal changes.

As Nick Hough, IMCA's Technical Adviser – Offshore Survey explained:

"As with horizontal positioning, vertical positioning is referenced to specified datums. Unlike land surveying, where vertical measurements (elevations) are made to and from a known, fixed position, vertical measurements offshore (depths) are taken against a moving dynamic surface.

"All absolute depths recorded from survey activities need to be adjusted for tide and reduced to a known constant vertical datum such as Mean Sea Level (MSL) or Lowest Astronomical Tide (LAT). The effect of tides will result in depth differences at different times of the day, and at the same times on different days.

"Advances in GNSS technology enable accurate and consistent calculation of height above a known datum, which means reliance on tide gauges or tide prediction tables is no longer necessary."

IMCA S 027 includes sections on tide theory; geodetic reference systems and tidal datums; tides from GNSS; quality assurance and quality control; as well as a useful glossary, plus references and a list of further reading which includes the recently revised IMCA S 015 – 'Guidelines for GNSS positioning in the Oil and Gas industry' produced with IOGP. IMCA S 027 is available for members to download free of charge. *www.imca-int.com*

ESA signs contract for new generation of Galileo

ESA has signed two contracts for an overall amount of €1.47 billion, to design and build the first batch of the second generation of Europe's Galileo navigation satellites.

Following an intense process of open competition, these contracts have been awarded to Thales Alenia Space (Italy) and Airbus Defence & Space (Germany) to create two independent families of satellites amounting to 12 Galileo Second Generation satellites in total.

These Galileo Second Generation (G2) satellites will revolutionise the Galileo fleet, joining the 26 first generation Galileo satellites in orbit today plus the 12 'Batch 3' satellites currently in production and testing. The first launch of these Batch 3 satellites will take place later this year.

The new G2 satellites will be constructed in a short time scale with their first launch expected in less than four years, allowing them to commence operations in space as soon as possible. It will gradually join the existing constellation, but will be much larger than existing satellites. Using electric propulsion for the first time, and hosting an enhanced navigation antenna, their fully digital payloads are being designed to be easily reconfigured in orbit, enabling them to actively respond to the evolving needs of users with novel signals and services.

New on-board technologies include electric propulsion to propel the satellites from the orbit in which they will be launched to the final operational orbits, allowing two satellites to be launched at once despite their increased mass. Inter-satellite links between the satellites will let them routinely cross-check their performance and reduce their dependency on the availability of ground installations. *www.esa.int*

Thales Alenia Space and Telespazio win contract for Sicral 3

Thales Alenia Space, the joint venture between Thales (67%) and Leonardo (33%), and Telespazio, the joint venture between Leonardo (67%) and Thales (33%), have signed a contract with the Italian Ministry of Defense, represented by TELEDIFE / Secretariat General of Defense, for the development of the SICRAL 3 secure satellite communications system, including its ground segment. Covering the development of phases B and C1, the contract is worth a total of approximately €159 million, as result of an articulated and complete negotiation process.

The SICRAL (Italian System for Secure Communications and Alerts) program deploys geostationary satellites for confidential strategic and tactical communications, to support defense missions both in Italy and abroad. The new SICRAL 3 system is designed to meet Italian defense communications and interoperability requirements. *www.thalesgroup.com*

OxTS Georeferencer, version 1.4

OxTS has released the latest version of its LiDAR georeferencing software – OxTS Georeferencer 1.4. It makes the process of pairing a LiDAR sensor with an inertial navigation system (INS) to generate a georeferenced pointcloud easier for surveyors, streamlining the process while simultaneously improving results. OxTS Georeferencer fuses position, navigation and timing (PNT) data from an OxTS INS with raw LiDAR data to output highly accurate 3D pointclouds. The software uniquely makes use of navigation diagnostic data that provides surveyors with LiDAR point error estimation. *www.oxts.com*

Honeywell debuts new rate sensors for small satellites

Honeywell has unveiled a new rate sensor specifically intended to help small satellites navigate increasingly crowded

orbits above the Earth's surface. The new micro-electromechanical system (MEMS)-based product will provide lower cost and power consumption in a smaller size, all while maintaining high levels of performance.

A space rate sensor, also known as an inertial reference unit or IRU, is a type of inertial sensor that is composed of three gyroscopes that work together to sense rotation rates. They determine an aircraft or spacecraft's change in rotational attitude over time and allow it to move from one location to another without using any external information. It can also serve as a back-up solution to provide extra redundancy in case other navigation systems fail.

