RNI: DELENG/2005/15153
Publication: 23rd of every month
Posting: 27th/28th of every month at DPSO

No: DL(E)-01/5079/2023-25
Licensed to post without pre-payment U(E) 28/2023-25
Rs.150

ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume XX, Issue 4, April 2024

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

The problem of

disruptions will never be solved, but it can be much better managed

Standards, challenges and prospects of geomatics education in Sri Lanka

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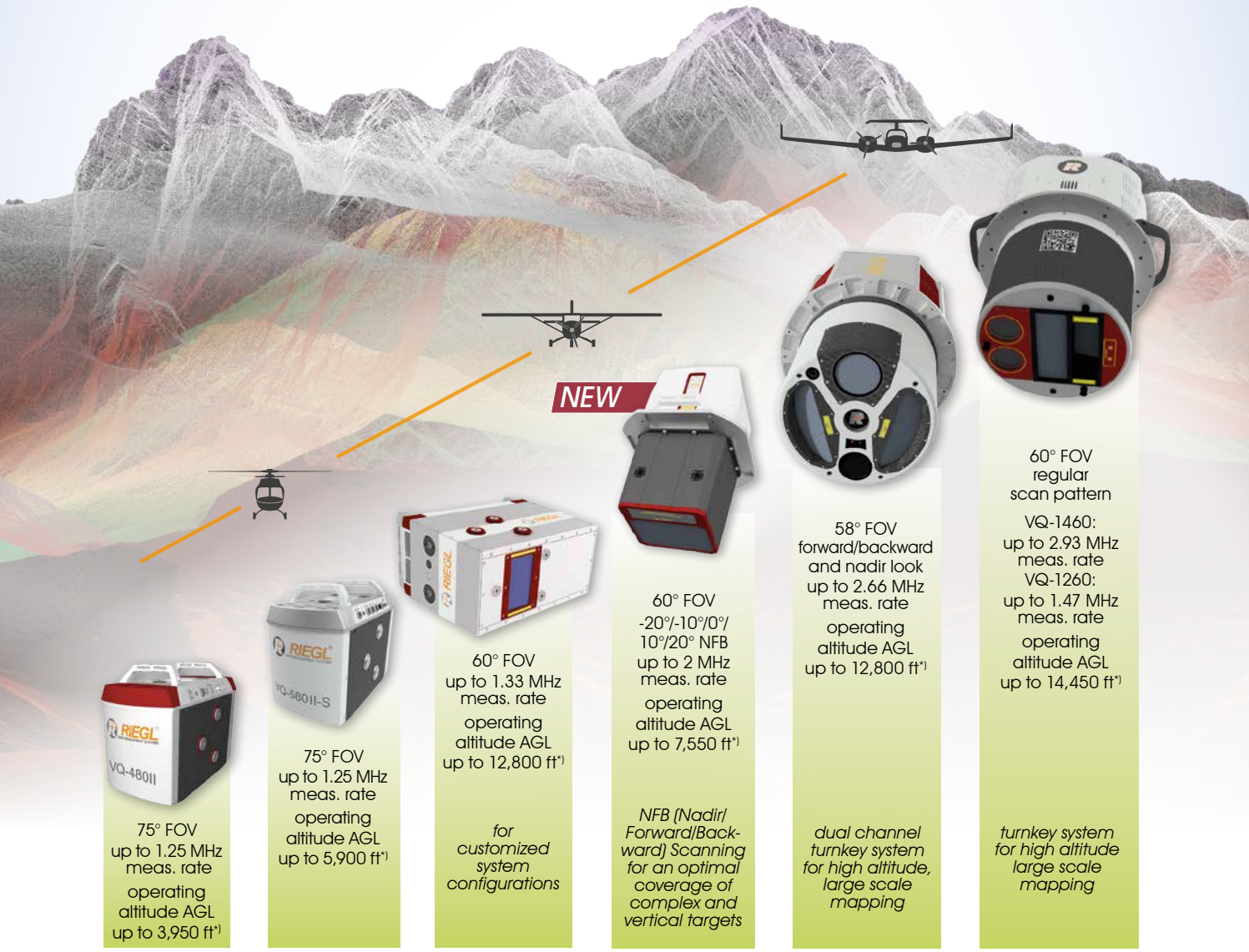

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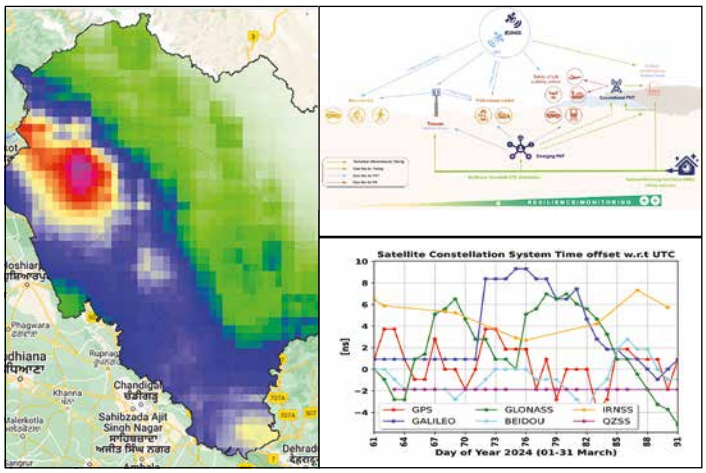


In this issue

Coordinates Volume 20, Issue 4, April 2024

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies
Beatrice Motella, Dana A. Goward, H. M. I. Prasanna, Joaquim Fortuny-Guasch, Lukasz Bonenberg, M. D. E. K. Gunathilaka, Matteo Paonni, Narayan Dhital, Satish Kumar Negi and Shashi Shekhar; Riegl, SBG System, and many others.

Mailing Address
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
Phones +91 11 42153861, 98102 33422, 98107 24567

Email
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
[subscriptions] iwant@mycoordinates.org
Web www.mycoordinates.org

Annual subscription (12 issues)
[India] Rs.1,800* [Overseas] US$100*
*Excluding postage and handling charges

Printed and published by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
Published at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.
Printed at Thomson Press (India) Ltd, Mathura Road, Faridabad, India

Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)

This issue of Coordinates is of 36 pages, including cover.

Deluge in the desert

The recent spell of downpour,

Of more than the annual rainfall in 24 hours,

In South West Asia during April 14-16,

Battered the Dubai city,

Triggered flash floods across northern Oman,

Affected many other countries in the region.

With several reported fatalities,

And significant damages to local infrastructure, buildings and agriculture,

The intensities of such extreme weather events,

Are likely to be amplified by human induced climate change.

And the concerns for climate change,

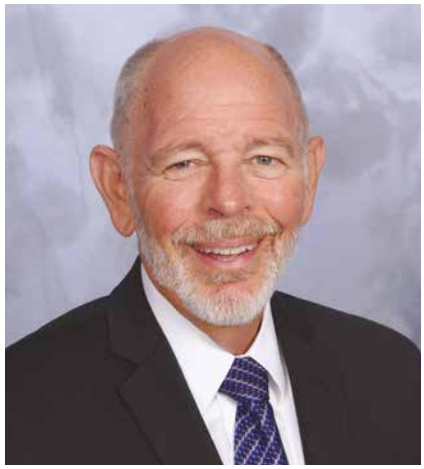
Need immediate actions,

For our own survival

Bal Krishna, Editor
bal@mycoordinates.org

"The problem of GNSS disruptions will never be solved, but it can be much better managed"

Says Dana A. Goward, President, Resilient Navigation & Timing Foundation in an interview with Coordinates



Dana A. Goward

Tell us briefly about the mission and objectives of Resilient Navigation and Timing Foundation.

The foundation advocates for policies and systems to protect GNSS satellites, signals and users. We are a chartered scientific and educational charity. As such we have no interest in any commercial products or services and do our best to focus on benefits to the public.

Would you like to comment on GPS III and also on other existing and upcoming systems?

GPS is a great system and supports an uncountable number of technologies and applications. It is no wonder the U.S. government is so committed to maintaining and continually improving it for decades to come.

With four global navigation satellite systems (GNSS) that are interoperable, users have access to a lot of L-band signa ls from MEO. I think that is why many folks are looking to the future of space-based PNT as being in LEO and/or GEO, and perhaps using additional frequencies.

Terrestrial systems are also interesting. There are a wide variety of solutions for different applications. Some can be deployed across, even continental sized, areas.

And then there are autonomous systems that have the promise of determining location without external signals. Artificial intelligence will likely accelerate development of these.

The key going forward is combining all of these in a resilient architecture to ensure users always have the information they need.

With increasing dependence on GNSS, how do you perceive PNT vulnerability?

GPS and other GNSS are great. They provide highly precise and accurate signals to any receiver with a view of the sky, free of charge to the user. But no system or set of systems is perfect. I am sure most of your readers already know that GNSS signals are very weak and can be easily denied or imitated. And that both accidental and malicious interference happens all the time.

Should users be concerned? It depends.

If they are using GNSS-based PNT for their fitness watch or to find their way to someplace they have already been many times, probably not so much.

But if they are using solely GNSS for mission critical or safety of life applications, they should be concerned. They should plan what they will do in a GNSS-denied or compromised situation.

Using multiple GNSS is generally better than using just one. But to significantly reduce their PNT vulnerability users must integrate non-GNSS PNT sources in their solutions

I am reminded of my grandmother's caution "Don't put all your eggs in the same basket!"

As the world is of multi-GNSS, don't you think it is better equipped to deal with the PNT vulnerability issues?

Users receiving multiple GNSS are, of course, less vulnerable than those using just one. Yet all GNSS share many of the same vulnerabilities.

They are all in the same general frequency band. Most jammers interfere with the entire band and deny reception of all GNSS. – In fact, I understand it is more difficult and expensive to build a jammer that interferes with only one system.

And the specifications for all GNSS signals are public knowledge so they are all fairly easy to compromise or spoof. - In 2018 a pair of researchers published a paper outlining how they built a device with about $400 in parts that spoofed all four GNSS at the same time.

And of course, all GNSS are in space and subject to the same threats from debris, solar activity, and attack by adversaries' militaries.

Using multiple GNSS is generally better than using just one. But to significantly reduce their PNT vulnerability users must integrate non-GNSS PNT sources in their solutions.

What is your take on the recent warning issued by the FAA dated Jan 25, 2024 recognizing and mitigating GPS/GNSS disruptions? Why it is so significant?

The FAA had issued warnings before, but I think this most recent is the most adamant and detailed so far. It was a significant step in the U.S. government's formal recognition that disruptions are really getting to be a problem, especially in aviation.

The warning includes an impressive list of systems that can be impacted, including inertial systems that are supposed to "backup" GNSS-based navigation.

It is a good reminder about over-dependence on GNSS, and the importance of properly integrating alternative systems.

Do you think that there is enough awareness regarding the GNSS vulnerability? What policy initiatives do you think should be taken by the governments?

There is definitely NOT enough awareness of GNSS vulnerability, despite all the evidence we see every day in the Baltic, Ukraine, and Middle East.

If policy makers were sufficiently aware of the vulnerabilities and the risks posed, every nation would be implementing a plan to ensure they had a resilient national PNT infrastructure. One that included multiple diverse methods of delivering secure and authenticated PNT for all their applications and citizens.

Affordable, wide-area terrestrial solutions give every nation the ability to have their own, sovereign PNT capability, while still using and cooperating with multiple GNSS.

So, it isn't a matter of technology or cost. It is a matter of decision makers not appreciating the need for action.

What has to be done technologically to handle these disruptions?

The problem of GNSS disruptions will never be solved, but it can be much better managed. The key is to make it more difficult to disrupt GNSS, and ensure users have alternatives when it is disrupted. This will make GNSS use safer by discouraging malicious interference. And it will make users safer by ensuring they can safely weather disruptions.

The presidential advisory board I am a member of advocates a holistic approach of Protect, Toughen, and Augment.

"Protect" means doing things to prevent interference, with GNSS signals, detect it when it occurs, and end the interference as quickly as possible. This requires the right laws and regulations, interference detection systems, and the ability to physically ensure an interfering signal is terminated.

If policy makers were sufficiently aware of the vulnerabilities and the risks posed, every nation would be implementing a plan to ensure they had a resilient national PNT infrastructure

"Toughen" is making receivers more robust with hardware and software that resist interference.

And "Augment" is ensuring users are able to access alternative PNT services when needed.

What's your opinion on GNSS back-ups? Its pros and cons. How have different countries responded to its adoption and deployment?

Before discussing individual GNSS augmenting, complementary, or alternative systems, nations must resolve to focus on users.

Putting users first should result in a nation establishing a national resilient PNT architecture. One that leverages all the benefits of GNSS and includes other diverse methods of PNT delivery that can be easily accessed by as many users as possible.

Several nations are in the process of combining GNSS with space-based augmentation, terrestrial transmissions, and fiber and clock networks to ensure users always have needed PNT. Some leaders in this are China, South Korea, and the United Kingdom.

With GNSS becoming almost ubiquitous, what technology trends do you envision and innovative applications you anticipate around it in near future?

GNSS as a foundational technology has massively increased our appreciation of the importance of accurately knowing "where" and "when" with a high degree of precision.

The biggest improvements in GNSS use in the near term will likely be integrating it with other systems and sensors to make users safer and more resilient.

How do you think the GNSS positioning technology can leverage alternative positioning technologies like cell phones, A-GPS, Bluetooth, WiFi, etc?

GNSS technology is amazing. But we are often so fascinated by the technology that we lose sight of the user. Combining GNSS with other technologies to create resilient national PNT architectures is the next essential step in the evolution of GNSS.

Would you like to comment on autonomous navigation?

Navigation without external signals has a lot of promise. Magnetometers, LIDAR, gravimetrics, cameras, highly accurate maps, quantum sensors and the like could be intelligently integrated and produce highly reliable and accurate location information.

GNSS technology is amazing. But we are often so fascinated by the technology that we lose sight of the user. Combining GNSS with other technologies to create resilient national PNT architectures is the next essential step in the evolution of GNSS

But, to paraphrase the poet, "no navigator is an island." All users will need common references to initialize time and location and safely operate with each other. So rather than replacing other technologies, I see autonomous systems becoming part of larger, user-focused PNT architectures.

How do you see the impact of AI in positioning and navigation domain?

"A prudent mariner uses every means available to determine their position" has been the navigator's motto since the days of sail. And it is surprising the number of things in a user's environment that can be sensed and used to determine location. Artificial intelligence will make it much easier to incorporate more external signals and environmental sensing into navigators' calculations to ensure safe and accurate precise navigation.

You had a long association with maritime navigation. How do see the evolution of navigation technology in general and marine navigation in particular?

I think all navigation tech is going to continue to evolve in two distinct ways.

First, it will continue to develop and benefit from increasing connectivity and the information that it makes available. For example, data to increase accuracy and authenticate signals will become more and more a matter of course rather than special services.

Users will also increasingly be able to navigate without external signals. Environmental sensing, map matching, internal and inertial sensors, and the like will enable relatively safe autonomous operation. And when the ship, aircraft or vehicle are connected, they will be ideal complements to the wealth of information available from other sources.

European Radionavigation Plan and the proposed EU Complementary Positioning, Navigation and Timing (C-PNT) Ecosystem

By establishing an EU PNT ecosystem that incorporates C-PNT technologies, we can enhance PNT resilience, availability, and continuity

Lukasz Bonenberg
Space Programmes Policy and Scientific Officer, Joint Research Centre (JRC), European Commission, Ispra, Italy

Beatrice Motella
Project Officer Joint Research Centre (JRC), European Commission, Ispra, Italy

Matteo Paonni
Deputy Head, Technologies for Space, Security and Connectivity Unit, Joint Research Centre (JRC) European Commission, Ispra, Italy

Joaquim Fortuny-Guasch
Head of the Galileo Sector at the European Commission Joint Research Centre (JRC) European Commission, Ispra, Italy

Introduction

Global Navigation Satellite Systems (GNSS) including Galileo and the European Geostationary Navigation Overlay Service (EGNOS), are widely regarded as the underpinning of the modern Position, Navigation and Timing (PNT), continuously providing time and position services across the globe. This service is essential to many economic sectors of our modern society, including transport (air, sea, and road), industry (telecommunication, energy, and finance), agriculture, fisheries, as well as security and defence.

According to the European Radionavigation Plan (ERNP) [1], over 10% of European Gross Domestic Product (GDP) is now enabled by economic activities underpinned by satellite navigation systems. The trends suggest that this will continue to increase, putting a premium on the uninterrupted delivery of PNT services.

Despite its technological excellence, GNSS can be subject to local (jamming/interference) or global (space weather, system fault) outages, and it is also unable to deliver full service in areas of limited sky visibility. With the widespread role of GNSS as the sole (or at least primary) source of PNT, it is important to consider other platforms or systems providing PNT, able to complement or backup GNSS services.

Alternative PNT Test Campaign

In December 2020, the Directorate General for Defence Industry and Space (DEFIS) of the European Commission (EC) launched the call for tender (CfT) DEFIS/2020/OP/0007 with three main goals:

- Assess the performance of A-PNT technologies to deliver positioning and/or timing information independently from GNSS and ideally extending the provision of PNT in environments where GNSS services cannot be delivered;
- Understand the requirements for the EU deployment;
- Provide inputs to the ERNP[1].

The Joint Research Centre is a part of European Commission and provides independent, evidence-based knowledge and science support to EU policies. JRC supports DG DEFIS and EUSPA on a wide set of topics related to Galileo and EGNOS. JRC supports the development of services, reference documents describing the service, publicly available through the Galileo Service Centre website and support R&D activities Horizon Europe and Galileo Fundamental Elements R&D Actions. Part of this work exploits JRC extensive laboratory expertise [4]

providing expert support, developing test vectors or related testing.