Celestial navigation options like star trackers are a popular method of obtaining pointing directions for satellites and spacecraft. This form of navigation uses angular measurements between objects in space (stars, planets, etc.) and the horizon to calculate location. However, sometimes these star trackers are blinded by the sun or affected by thruster gases. In this case, Honeywell's HG4934 can act as a secondary method of attitude determination. *aerospace.honeywell.com*

LiDAR-based adaptive perception software for smart cities

Cron AI and Innoviz Technologies have announced a new partnership to deliver an enhanced deep learning enabled perception solution for 3D point cloud data on the sensing edge. The collaboration between the two will accelerate the adoption of the InnovizOne LIDAR sensor and Cron AI's senseEDGE platform into the intelligent transport systems, V2X and smart city markets.

With mobility and vehicle electrification accelerating at a rapid pace to meet a greener transportation future, Cron AI and Innoviz's partnership aims to ensure that smart city, road and infrastructure operators also take a forward-looking and connected approach to delivering high-quality, real-time contextual data about objects that move and interact on roads, including vehicles, bicycles, pedestrians, and other road users. *www.cronai.ai*

Four spherical satellites into orbit in four years by Russia

Russia plans to launch four spherical satellites into orbit in 2025, for calibrating ground optical stations and serving other purposes for the Glonass navigation system. According to Russian space agency Roscosmos, Russia plans to launch the four satellites from the Vostochny spaceport using the Russian Soyuz-2.1b carrier rocket. Three Gonets-M communications satellites will be launched together with the four spherical satellites. *www.urdupoint.com*

CATALYST collaboration with AWS

CATALYST is collaborating with Amazon Web Services (AWS) to take satellite-based earth observation intelligence to the mainstream business community via AWS Cloud. The CATALYST-AWS collaboration will deliver actionable geoscience analytics to users with any level of technical expertise.

CATALYST's initial solution, available through AWS Data Exchange, is an infrastructure risk assessment service that uses satellite data to continuously monitor millimeter-level ground displacement over a subscriber's area of interest anywhere on Earth. It is exploring additional risk mitigation solutions and monitoring services using AWS. *https://catalyst.earth*

First floating lidar survey in Vietnam

Enterprize Energy commissioned geo-data specialist Fugro and local partner PetroVietnam Technical Services Corporation (PTSE) to install the first floating LiDAR survey technology in Vietnamese waters at the site of the 3.4GW Thang Long offshore windfarm. This is the first time such technology has been used in Vietnam. This announcement for the installation of floating LiDAR marks the next step in the surveying process for Thang Long, the only large-scale offshore wind farm to be granted a survey license by the Vietnamese government. To date, a full year of wind data measurements has been collected via fixed LiDAR to assess resource over the allocated area, with reconnaissance surveys to support the project team's understanding of geological and seabed features occurring earlier this year. Based on initial results, Enterprize Energy has confirmed there will be no reduction in prospective area due to unsuitable seabed features such as basalt intrusions. *https://enterprizeenergy.com*

UP42 announces Copernicus Masters Challenge

UP42 has announced the UP42 Airbus Challenge in the 2021 Copernicus Masters Competition. With EUR 100,000 in awards at stake, including commercial satellite data from the Airbus OneAtlas Living Library, UP42 seeks researchers, companies, and students to submit algorithm development ideas to provide new ways of performing EO analytics.

Copernicus Masters is an international competition held annually to foster innovative applications of EO data that address the world's most compelling environmental, social, and business problems. In 2021, UP42 joins other leading geospatial organizations such as the European Space Agency (ESA), European Commission, and German Aerospace Center (DLR) in devising 10 Challenges spanning the full spectrum of EO applications.

The UP42 Challenge calls on participants to propose algorithms that advance EO analytics by using Generative Adversarial Networks (GANs) to augment satellite imagery. GANs are an advancement in deep learning technology to generate realistic synthetic data to supplement existing data sets.

The deadline for idea submissions is July 19, 2021. UP42 and Airbus experts will select five finalists to move on to the evaluation and live pitch phase based on scientific merit, business value, quality of implementation, and ecological impact. One Challenge winner will be chosen from the five finalists.*https://copernicus-masters.com*

Real-time, location-based innovation for TCS DigiFleet

HERE Technologies has partnered with Tata Consultancy Services(TCS) to bring real-time location-based services and analytics to its IoT-enabled SaaS suite, TCS DigiFleet, which leverages IoT, AI, and machine learning to address global logistics challenges. Powered by the HERE location platform, the enhanced fleet and freight management solution will enable TCS to provide its customers with up-to-date map visualization, historic and real-time route optimization, robust geocoding and provide end-to-end supply chain visibility. Other key capabilities of the enhanced solution include navigation, route assistance, vehicle health management for automotive fleets and last mile delivery for enterprises across the global supply chain, and the e-commerce sector.