Given this extensive knowledge JRC was best suited to manage the test campaign. The majority of testing activities were conducted at the Ispra site, located in Northern Italy. The timing testing was conducted in the dedicated labs, the indoor positioning was conducted in two buildings and outdoor positioning testing across the site in three different environments (open, woodlands, and urban). Testing required extensive infrastructure installation and network access, which were organised for each platform separately. This included the installation of transmitting equipment around the campus and temporary licenses granted by the IT Spectrum Regulator for one of the participants.

JRC have utilised dedicated reference platforms for testing:

- For timing, the assemble of GNSS receivers and Rubidium atomic clock was calibrated by the Istituto Nazionale di Ricerca Metrologica (INRiM);
- For position, of the moving IMU and GNSS unit or, for indoors, total station tracking was used.

Key Performance Indicators

The Key Performance Indicators (KPIs) were defined by the tender as follows:

- Ability to deliver positioning and/or timing information independently from GNSS, in Universal Time Coordinated (UTC) for time and in European Terrestrial Reference System 89 (ETRS89), respectively) for position;
- Acting as a backup in the event of a GNSS disruption or outage;
- Providing coverage for the EU European territory, including in-land waters;
- Being resilient to GNSS failure modes and vulnerabilities (including GNSS frequency jamming and spoofing or unintentional interference);
- Having a TRL greater than 5 for position/navigation services OR greater than 6 for timing services;
- Providing a minimum performance of the alternative PNT service for at least 1 day upon GNSS loss, i.e.: (i) Positioning Accuracy (Horizontal and/or Vertical at 95%) < 100 m OR Timing Accuracy to UTC (99.7%) < 1 microsecond with (ii) Availability > 99%.

The KPIs were assessed after 1 day, 14 days, and 100 days of GNSS services loss. Additionally, systems were expected to provide position and/or time information in environments where GNSS cannot be efficiently delivered, including urban canyons, indoor, underground, underwater, and for fast-moving platforms such as spacecraft and launchers.

Participants were also asked to provide a description of the possibility to deploy the services on a local, regional, or continental scale.

Technologies Under Test

Out of seven participants, four demonstrated timing services (OPNT, 7 Solutions SL, SCPTime and GMV), and remaining three (Satelles, Locata Corporation, and NextNav) demonstrated both positioning and timing services, as presented in the table below. Six contractors were selected through the DEFIS/2020/OP/0007 with NextNav approaching independently and tested in the same regime.

Given the tight timetable, COVID restrictions as well as financial burden to contractors, some of the tests were conducted in sites across EU and US, as indicated by the table below.

Each participant agreed specific tests plans for timing and three of them also for position testing. A demonstration of platform resilience to external threats, system monitoring and other cybersecurity element understand each technology. [2] provides in-depth description of tests while [3] describes additional candidate technologies, not covered by the testing campaign.

Results of the JRC Test Campaign

The test campaign firstly aimed to understand the maturity and readiness of A-PNT technologies for operational use, and secondly, to assess the

Provider	Country	Type of technology	Provision of
OPNT BV	Netherlands	optical wavelength modulation (fiber) and Over-the-Air (OTA)	Time and frequency transfer
7 Solutions SL	Spain	fiber	Time and frequency transfer
SCPTime	France	electrical current modulation (fixed telecom networks)	Certified time transfer
GMV AD SAU	Spain	Fixed telecom networks	Time generation and transfer
Satelles Inc	USA	LEO, OTA	PNT
Locata Corporation Pty Ltd	Australia	Pseudolites, OTA	PNT
NextNav LLC	USA	Pseudolites, OTA	PNT

Figure 1 A-PNT technologies demonstrated at the JRC

Provider	JRC site	Other sites	Other site location
OPNT BV	•	•	Amsterdam, Netherlands;
7 Solutions SL	•	•	Granada, Spain;
SCPTime	•	•	Paris and Grenoble, France
GMV AD SAU		•	Madrid, Spain
Satelles Inc	•		
Locata	•	•	Düsseldorf, Germany
NextNav LLC	•	•	San Jose, USA

Figure 2 Location of tests executed outside the JRC Ispra site

performance of the proposed PNT platforms against common baseline KPIs. This was in line with the objective of understanding the advantages and limitations of each provided solution and developing the future EU PNT vision.

Due to the diverse nature of the tested technologies, the results should not be directly compared; instead, they should be regarded as individual assessments of each solution.

Overall, each participant fulfilled the required KPIs. Three PNT technologies tested were able to provide meters level position, with notable cm level performance from Locata. All seven technologies provided time transfer well below nanosecond, with notable White Rabbit sub-ns performance (OPNT and 7Solutions) and ns level performance from Locata. It should be noted that EU companies exhibited an excellent record in the time transfer. Additionally, multiple Master Clock inputs with voting and seamless switchovers were demonstrated by OPNT, Seven Solutions, and Locata.

Similarly, each demonstrated stringent cybersecurity performance. This includes secure remote access to hardware, over-the-air updates, whole network monitoring, and reporting. Hardware also deploys modern programming techniques such as virtualization, allowing for rapid deployment and updates if required. Some critical elements (including operation mode and implementation) cannot be captured by KPI metrics, and simplifications were made for the sake of the assessment.

The Achilles heel of those technologies is the UTC reference (captured above as Maximum Time Interval Error (MTIE) and Time Generation values) which could also be read as time generation performance without GNSS. Without precise atomic clocks (as demonstrated by 7Solutions and GMV), a connection to National Metrological Institute (NMI) (OPNT), or both (Satelles), it was not possible to extend this capacity beyond a few days.

The results highlighted the important role of NMIs across Europe and identified that GNSS serves as the foundation for PNT services and is expected to continue doing so in the future, as no other technology can match its performance at this price point to end-user. Nevertheless, the platforms tested have demonstrated the capacity to provide time and position in areas of limited sky visibility that limits GNSS.

2D Positioning Performance	Static Outdoors [m]	Static Indoor [m]	Kinematic Outdoors [m]	Kinematic Indoors [m]
Satelles Inc	17.0	15.0	N.A.	N.A.
Locata Corp	< 0.01	< 0.01	< 0.02	< 0.02
NextNav LLC	9.0	14.0	11.0	N.A.

Figure 3 Summary of planar position performance at 95 percentile

Timing Performance	Time Generation [days]	MTIE [ns]	Time Transfer Fibre [ns]	Time Transfer Networks [ns]	Time Transfer OTA Outdoors [ns]	Time Transfer OTA Indoors [ns]
OPNT BV	N.A.	N.A.	0.057	N.A.	< 200 (±100)	N.A.
7 Solutions SL	80	280	0.089	N.A.	N.A.	N.A.
SCPTime	1	< 1000	N.A.	35	N.A.	N.A.
GMV AD SAU	100	57	1	500	N.A.	N.A.
Satelles Inc	110	364	N.A.	N.A.	145	< 340
Locata Corp	1	< 1000	0.4 (4.9)	0.4 (6.1)	0.7 (6.1)	0.2 (5.2)
NextNav LLC	11.6	40	N.A.	N.A.	N.A.	< 39

Figure 4 Summary of time performance at 99.7 percentile

European Radio Navigation Plan

The ERNP 2023 [1] is a European Commission staff working document, written by DG DEFIS in cooperation with the DG Joint Research Centre (JRC). The document was mandated in the 2016 Space Strategy for Europe and its first edition was released in March 2018. The current 2023 edition is its second and it was expanded to address the following aims:

1. Provide information on conventional and emerging PNT systems and services, their use, typical performance, strengths, weaknesses, developments, trends, challenges, and opportunities.
2. Facilitate the uptake of the European GNSS (Galileo and EGNOS) services by:
   - Providing detailed information on European GNSS current and future services and their added value;
   - Recommending EU level actions for the uptake of EGNSS across market domains/sectors, including legislation and standards.
3. Recommend actions to increase the resilience of PNT services in the EU and explain the EU PNT policies while summarizing international ones.
4. Outline the medium-term vision of EU PNT evolution based on the COM exercise (2022-2023), inputs from stakeholders and the A-PNT Test Campaign described above. This is an outlook and not yet an agreed policy.

The conclusions of the test campaign were used to define the last point. The campaign allowed a better understanding of the possible evolution of the landscape of PNT infrastructures in the EU, including new emerging systems.

Towards C-PNT vision

Before the JRC Test Campaign described above, the assumption was that new emerging systems could act on their own, providing an alternative source of PNT that is able to deliver positioning and/or timing information independently from GNSS. Hence, the A-PNT indication.

The need for C-PNT technologies in Europe is a testament to the indispensable role of Galileo and EGNOS. Our reliance on GNSS services is so great that it is essential to have both backup and alternative systems in place to mitigate the risk of PNT service interruption

However, as discussed, this was found to be a sub-optimal approach. Firstly, the tested technologies have demonstrated complementing capacity, both to each other and GNSS. Secondly, UTC required the connection to the external atomic clock (or NMI), something that could be fulfilled by GNSS. Thirdly, if systems were to be utilized coherently, they could provide another independent source of information, hence increasing the overall resilience more than an independent system could do on its own, as long as a common reference exists.

Based on the above findings, ERNP [1] suggests the most optimal approach is the system of systems approach (SOSA). This would consist of space and terrestrial assets, as presented in the figure below.

The proposed ecosystem is composed of multiple autonomous systems that share a common time and position reference frame (UTC and ETRS89, respectively). For this purpose, both terrestrial and space assets are underpinned by GNSS for UTC, with additional EU terrestrial backbone providing independent UTC. This creates increased resilience and monitoring for Critical Infrastructure (CI), as well as creating infrastructure which can be utilized for safety of life and professional markets, and with time extended to the mass market applications. This approach also allows for the gradual extension of the PNT service, without disturbing the existing provision, while allowing for a greater participation of commercial entities. Future interconnectivity is regulated by the common time and position reference frame.

Within this system of systems approach (SOSA), the non-GNSS components would be best referred to as Complementary (Continuous) PNT (C-PNT), given their aim to provide resilience, extend PNT to environments that cannot be served by GNSS, and also function as limited spatial and temporal backup systems supporting existing infrastructure.

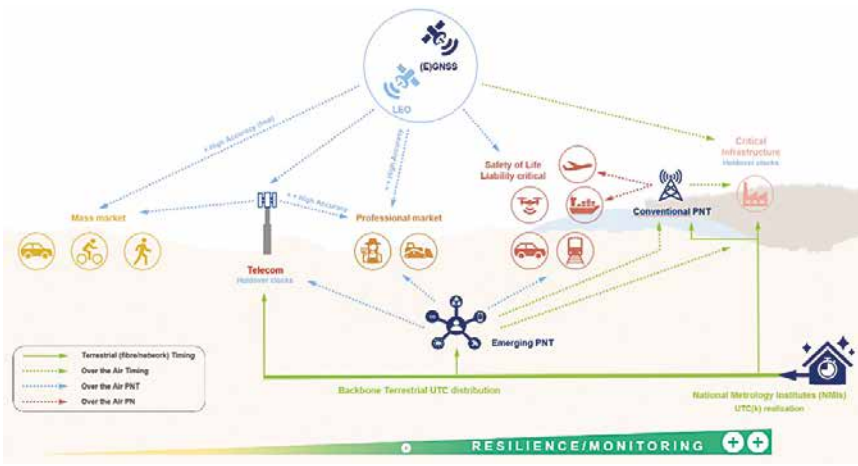


Figure 5 Proposed EU PNT Ecosystem, after [1]

Conclusion

The need for C-PNT technologies in Europe is a testament to the indispensable role of Galileo and EGNOS. Our reliance on GNSS services is so great that it is essential to have both backup and alternative systems in place to mitigate the risk of PNT service interruption. By establishing an EU PNT ecosystem that incorporates C-PNT technologies, we can enhance PNT resilience, availability, and continuity, thereby strengthening EU autonomy, resilience of the economy, and through technical development also EU's global standing.

The candidate C-PNT technologies description can be found in [1], [3], with latter also proposing EU PNT Ecosystem, supported by the results of the 2021-22 A-PNT Test Campaign summarised in [2]. It also concluded that a resilient EU PNT requires a system of systems approach with a mix of technologies, supported by industry standards to ensure the required interoperability. The proposed first step should be to provide the timing backbone by interconnecting European NMIs, with further steps including investigation on the feasibility of dedicated terrestrial spectrum for C-PNT use and how it could be integrated/standardized in devices. It is essential that the EU prioritize the development and implementation of C-PNT technologies, as described in [3], to ensure the continued reliability and stability of its PNT services.

This article expands further on the vision presented in [1] and describes the EU PNT ecosystem based on the system of systems approach (SOSA), underpinned by GNSS. It should be noted that the EU PNT ecosystem is a proposal and not a policy.

It is worth noticing that the European Commission has also undertaken regulatory actions aimed at enhancing the resilience of PNT infrastructures and services in the EU. The main policy actions addressed include the EU Space Programme Regulation, the update of the EU CI and Network Information Systems (NIS) Directives, and the publication

of a Commission Staff Working Document defining the use of EGNSS for timing and synchronization in CI.

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The reports [1],[2] discussed in this article are available from https://joint-research-centre.ec.europa.eu/scientific-activities-z/complementary-and-alternative-pnt_en.

US agency probes risks of foreign satellite use by handheld devices

The Federal Communications Commission said recently that it is investigating if the use of Russian and Chinese foreign satellite systems by U.S. mobile phones and other devices poses security threats.

The FCC has concerns U.S. handheld devices are receiving and processing GNSS signals from satellites controlled by foreign adversaries in violation of commission rules. The FCC is seeking answers from handset manufacturers Apple, Google, Motorola, Nokia, Samsung and others that collectively cover over 90% of the U.S. smartphone marketplace. The companies did not immediately respond to requests for comment.

"There is no established record of what security threats, if any, these signals carry and whether the manufacturers of handheld devices are processing these signals in violation of the Commission's rules," a FCC spokesperson said. Representative Mike Gallagher, chair of the House Select China Committee, wrote FCC Chair Jessica Rosenworcel earlier this week raising concern about reports that U.S. cell phones were receiving and processing signals from Chinese and Russian satellites.

The FCC has only approved U.S. phones to receivers to receive and process signals from the U.S. GPS and only the European Galileo GNSS has been approved. Gallagher said U.S. devices are receiving signals from the PRC BeiDou and Russian GLONASS GNSS constellations.

"Current events in Eastern Europe (including significant Russian jamming and spoofing of GNSS signals) call into question the wisdom of accepting this workaround and suggest it is critical that the FCC enforce its rules against using unauthorized signals from foreign satellites," Gallagher said. Rosenworcel in 2018 raised concerns saying U.S. phones have chips designed to operate with global navigation satellite systems of other countries. "Many devices in the United States are already operating with foreign signals," she said in 2018.

The FCC wants to know "whether their devices are in compliance with FCC rules and what vulnerabilities" may exist in how they process GNSS signals. *www.reuters.com*

ESA kicks off two new navigation missions

ESA has signed contracts with several European companies for an overall amount of € 233 million to develop Genesis and a LEO-PNT demonstrator, two new missions within the FutureNAV programme that will keep Europe at the forefront of satellite navigation worldwide.

The contract for Genesis amounts to € 76.6 million. A consortium of 14 entities led by OHB Italia S.p.A. (IT) is tasked with developing, manufacturing, qualifying, calibrating, launching and operating the Genesis satellite, including all its payloads. This mission is supported by Italy, Belgium, France, Switzerland, Hungary and the UK. The Genesis satellite is planned to launch in 2028, followed by years of scientific exploitation.

For LEO-PNT, two parallel contracts of € 78.4 million each have been signed for two end-to-end low Earth orbit positioning, navigation and timing (LEO-PNT) in-orbit demonstrators. The contracts include the design and development of satellites and payloads, ground segment, test user segment and satellite launches, operations, experimentation and demonstration of services with end users.

One of the contracts for LEO-PNT demonstrator is led by GMV Aerospace and Defence S.A.U. (ES), as overall system prime and OHB System AG (DE) as space segment prime and core partner. The other contract is led by Thales Alenia Space France S.A.S (FR) as overall system prime and Thales Alenia Space SPA (IT) as space segment prime.

The missions were approved at ESA's Ministerial council of 2022 as part of FutureNAV programme, in ESA's Navigation Directorate. FutureNAV enables ESA to respond to trends and needs in the field of positioning, navigation and timing, and allows Europe to stay on the cutting edge of satellite navigation technology. *www.esa.int*

GNSS Constellation Specific Monthly Analysis Summary: March 2024

The analysis performed in this report is solely his work and own opinion. State Program: U.S.A (G); EU (E); China (C) "Only MEO- SECM satellites"; Russia (R); Japan (J); India (I)

Narayan Dhital
Actively involved to support international collaboration in GNSS-related activities. He has regularly supported and contributed to different workshops of the International Committee on GNSS (ICG), and the United Nations Office for Outer Space Affairs (UNOOSA). As a professional employee, the author is working as GNSS expert at the Galileo Control Center, DLR GfR mbH, Germany.

Introduction

The article is a continuation of monthly performance analysis of the GNSS constellation. In this month's issue, there is an additional monitoring of the satellite Timing Group Delay (TGD)/Broadcast Group Delay (BGD) parameters. The regular analysis of Earth Rotation Parameters (ERPs) and satellite attitude dynamics is omitted in this month's issue and will be covered again in coming months.