TCS DigiFleet uses the power of IoT, AI, and machine learning to solve fleet management challenges. A network of IoT devices helps to establish end-to-end connectivity across the fleet and related assets such as warehouses. It leverages AI and ML to analyze data and recommend the best routes, load composition, and maintenance measures. *www.here.com*

Test solution for UWB device localization

Rohde & Schwarz and Colby Instruments have joined forces to provide the UWB ecosystem with an extremely accurate test solution for angle of arrival (AoA) and phase difference of arrival (PDoA)characterization.

Engineers testing UWB devices now can combine the R&S CMP200 radio communication tester and WMT software service to implement automated wireless manufacturing testing from Rohde & Schwarz with the high-precision delay lines XT-200 from Colby Instruments to perform measurements in conducted mode including calibration and verification. In UWB technology, the distance between two devices is calculated by accurately measuring the time a UWB signal needs to travel from a transmitter to a receiver (time of flight). By measuring the time or phase difference of a signal received at both UWB receive antennas, it is possible to calculate the angle of arrival. The delay lines let users characterize the DUT with a delay range from 0 to 625 ps and a resolution of 0.50 ps, making it possible to simulate even granular angles and distances. The R&S CMP200 combines the capabilities of a signal analyzer and generator in a single instrument and offers a complete solution for transmitter and receiver measurements in conducted and radiated environments. *www.rohde-schwarz.com*

Pilot safety framework for off-highway autonomous vehicle deployment

Oxbotica and TRL have piloted the use of the first Code of Practice for the safe and cost-effective deployment of autonomous vehicles in unstructured off-highway environments, with a live trial conducted in a quarry using a number of off-road vehicles. The Innovate UK-funded consortium has developed and demonstrated capabilities to adapt and retrofit autonomy, using robust low-cost sensors, to any vehicle, as well as drafting a Code of Practice that identifies the key elements for safe and efficient deployment of autonomous vehicles in off-road industries.

To demonstrate the Code Of Practice and highlight its potential to work across a range of vehicles and industries, Oxbotica and TRL deployed a Ford Ranger and Range Rover Evoque, retrofitted with Oxbotica's autonomy software platform, in a UK quarry in April 2021. The vehicles were fitted with a full suite of sensors, including LiDAR, RADAR, and stereo cameras. *www.oxbotica.com*

Next stage of autonomous vehicle trials on public roads

Project Endeavour – a Government-backed mobility research project – is the UK's first multi-city demonstration of autonomous vehicle services and capability. The Birmingham trials follow a successful deployment in Oxford and the project will culminate with a final demonstration at a showcase event in Greenwich in August 2021.

The Project Endeavour trial will feature four Ford Mondeo vehicles fitted with LiDAR, radar and stereo cameras and integrated with Oxbotica's autonomy software platform. The fleet, capable of Level 4 autonomous driving, will operate in a five mile area around Lea Hall station, between Birmingham International Airport and the city center. During the trials, a professionally-trained safety driver will be in the vehicle, capable of resuming control if necessary.

Trials will run throughout the day for several weeks, allowing Oxbotica's autonomous vehicles to experience a range of traffic scenarios and weather conditions. The routes include roundabouts, traffic lights, and junctions in both industrial and residential areas – all providing their own individual scenarios and challenges for the autonomous vehicles to demonstrate capability.

Launched in March 2019, the consortium project, part-funded by the Centre for Connected and Autonomous Vehicles (CCAV) and delivered in partnership with Innovate UK, is being led by Oxbotica, in collaboration with DG Cities, Immense, TRL, BSI, and Oxfordshire County Council. *www.projectendeavour.uk*

Amazon Location Service is now available

Amazon Web Services, Inc. (AWS has announced the general availability of Amazon Location Service, a new service that makes it easier and more cost-effective for customers to add location functionality to their applications without compromising on user privacy or data security.

With Amazon Location Service, customers can embed location functionality in their applications using data from location-based service (LBS) providers Esri and HERE *https://aws.amazon.com*

'Giant Step for Urban Drone Environments'

The Hera Drone Hub has announced Altitude Angel, UTM (unified traffic management, or U-Space) technology provider, is to provide UTM through its GuardianUTM Enterprise platform to the world's first urban test centre in a CTR.