Analyzed Parameters for March, 2024

(**Dhital et. al, 2024**)) provides a brief overview of the necessity and applicability of monitoring the satellite clock and orbit parameters..

a. Satellite Broadcast Accuracy, measured in terms of **Signal-In-Space Range Error (SISRE) (Montenbruck et. al, 2010)**. Due to the data latency of 2 weeks for precise satellite clocks and orbits, at the time of analysis for February, only 01-18 February, 2024 time frame was used. The remaining days of February are also covered in this month's overall statistics.

b. SISRE-Orbit (only orbit impact on the range error), SISRE (both orbit and clock impact), and **SISRE-PPP** (as seen by the users of carrier phase signals, where the ambiguities absorb the unmodelled biases related to satellite clock and orbit estimations. Satellite specific clock bias is removed) (**Hauschlid et.al, 2020**)

c. Clock Discontinuity: The jump in the satellite clock offset between two consecutive batches of data uploads from the ground mission segment. It is indicative of the quality of the satellite atomic clock and associated clock model.

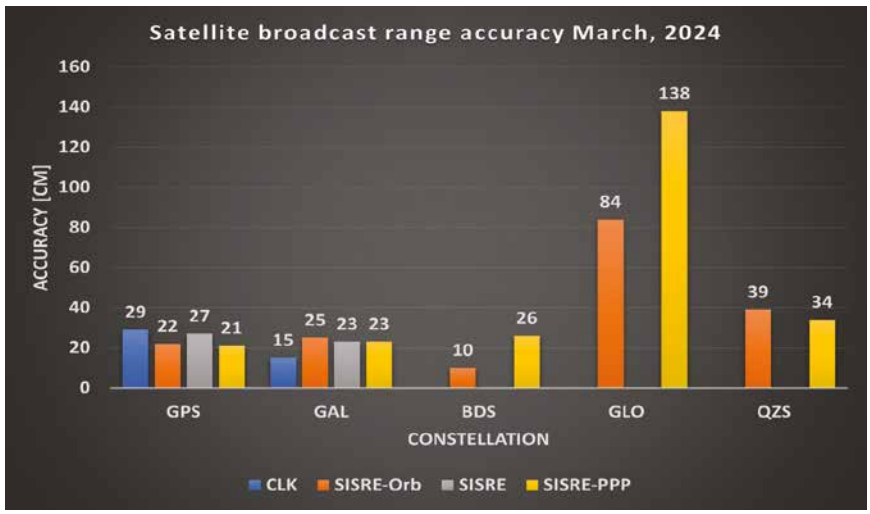
d. URA: User Range Accuracy as an indicator of the confidence on the accuracy of satellite ephemeris. It is mostly used in the integrity computation of RAIM.

e. GNSS-UTC offset: It shows stability of the timekeeping of each constellation w.r.t the UTC

f. Satellite Hardware Delay (TGD/BGD): The hardware delays originating from the analog and digital parts of the satellite's transmission. Mostly, the time difference between the transmitted RF signal,measured at the transmitting antenna, and the signal at the output of the onboard frequency source.

Note:- for India's IRNSS there are no precise satellite clocks and orbits as they broadcast only 1 frequency which does not allow the dual frequency combination required in precise clock and orbit estimation; as such, only URA and Clock Discontinuity is analyzed.

(a), (b) Satellite Clock and Orbit Accuracy (monthly RMS values)



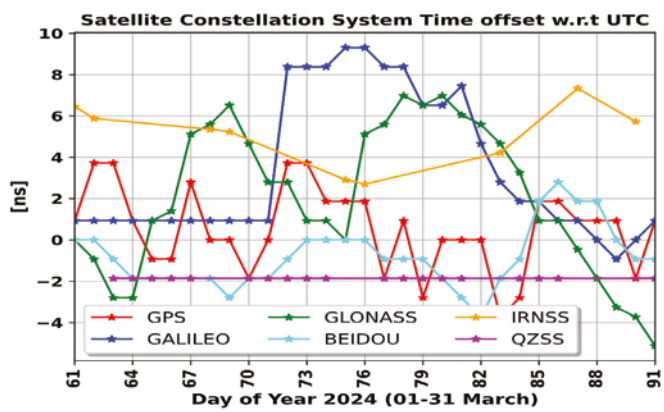
(c) Satellite Clock Jump per Mission Segment Upload

Const	Mean [ns]	Max [ns]	95_ Percentile [ns]	99_ Percentile [ns]	Remark (Best and Worst 95 %)
IRNSS	4.33	1021.12	6.22	30.57	Best I03 (2.95 ns) Worst I06 (13.43 ns) I10 had large jumps on multiple occasions
GPS	0.41	8.73	0.95	2.14	Best G14 (0.39 ns) Worst G03 (2.36 ns)
GAL	0.08	3.38	0.17	0.41	Best E21 (0.15 ns) Worst E34 (0.21 ns)

(d) User Range Accuracy (Number of Occurances in Broadcast Data 01-31 March)

IRNSS-SAT	2 [m]	2.8 [m]	4.0 [m]	5.7 [m]	8 [m]	8192 [m]	9999.9	Remark Other URA values (frequency)
I02	2938	11	17	2	4	5	29	URAs 11.3 (1), 32 (2)
I03	535	-	-	-	1	-	-	-
I06	654	7	5	1	2	-	1	-
I09	464	1	1	-	-	-	-	-
I10	772	2	1	1	4	1	-	URAs 11.3 (2), 32 (1)

(e) GNSS-UTC Offset



(f): Satellite Hardware Delay (TGD/BGD)

The TGD/BGD parameters transmitted by the GNSS satellites are very useful for code based positioning and timing applications of single-frequency users as well as dual-frequency users. Such parameters also provides enhanced solutions for precise point positioning by reducing the convergence time and enabling the ambiguity fixing of the carrier phase. The inherent nature of the satellite broadcast clock offset estimation requires the users to be consistent with the signal combination used in the ionosphere-free combination of the satellite clock offset computation. When other signal combinations are desired at the user level, the respective hardware delays captured by the TGD/BGD parameters are applied. The values for TGD/BGD are either calibrated and uploaded to the satellite or estimated as a part of the mission control activities and then uploaded to the satellite with varying temporal resolutions (Wang et.al, 2019).

It is to be noted that the absolute hardware delay is not observable from the available measurements and hence, the delay in a particular signal is estimated with reference to another signal. In a post-process estimation, as in the case of IGS products, such parameter is referred to as Difference Code Biases (DCBs). Different conventions and assumptions are used in the estimation of TGD/BGD at the mission control segment. The functional model in the GNSS estimation of DCB suffers from a rank deficiency in which only the sum of the satellite and receiver (the ground network used for the DCB estimation) is estimable. The common approach to overcome the rank deficiency has been the application of a constellation zero-mean constraint. This method is used in the computation of BGD for Galileo constellation. For GPS, a calibrated reference receiver is used to generate the TGD. Beidou constellation does not apply the zero-mean constraint but there is a strong indication that a reference satellite with pre-calibrated biases is used for the

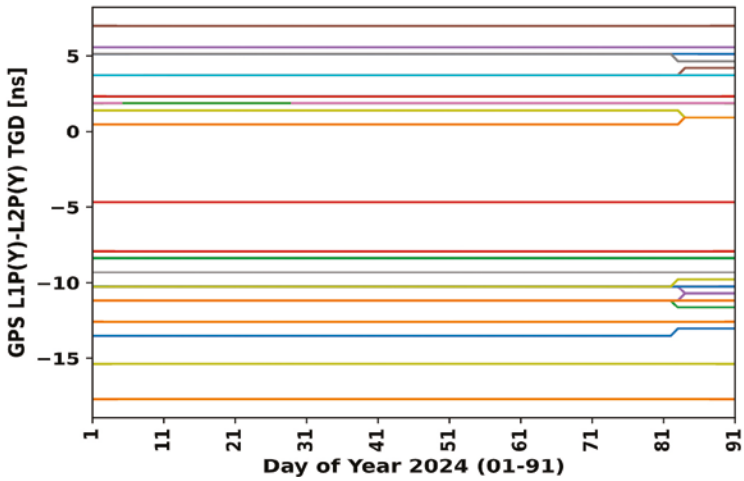


Figure f a: Temporal evolution of TGD values transmitted by GPS. Only around day of year 083, the values for some satellites were updated by the mission segment. This also indicates that constellation-shift is absent as no constellation wide constraint is applied in the generation of TGD.

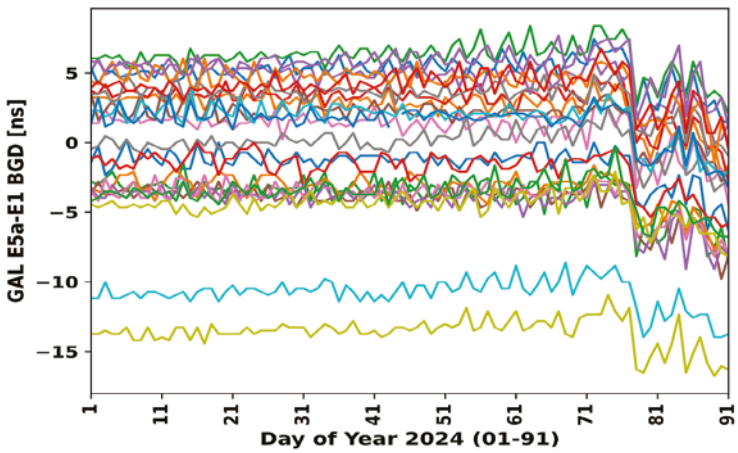


Figure f b: Temporal evolution of BGD values transmitted by Galileo satellites in FNAV messages. There is a regular upload of values from the mission segment and on day of year 078, there appears a re-alignment in the estimation of BGD and the values of the whole constellation shifted.