Spanish city of Zaragoza have become the first European city to authorise drone testing and drone pilot training in the Control Zone (CTR) of an airport region within an urban airspace. The test environment, which will allow operators and pilots to train with drones of up to 500kg in weight, is made up of two TSAs within the Zaragoza CTR which are approx. 2.5 kilometers (1.55 miles) apart. The River Ebro, which cuts through the city, provides a natural corridor over which drones can operate between the two TSAs.

GuardianUTM Enterprise is an intuitive, cost-effective U-Space platform which was initially developed to support regional and local airports manage drone operations within their managed airspace. Its deployment at the Hera Drone Hub will be its first in a city environment. *www.altitudeangel.com*

Pegasus Imagery, Kongsberg Geospatial Sign MOU

Kongsberg Geospatial, and Pegasus Imagery Ltd. have recently signed an MOU to work together to advance the development of safe, autonomous Unmanned Aircraft.

Pegasus designs, manufactures and operates autonomous Unmanned Aerial Systems (UAS) to deliver Intelligence Surveillance Reconnaissance (ISR) solutions at scale for industry and government. It will be implementing Kongsberg Geospatial's IRIS UxS airspace situational awareness system as a navigational system for their Beyond Visual Line-of-Sight flight operations, and as part of their PV-02 Eos autonomous aircraft system. *https://kongsberggeospatial.com*

Drone deliveries of medical supplies in Telengana

Flipkart, India's homegrown e-commerce marketplace, has announced its partnership with the Telangana government to lead a consortium tasked with the development and execution of the drone deliveries of medical supplies to remote areas under the 'Medicines from the Sky' project.

These efforts will be complemented with technologies such as geo mapping, routing of shipments and track and trace of location etc., developed by Flipkart over the years. A combination of these technologies will then be used to conduct Beyond Visual Line of Sight (BVLOS) deliveries in remote areas of the state where the road infrastructure is not conducive for fast delivery of vaccines. https://www.thenewsminute.com/article/flipkart-partners-telangana-govt-drone-deliveries-medical-supplies-150550

Delivery of COVID-19 vaccines to remote areas by drones in India

The government of India has invited bids for the use of drones to deliver COVID-19 vaccines and drugs to remote and difficult-to-reach areas to ensure last-mile coverage in select locations of the country.

The Indian Council of Medical Research (ICMR) conducted a successful feasibility study in collaboration with the Indian Institute of Technology (IIT), Kanpur and has developed a standard protocol for the delivery of vaccines using Unmanned Aerial Vehicles (UAV), according to the bid document.

On behalf of the ICMR, the HLL Infra Tech Services Limited (Procurement Support Agency) has invited expression of interest (EOI) through the Central Public Procurement Portal from experienced Indian agencies for the delivery of medical supplies (vaccines/drugs) by UAVs.

According to the tender criteria, the ICMR shall engage UAV operators who are able to conduct beyond visual line of sight (BVLOS) operations in fixed pre-defined flight paths, deliver medical supplies payload at select locations in India and return to the command station.

According to the specifications, UAVs should be able to cover a minimum aerial distance of 35 km, able to take off vertically and carry a minimum payload of 4 kg and should be capable of returning to command station after delivering the payload. *www.thehindu.com*

Airpeak S1 professional drone

Sony Electronics Inc. has announced their first-ever professional drone, the "Airpeak S1"i. It is the world's smallestii drone that can be equipped with a full-size mirrorless interchangeable-lens Alpha camera, opening up a new world of creative possibilities. The new drone utilizes a proprietary motor, propeller, control system and sensing technology, allowing it to fly at extremely high speeds with very stable wind resistance. It also features an advanced remote controller that can support the production of high-quality aerial images and freely control the aircraft. It also includes obstacle detection, automatic flight control via sensing and increased safety via cloud management of the aircraft and flight information. *https://electronics.sony.com*

Intelligent Drone Deliveries in the US

Drone Express has partnered with FarEye, an Intelligent Delivery Management Platform, to power autonomous drone deliveries for leading retailers in the United States.

Drone Express operates as a logistics company, working with companies to strategically introduce drone package delivery into their supply chains and service offerings. FarEye provides Intelligent Delivery Orchestration solutions helping retail enterprises provide new delivery experiences. End-to-end visibility is achieved by optimizing routes resulting in a positive customer experience. *https://droneexpress.ai*

Intermap integrates NEXTView with IDRONECT UTM for Africa

Intermap Technologies has announced the successful integration of its NEXTView platform with Aviatize's IDRONECT UTM to support a medical delivery pilot project in Africa. Developed in partnership with Lufthansa Systems, this is the second strategic deployment for NEXTView in Africa. Aviatize's IDRONECT UTM (Unmanned Traffic Management system) will be the control hub for drones to fly beyond visual line of sight (BVLOS) when delivering medicine to remote locations. *www.intermap.com*

ResponDrone adds 3D mapping abilities

The international ResponDrone project has integrated into its situation awareness system for emergency situations a near real-time 3D mapping solution to provide on-site emergency teams with tools that will help them to better evaluate their working environment. The upgraded ResponDrone System will provide accurate location information to first responders, especially in relation to infrastructure, when called on to deal with a fire, flood or any other natural disaster. It has signed an agreement with Hivemapper to integrate its latest crowdsourced mapping technology. It can now fly a mission over an area, process the collected data and turn it into an up-to-date 3D map. *https://respondroneproject.com*

Terra Drone conducts flare stack inspection

Terra Drone has successfully conducted visual inspection of flare stacks for Chile's state-owned energy company ENAP. In this project, three flare stacks – each about 70m tall – were inspected in 45 minutes using drones. This proved to be significantly more cost-effective and quicker, than the conventional method, of engaging the services of a professional photographer, in a manned helicopter. Terra Drone used a DJI M210 RTK drone mounted with 2 cameras – a Zenmuse Z30 (zoom camera) and a Zenmuse X5S (high-resolution camera) – for this activity. *https://terra-drone.eu*

Eos Positioning Systems announces the Eos Bridge

Eos Positioning Systems have released a new product called the Eos Bridge™. The Eos Bridge™ enables almost any instrument to become iOS Bluetooth compatible. It is a small, pocket-sized device that connects to instruments via Bluetooth Classic or serial port, and transmits data from them to any Apple iOS device, such as iPhone or iPad, Android device or Windows mobile device.

The Eos Bridge™ is lightweight, at approximately 150 grams (about 5.3 ounces). It can be worn inconspicuously by being clipped to a belt, stored in a pocket, or mounted to an instrument or sensor. Its battery lasts 48 to 72 hours. *www.eos-gnss.com*

GMV to Upgrade the GSSAC Mission System

GMV has been awarded by a new contract by the German Space Agency at DLR for maintenance and upgrade of the Mission System of the German Space Situational Awareness Centre (GSSAC), located in Uedem, Germany. This new project is part of data processing activities within EU SST under German Space Agency's responsibility. *www.gmv.com*

Sonardyne and SeeByte advance UMS navigation and autonomy in challenging environments

Sonardyne and uncrewed maritime systems (UMS) software experts SeeByte have been awarded UK Defence Science and Technology Laboratory (Dstl) funding to enhance and extend the future operational capability of autonomous and remotely operated systems in challenging battlespace domains.

As part of the project, Sonardyne and SeeByte will be using surface and underwater assets from Project Wilton, a recently formed maritime autonomous systems (MAS) team based out of HM Naval Base Clyde. The collaboration will culminate in a series of in-water demonstrations at Project Wilton facilities in the UK.

This project will enable optimal uncrewed underwater vehicle (UUV) distribution for improved subsea communications and navigation in a range of challenging environments. *www.sonardyne.com*

Automotive GNSS positioning module for ADAS and autonomy by NovAtel

NovAtel has introduced the PIM222A, part of a new family of automotive GNSS positioning products for advanced driver assistance systems (ADAS) and autonomy.

Built with automotive-qualified hardware in a package that is easy to integrate, the PIM222A leverages SPAN technology from NovAtel to provide accurate position data in urban environments that challenge GNSS availability. Deeply-coupled GNSS receivers and inertial measurement units (IMUs) ensure continuous availability of position, velocity and attitude, even when satellite signals are briefly blocked.

The PIM222A, which was created in collaboration with STMicroelectronics, is a lightweight, power-efficient, solder-down module that maximizes flexibility for integration. The receiver design can be applied to low-, medium- and high-production volumes while retaining a rich array of features, including options such as

multi-frequency, multi-constellation, RTK and dual-antenna precision. *NovAtel.com*

Tractive raises $35 Million!