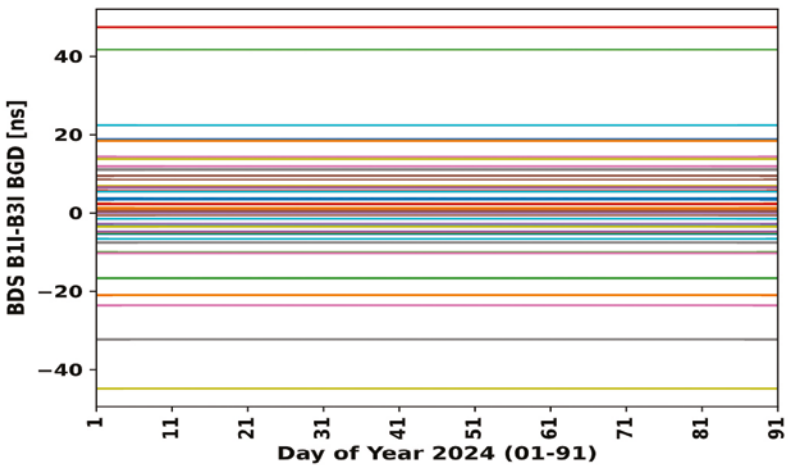


Figure f c: Temporal evolution of TGD values transmitted by BDS CNAV messages. The lines are all flat indicating there was no upload of new values from the mission segment.

generation of TGD. The values of TGD/BGD are not changing ones and remain stable for several days/weeks. In fact the mission segment update rate can range from several days to weeks to months. Only Galileo constellation provides a frequent update (daily/sub-daily basis) on the parameter. It is, therefore, interesting to look into the time-series of these parameters per constellation and monitor how and when there is a shift/jump.

For GPS satellites, the hardware delay differences between onboard **L1P(Y) and L2P(Y)** signals are captured by the TGD parameters transmitted in the legacy navigation LNAV message.

For Galileo satellites, the BGD is based on the FNAV signal with a combination of **E5a-E1.**

For Beidou satellites, the CNAV signal provides TGD based on **B1I and B3I** signals.

For QZSS, the TGD parameters are based on **L1C/A and L1C/B**.

For IRNSS satellites, the TGD is based on **L5 and S** signals.

In the coming issues of the monthly performance analysis, an effort will be made to analyze the quality of the broadcast TGD/BDG against the more precise DCBs. There will also be some perspectives on the factors that trigger the updates/changes of TGD/BDG values.

Monthly Performance Remarks:

1. Satellite Clock and Orbit Accuracy

- For GPS, the satellite clock and orbit accuracy shows better performance in March 2024. The atomic clocks on-board the GPS satellites showed greater performances. This is reflected also in the overall statistics of satellite clock jumps. It is slightly improved in comparison to previous months.
- For Galileo, all parameters showed consistent performances.
- For GLONASS, no large clock offsets were detected unlike in

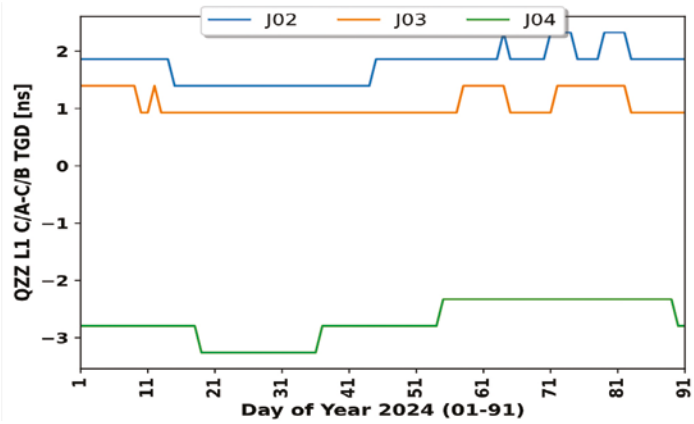


Figure f d: Temporal evolution of TGD transmitted by QZS. There are some updates of the values from the mission segment.

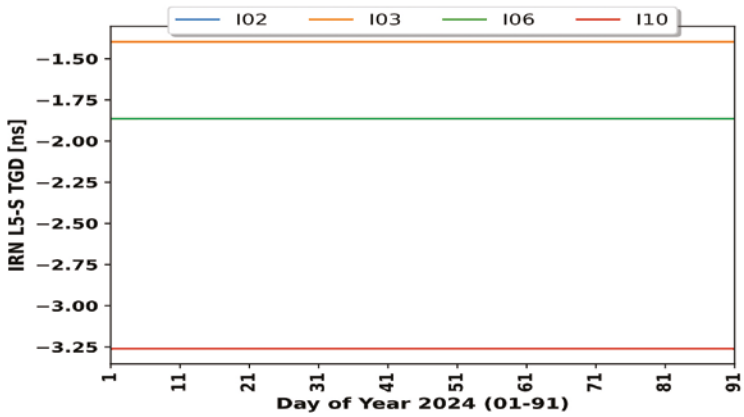


Figure f e: Temporal evolution of TGD transmitted by IRNSS. The values remain flat indicating no uploads of new values in this timeframe from the mission segment.

January. The performance looked similar to the past months.

- For BDS and QZSS, the performance looks very much the same as in December 2023. For QZSS, there are days with better orbit quality and some days with degraded performance. With regard to BDS, satellite C35 was non-healthy from day of year 066 until 080.
- For IRNSS, the notable difference in this month's performance is the inconsistent URA for I02 satellite. There were a varying confidences in the range accuracy for I02.

2. UTC Prediction (GNSS-UTC):

- Galileo constellation showed a distinct variations in the GNSS-UTC prediction. From day of year 071 to 084, the values ranged from 1 ns to 9 ns.

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(The monitoring is based on following signals- GPS: LNAV, GAL: FNAV, BDS: CNAV-1, QZSS:LNAV IRNSS:LNAV GLO:LNAV (FDMA))

Standards, challenges and prospects of geomatics education in Sri Lanka

With the evolvement of new technologies and new opportunities enabled surveyors to broaden their skills and competencies

Prof. H. M. I. Prasanna
Professor in Geodesy,
Faculty of Geomatics
Sabaragamuwa
University of Sri Lanka,
Belihuloya, Sri Lanka.

Dr. M. D. E. K. Gunathilaka
Senior Lecturer,
Faculty of Geomatics
Sabaragamuwa
University of
Sri Lanka, Belihuloya, Sri Lanka.

History and current status of the geomatics education in Sri Lanka

In Sri Lanka, land surveying and geomatics related activities are officially commenced after the establishment of the Sri Lanka Survey Department (SLSD) which has been founded by a governor's proclamation dated August 02, 1800, just four years after the British occupied the island's coastal sector; as a result, the Sri Lanka Survey Department is the oldest civil state department in the nation.

On October 20, 1896, the Govt. Technical College in Colombo, Sri Lanka, began the first systematic training program for surveyors. Later, departmental officers took over the training. Due to this, in 1912, the Sri Lanka Survey Department established its own training facility in Modara, with the practical training taking place in Padukka, which is located closer to Colombo. The training school moved to its current site in Diyatalwa, Sri Lanka, in 1924. The United Nations Development Program (UNDP) helped to improve it in 1968, and an Act of Parliament No. 21 of 1969 founded the Institute of Surveying & Mapping Diyatalwa (ISMD). Initially, the training activities were purely confined to the training of surveyors for Survey Department, and later has gradually taken over almost all the basic training needs of the Survey Department and some other organizations at their request. In 1990, the ISMD was upgraded as a degree awarding institute by a gazette notification No. 620/4 under the section 25A of the Universities Act No. 16 of 1978. Again, UNDP played a prominent role by making necessary funds to strengthen ISMD physically. Since then, the ISMD conducts a four-year degree course in Surveying Sciences in addition to diploma courses for the government surveyors.

The Faculty of Geomatics (FOG) was established in 2004 as one of the nine faculties of the Sabaragamuwa University of Sri Lanka (SUSL). It is the successor to the Department of Surveying Sciences, which introduced the Bachelor of Science in Surveying Sciences degree Programme in 1997. This was the first time in the history of Sri Lanka's university system that a university established a degree program in this scientific field, meeting a pressing demand for the nation. The Degree Programme is a four-year course leading to an honours degree in Surveying Sciences, subsequently becoming the first such degree awarded in Sri Lanka under the purview of the University Grants Commission (UGC). Currently the faculty offers five specialization programmes: Surveying and Geodesy, Hydrographic surveying, Land management, Remote sensing, and Geographic information systems (GIS).

The General Sir John Kotelawala Defence University (KDU) of Sri Lanka-Southern Campus has also initiated a Surveying science degree programme under the Department of Spatial Sciences covering all the aspects of Spatial Sciences such

as Land Surveying, Hydrographic Surveying, Remote Sensing, GIS, Photogrammetry, Cartography, and Construction Surveying in 2015.

National standards of Sri Lankan degree programmes

According to the UGC standard, a student's program of study is an independently recognized curriculum they follow that helps them qualify for a degree from a given organization. The term "courses/modules" refers to the formalized, self-contained elements that make up a curriculum. Academic programs of study should reflect the mission, aims, and goals of the university or HEI. They are provided in accordance with a needs analysis based on an examination of already offered courses and programs, market research, industry liaison, national and regional priorities, and established procedures. When creating the structure and content of a new degree program, Subject Benchmark Statements (SBS) and professional body criteria serve as helpful external reference points. Students are given the knowledge, abilities, and attitudes necessary to excel in the workplace and in lifelong learning through a curriculum that is outcome-driven (PR manual, 2015).

Beginning with a description of the program's graduate results, the course/module outcomes are then directly mapped to the program outcomes. The Sri Lanka Qualification Framework (SLQF) is used to establish and explain learning outcomes in relation to a specific level of study. Every program's objectives must to be explicitly in line with the course's objectives, content, teaching/learning methods, and evaluation techniques (constructive alignment). In order to establish compatibility between the curriculum, student-centered teaching strategies, and assessment processes, programs should aim to involve students in a variety of learning activities. These activities should encourage diversity, flexibility, accessibility, and autonomy in learning. The final curriculum is essentially the result of interactions between learning objectives, evaluation techniques, instructional strategies, and content.

Sri Lanka Qualification Framework (SLQF) and subject benchmark statement in geomatics

Recent years have seen a substantial growth in the mobility of learners and educators between nations and regions of the world, necessitating the support and adaptation of national higher education institutions. Considering this, the Sri Lanka Qualifications Framework (SLQF) is a significant component of the development of systems in the higher education sector. It provides a clear and consistent framework for the learner to optimize his or her goal of learning throughout life, while also enhancing many essential aspects of learning and evaluating the learning process. The SLQF's establishment will contribute to various improvements in learning processes and aspects. Additionally, it will raise the standard of education in the country while simultaneously offering a clear method for establishing connections with higher education institutions outside.

The SLQF serves as a uniform national foundation for all higher education credentials provided in Sri Lanka. All higher education institutions (HEIs), including public and private, that offer post-secondary education are subject to the SLQF. It acknowledges the amount of learning that students have done and lists the learning objectives that certification holders must meet. The SLQF consists of twelve levels, and each level's descriptors are fully stated (Table 1). SLQF contributes significantly towards strengthening quality

Table 1: Minimum learning volume needed for each Level of the SLQF (Source: SLQF, 2015)

SLQF Level	Qualification Awarded	Minimum Volume of Learning for the Award
12	Doctor of Philosophy / MD with Board Certification/Doctor of Letters/Doctor of Science	Minimum 3 years of fulltime or equivalent time of original research after SLQL 6 or above
11	Master of Philosophy	Minimum 2 years of fulltime or equivalent time of original research after SLQL 6 or above
10	Masters with course work and a research component	60 credits after SLQL 5 or SLQL 6 including a research component of minimum 15 credits
9	Masters by course work*	30 credits after SLQL 5 or SLQL 6
8	Postgraduate Diploma*	25 credits after SLQL 5 or SLQL 6
7	Postgraduate Certificate*	20 credits after SLQL 5 or SLQL 6
6	Bachelors Honours	120 credits after SLQL 2 of which 90 credits after SLQL 3, of which60 credits after SLQL 4, of which 30 credits after SLQL 5
5	Bachelors	90 credits after SLQL 2 of which 60 credits after SLQL 3, of which 30 credits after SLQL 4
4	Higher Diploma	60 credits after SLQL 2 of which 30 credits after SLQL 3
3	Diploma	30 credits after SLQL 2
2	Advanced Certificate (GCE A/L or equivalent)	
1	Certificate (GCE O/L or equivalent)	

As the universities began awarding the Geomatics degrees, it is not restricted to cater the local demand. This has opened a new door to cater the international market while fulfilling the local professional requirements as well. Currently all the Geomatics related degrees awarded in Sri Lanka fulfil the basic academic requirements as laid down by the Survey Act 2002.

assurance mechanisms of the entire higher education sector in Sri Lanka.

Since SLQF is a nationally consistent framework for all higher education qualifications offered in Sri Lanka and applies to all higher education institutions, All Geomatics degree programme have adopted SLQF guidelines. Also, SLQF implementation is a must to get UGC recognition and accreditation for the degree programmes. In general all the four year degrees are placed under SLQF level 6.

Further, the UGC has developed the Subject Benchmark Statement (SBS) for each of the degree programme including Geomatics with a wider stakeholder participation in 2010 through the Quality Assurance and Accreditation Council (QAAC) of UGC. Subject benchmark statement is an essential component of quality assurance in the university system. This statements support to the academic community to describe the nature and characteristics of a specific subject or subject area (SBS Geomatics, 2010).

The role of professional institutions in higher education

In general, important stakeholders in higher education are students, alumni, employers and faculty members. However, when referring key stakeholders of higher education in professional degree programmes, professional bodies play an important role. Professional bodies contribute: creating high quality graduates with appropriate balance between practical experience and theoretical knowledge; making relationship between professional bodies' requirements and university curricula; minimizing the risk of having low or high entry to a certain profession related to areas to the profession or to the quality of the students; providing internships or apprenticeships; and identifying the additional skills required by the qualification such as soft skills including communication, IT or so-called transferable skills. Therefore, professional bodies can contribute to the teaching and education performance for better skilled graduates at universities which become learning organizations of their programmes and current in targeting market needs. As a whole, role of professional bodies to contribute to higher education can be broadly categorised as:

- Providing input towards up to date programs
- Acting a pro-active stakeholder engagement to the market and its needs. New trends in the profession, new market.
- Observing theoretical knowledge, practical knowledge and required professional skills
- Implementing the challenges in the market, ethical practices and codes of conduct
- Maintaining transparency through the involvement of professional bodies.

When it comes to professional bachelor's degrees like Geomatics, these programs generally have a different structure than a common Bachelor of Science program, because these professions are regulated by the relevance professional bodies and most of these curricula is focused on the practical training aspects and professional ethics. Therefore in producing graduates in a Geomatics requires an exclusively planned curriculum addressing the prevailing professional requirements. Therefore, the faculties have appointed the officers from the respective local professional bodies as advisors in various committees such as course advisory committees to obtain their valuable inputs as well as time to time obtaining the feedbacks from them including the other stakeholders.

Importance of local and global accreditations

As the universities began awarding the Geomatics degrees, it is not restricted to cater the local demand. This has opened a new door to cater the international market while fulfilling the local professional requirements as well. Currently all the Geomatics related degrees awarded in Sri Lanka fulfil the basic academic requirements as laid down by the Survey Act 2002. The qualified graduates have acquired the professional membership in the SISL and licensing from the LSC after proving their substantial professional experience after graduation.

Apart from that, the international accreditation enhances the recognition of a degree worldwide. It assures employers, academic institutions, and other stakeholders that the graduate has received education of a certain standard, making it easier for them to trust the qualifications. This ensures better employability opportunities and better pays. Overall, both local and global accreditations play a crucial role in validating the quality and integrity of degrees, providing assurance to students, employers, and to the society at the end.

Global and local professional bodies involved in geomatics education in Sri Lanka

The Surveyors' Institute of Sri Lanka (SISL) is the National Professional Body of the Surveying Profession. It is also a

Founder Member of the Commonwealth Association of Surveying & Land Economy (CASLE) and the Organisation of Professional Associations (OPA). Further, it is also a Member of the International Federation of Surveyors (FIG). The Parliament Act No. 22 of 1982 incorporated the Institute (Surveyors' Institute Sri Lanka (Incorporation) Act).

According to the Survey Act No. 17 of 2002 of Sri Lanka, Land Survey Council (LSC) has been established as the governing body to regulate the professional conduct of surveyors. According to this acts, both SISL and LSC, are responsible for supporting and standardizing the professional education of Surveying in Sri Lanka. As one of the duties of LSC, it is responsible for recognising the academic and professional qualifications in land surveying (Survey Act, 2002). This is important for benchmarking and standardizing the degree programmes since there are few institutions which offer geomatics related degree programmes. For any professional degree programmes, there should be essential components to be included in their curricula. These fundamental course modules to be decided by the discussion and agreement of respective professional bodies.

Beside the local professional bodies, the education institutions have also considered some important elements from international professional bodies such as Royal Institution of Chartered Surveyors (RICS). At the moment, Faculty of Geomatics is having the RICS accreditation for all of its specialisations as well as its Hydrographic specialisation has obtained the FIG/IHO/ICA Category B recognition from International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) since 2015. These remarks clearly indicate that the Faculty of Geomatics, Sabaragamuwa University of Sri Lanka has become a world-class degree awarding institution in the field of Geomatics and Hydrography in this part of the world.