Tractive has closed $35 million in growth funding led by Guidepost Growth Equity. The investment will accelerate innovation and adoption of the company's industry-leading pet tracking device, which currently serves over 400,000 active subscribers across 175 countries. Tractive announced significant improvements to the battery life of its latest generation GPS tracker for dogs and cats. With new software that leverages an owner's WiFi to reduce unnecessary battery strain when pets are at home, Tractive has extended battery life by 5x. *www.tractive.com.*

TRX Systems delivers dismount NAVWAR threat mapping

TRX Systems has announced the delivery of the TRX Systems Dismount Electronic Warfare (EW) Kit, developed as a U.S. Army Rapid Capabilities and Critical Technologies Office (RCCTO) prototype to extend Electronic Warfare (EW) and Signal Intelligence (SIGINT) for the dismounted warfighter. The TRX EW Kit adds powerful new capabilities to the company's NEON Personnel Tracker-MIL solution, expanding the integration between the NEON Location Service and the ATAK application to better equip dismount personnel for detection and mapping of jamming and spoofing attacks. *www.trxsystems.com*

GMV at the core of the GALILEO high accuracy service

GMV has been awarded by the European Union Agency for the Space Programme (EUSPA) with the contract for the implementation of the Galileo High Accuracy Data Generator (HADG), which will be the facility in charge of generating the high-accuracy corrections data to enable the provision of the Galileo High Accuracy Initial Service (HAS).

The purpose of the HADG is to ensure the continuous provision of HAS data with a proper rate, accuracy, availability, continuity and latency. The data will encompass orbit and clock corrections, biases, quality indicators and service parameters. *www.gmv.com*

Iridium makes strategic investment in DDK Positioning

Iridium Communications Inc. has made a strategic investment in DDK Positioning (DDK), an Aberdeen, Scotland based provider of enhanced Global Navigation Satellite System (GNSS) accuracy solutions. DDK uses the Iridium® network to provide global precision positioning services that can augment GNSS constellations, including GPS and Galileo, to significantly enhance their accuracy for critical industrial applications. It is also developing similar services for other GNSS constellations, such as GLONASS and Beidou. Standard positioning accuracy through a system like GPS is typically within 10 meters; however, by using the Iridium network, DDK's enhanced GPS accuracy service brings incredibly precise positioning of five centimeters or less. *www.iridium.com*

Trimble and Infotech to streamline inspection measurement workflows

Trimble has announced that Infotech is adding high-accuracy positioning and measurement capabilities to its Mobile Inspector Measure Service application through an integration with Trimble AccessTM field software. Infotech provides field staff with simple, yet powerful and configurable, mobile apps to manage data collection and inspection activities for digital delivery of civil infrastructure including Federal and State Department of Transportation (DOT) projects. *www.trimble.com*

Vegetation management solution by Trimble

Trimble has announced a new solution that helps utilities better manage the risk posed by vegetation-related outages—Trimble® Vegetation Manager. The modular software provides an end-to-end solution for driving down utility vegetation management operating expenses and improving safety, regulatory compliance, performance and reliability of electric transmission and distribution infrastructure. According to the US Federal Energy Regulatory Commission (FERC), the single largest cause of electric power outages occurs when trees grow or fall into overhead power lines. In addition, tree and power line conflicts have also caused significant wildland fires in both the US and Canada. *www.trimble.com*

Trimble expands its geospatial automated monitoring portfolio

Trimble has announced the addition of a geotechnical portfolio to its geospatial automated monitoring portfolio through a collaboration with Worldsensing, a wireless connectivity technology provider and an industry-leading manufacturer of geotechnical IoT monitoring systems. The collaboration enables survey, geotechnical and structural engineers to seamlessly expand their monitoring business opportunities with a comprehensive solution that incorporates geotechnical and geospatial data. *www.trimble.com*

HxGN Mass Transit to improve public transportation operations

Hexagon's Safety, Infrastructure & Geospatial division introduced HxGN Mass Transit, a geospatial transportation infrastructure management system with 3D and AI capabilities. It serves as a single source of truth for infrastructure data, enabling rail-bound and transit operators to easily inspect, validate and share information on the fly.

HxGN Mass Transit combines asset and spatial data from various business systems into an integrated system, allowing operators to visualize and analyze their entire network and services. Additionally, it reduces data duplication, provides access to accurate and up-to-date information and delivers greater efficiency for managing data, workflows and transit networks and operations. *hexagon.com*

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DeepMap announces RoadMemory

DeepMap, Inc., has announced DeepMap RoadMemory™, a crowdsourced mapping service, which enables automakers to accelerate the creation and deployment of large-scale digital maps via data collected from their own fleets of passenger vehicles and trucks. It is designed to expand geographic coverage more quickly and support hands-off autonomous driving features everywhere.

RoadMemory will automatically build maps using crowdsourced data collected from on-car sensors such as cameras, radars, and newly-available automotive-grade LiDARs. It is sensor-agnostic, providing a high degree of flexibility to automakers who require an open system and a choice of sensors to meet their needs. *www.deepmap.ai*

Esri releases new 2020 global land cover map

Esri is releasing for the first time ever a new high-resolution, 2020 global land cover map as part of the company's Living Atlas. The map was built using European Space Agency (ESA) Sentinel-2 satellite imagery, and developed using a new machine learning workflow teaming with new Esri Silver Partner Impact Observatory, as well as long-time partner Microsoft.

The new map will be updated annually supporting change detection and highlighting planetary land changes, especially related to the effects of human activity. A consistent map of land cover for the entire world based on the most current satellite information, the 2020 Global Land Cover Map can be combined with other data layers for green infrastructure, sustainability projects, and other conservation efforts that require a holistic picture of both the human and natural footprint on the planet. Later this year, Esri and Impact Observatory will make this new land cover model available to support on-demand land cover classification, allowing the GIS community to create maps for project areas as often as every week. *www.esri.com*

Innovyze introduces Dynamic Digital Twins

Innovyze has announced the general availability of its cloud-based, AI-powered platform for real-world water lifecycle management, Info360. Combined with Info360 Insight, a data visualization and workflow solution, the first-of-its-kind platform enables Dynamic Digital Twins for the water industry.

Dynamic Digital Twins are virtual models of real-world assets and systems that can learn and adapt to changing circumstances. Built upon Amazon Web Services (AWS), Info360 is uniquely designed to support Dynamic Digital Twins by gathering and unifying asset information, connecting live and historic performance data to Innovyze as well as third-party applications. *www.innovyze.com*

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July 2021

Smart Geo Expo 2021
21-23 July,
Seoul, S. Korea
https://smartgeoexpo.kr

September 2021

Commercial UAV Expo Americas
7-9, September
Las Vegas USA
www.expouav.com

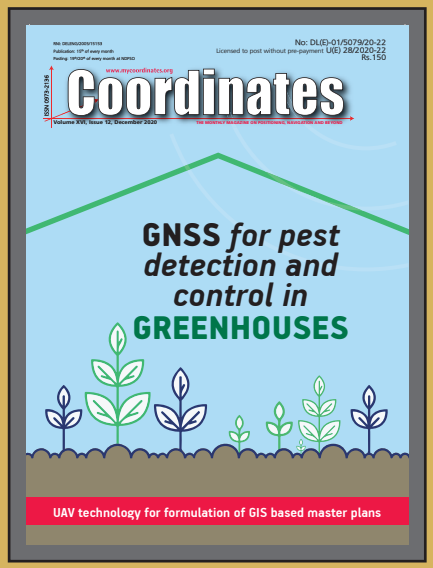
ION GNSS+ 2021
20-224 September
St. Louis, Missouri, USA
www.ion.org/gnss/index.cfm

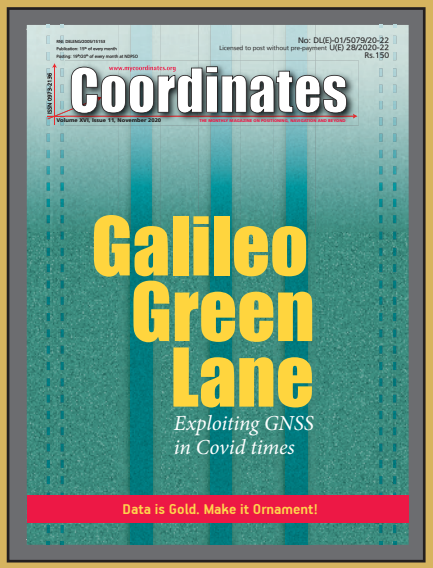
Mapping The Future Of Land Administration & CSDILA's 20 Years Celebration Event
20-23 September, 2021
Melbourne, Australia
https://www.csdila20-fig.org

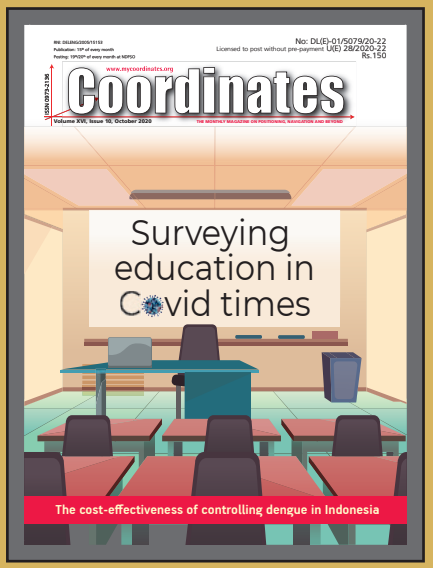
November 2021

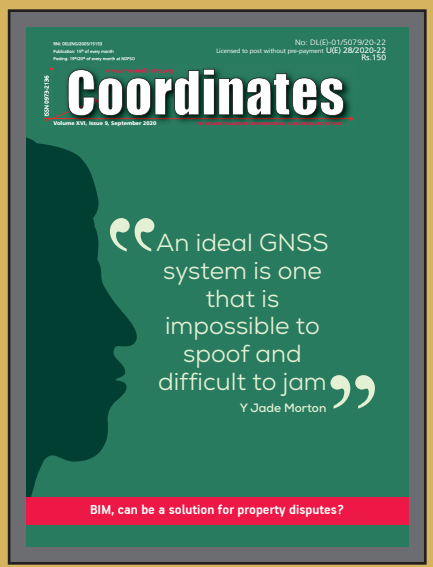
Digital Construction Week
24-25, November
London, UK
www.digitalconstructionweek.com

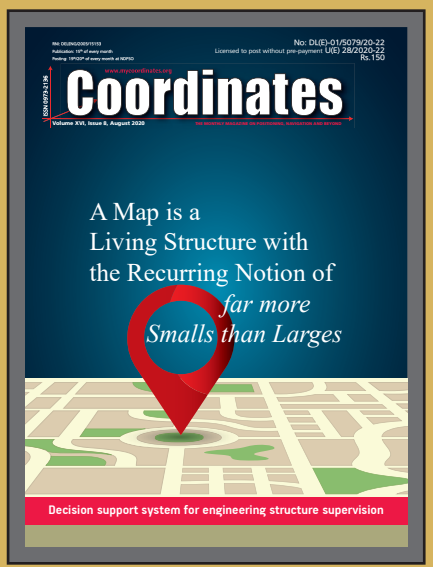
GEO Business
24-25 November
London, UK
www.geobusinessshow.com

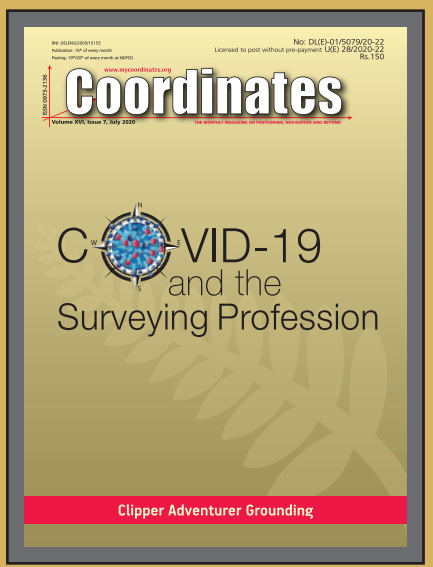


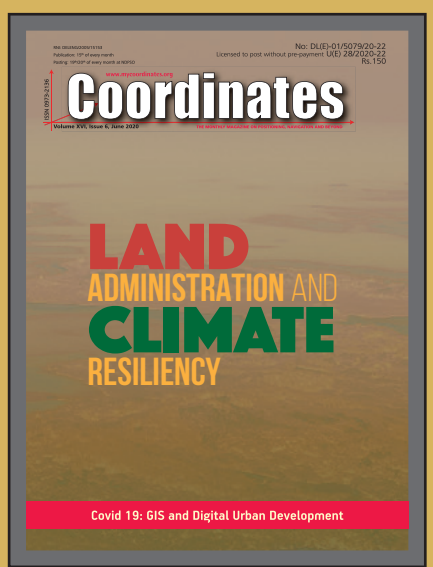


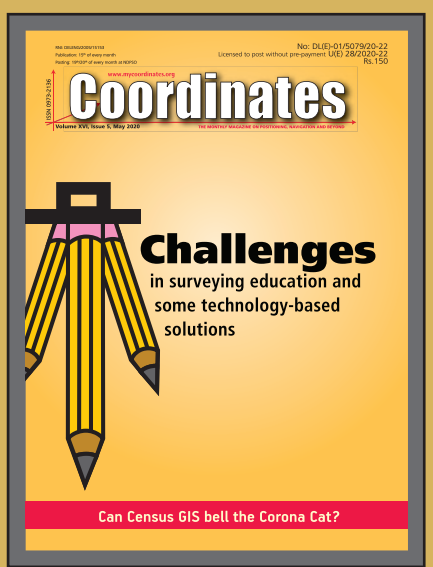












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