Future pathways of Geomatics Education

With the evolvement of new technologies and new opportunities enabled surveyors to broaden their skills and competencies than they were traditionally involved as the surveying profession moves into the 21st century. These led to several challenges in defining the boundary of the profession. Today it is so much diversified by encompassing various other activities such as real estate management, digital image processing and Artificial Intelligence (AI), engineering design, planning & decision making, space navigation, Big Data, Geo statistics, etc. The Royal Institution of Chartered Surveyors defined some 11 mandatory competency aspects, 13 core competency aspect areas and another 10 optional competency areas leading towards almost over 100 specific technical competencies which requires at various levels of its membership (RICS, 2018). This implies that modern surveying programmes must be developed into multi-talented professional people capable of handling large data and AI based smart solutions. Therefore, the curriculums must be revised by incorporating such future trends in order to produce Geomatics graduates to thrive in the future job market.

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$4 billion investment in Anthropic by Amazon

Amazon invested a total of $4 billion in Anthropic, with $2.75 billion being the second tranche of their investment. This investment is the largest venture investment Amazon has ever made. The aim is to bolster Amazon's position in the field of Artificial Intelligence, with Anthropic being a leader in generative AI. *www.aboutamazon.com*

Microsoft invests in G42

G42, UAE-based AI technology holding company, and Microsoft Corp. has announced a $1.5 billion strategic investment by Microsoft in G42. This expanded collaboration will empower organizations of all sizes in new markets to harness the benefits of AI and the cloud while ensuring they are adopting AI that adheres to world-leading standards in safety and security.

G42 will run its AI applications and services on Microsoft Azure and partner to deliver advanced AI solutions to global public sector clients and large enterprises. *news.microsoft.com*

NYC autonomous vehicle testing program

Mayor Eric Adams and the New York City Department of Transportation (DOT) Commissioner Ydanis Rodriguez have introduced a new permit program designed to oversee the testing of autonomous vehicles in New York City. The program is part of the city's initiative to ensure the safe and responsible exploration of autonomous vehicles. With safety as the primary concern, the program mandates that a trained driver must be present behind the wheel of any autonomous vehicle being tested, ready to take control at any moment. *www.nyc.gov*

Harnessing geospatial insights: understanding Himachal Pradesh's flash flood vulnerability

The paper analyses the natural disaster that struck the State of Himachal Pradesh in 2023

Shashi Shekhar
Scientific Officer,
Himachal Pradesh
State Pollution
Control Board, India

Dr. Satish Kumar Negi
Associate Professor in
Geography, Govt. Degree
College Dhrampur,
Himachal Pradesh, India

Abstract

The paper aims to analyse the natural disaster that struck the State of Himachal Pradesh in 2023, resulting in significant losses to human life, property, and infrastructure due to flash floods triggered by heavy rainfall from July to September 2023. Specifically, the analysis focuses on the spatio-temporal rainfall/flooding patterns in five districts of Himachal Pradesh: Kullu, Mandi, Shimla, Solan, and Sirmaur. Utilizing Google Earth Engine, which integrates a vast catalog of satellite imagery and geospatial datasets with advanced analysis capabilities, the authors conducted in-depth spatio-temporal analysis of flooding & river morphology. Despite the mountainous terrain of these districts, which complicates the analysis of inundation patterns due to the rapid onset of flash flooding, efforts were made to understand the impact & behaviour. Flash floods, characterized by sudden floods resulting from intense rainfall within a short duration, typically less than 6 hours, pose significant risks to communities, sweeping through riverbeds, urban areas, and valleys, causing extensive damage and loss of life. The study also explored flood analysis using Sentinel-1 GRD imagery, a weather-independent satellite source. Additionally, river and topographic profiles of the study area were analysed using Google Earth Engine and other Geographic Information System (GIS) software tools.

Background

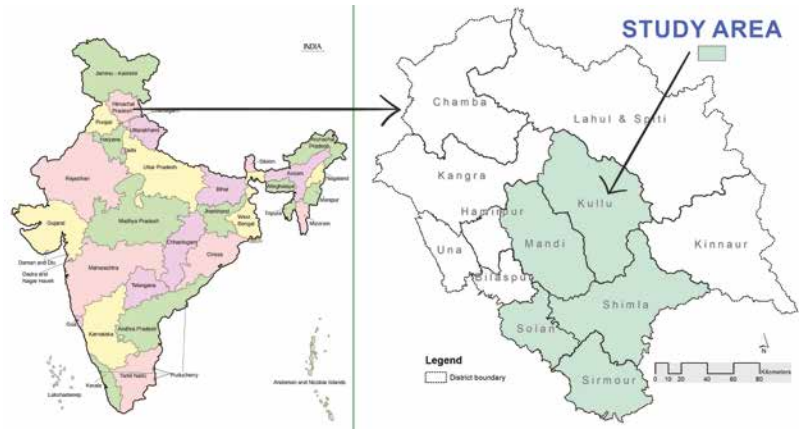
During the year 2023, Himachal Pradesh bore the brunt of natural calamities, with staggering statistics reflecting its severity. Himachal Pradesh suffered losses to the tune of Rs 9,905.77 crore due to heavy rains during monsoon in 2023. As per https://environicsindia.in/ "Extreme events such as flash floods and cloudbursts and associated landslides, subsidence and sinking of land and complete failure of populated hill slopes devastated lives across the State. Estimates suggest 404 people lost their lives, 377 have been injured in the various events across the State. Besides this huge loss of human lives. Over 10,000 livestock perished, and 5,644 cowsheds too were destroyed. Damages to buildings have been significant with 2546 houses and 317 shops completely damaged and 10853 houses partially damaged leaving a large population to seek alternate places to live". The aftermath of this disaster saw over 1,000 roads rendered impassable due to downed power lines and extensive infrastructure damage. Notably, around 70,000 tourists were evacuated from the affected areas, as confirmed by the Hon'ble Chief Minister, Himachal Pradesh, Sh. Sukhvinder Singh Sukhu. The rescue operations, spearheaded by the Indian army and the National/State Disaster Response Force, underscored the gravity of the situation. Numerous districts endured a deluge that equated to a month's worth of rainfall within a single day. The overflowing rivers exacerbated the situation, causing floods and landslides that obliterated vehicles, bridges, roads, and disrupted power and electricity supply.

The landslides inflicted further havoc, washing out key transportation arteries such as the Himalayan Expressway and sections of the Kalka–Shimla Railway. In Shimla region, the additional floods and landslides claimed the lives of 71 individuals. Notably, a massive landslide in Shimla decimated roads and structures, adding to the city's woes. (https://en.wikipedia.org/)

(Pic:1 AI generated picture by Shashi Shekhar- Author, depicting that our lifestyle will decide our future)

Study area

Three intense spells of extreme weather occurred between July 8th to 11th, August 14th to 15th, and August 22nd to 23rd, resulting in significant impact, with 163 identified landslides and 72 flash floods. As per the Himachal Meteorological Department, the state received 224.1 mm of rainfall during five days between July 8 and July 12 against 2023 its normal rainfall of 42.2 mm, a deviation of 431% from average rainfall, which was the highest since 1980. Among the severely affected regions were Kullu, Mandi, Shimla, Sirmaur, Solan, and Chamba districts of Himachal Pradesh. Considering the districts most severely impacted, the study area for the current analysis has been narrowed down to five districts: Kullu, Mandi, Shimla, Sirmaur, and Solan.



Map-1: Study area in Himachal Pradesh

Population pattern

The population concentration primarily resides within the valley, gradually extending into higher elevations. According to WorldPop data, population density is highest in plains and valleys, reaching up to 224 persons per 90-meter pixel. This observation aligns with the land use patterns depicted in the ESRI 2020 land use and land cover dataset, where built-up areas exhibit a similar distribution (Refer Map 3&4).

Map-2: Major settlements in study area

Rainfall-induced flash floods

Mapping rainfall-based flash floods in mountainous regions poses significant challenges due to the intricate terrain and

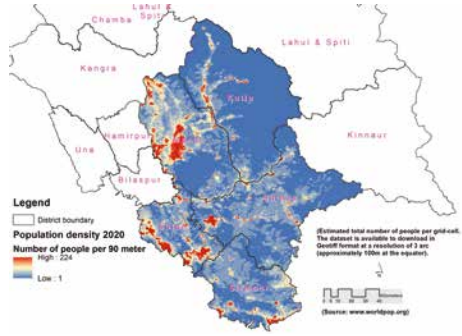
dynamic weather patterns. Many satellites operate on a five-day revisit cycle, which often proves insufficient for capturing flash flood events in mountainous areas. The rugged topography of mountains accelerates rainfall accumulation, fostering unpredictable runoff and erosion dynamics. Moreover, steep slopes and narrow valleys exacerbate rainfall intensity, complicating precise predictions of flash flood occurrences. Furthermore, restricted access to remote regions and sparse monitoring infrastructure impede endeavours to effectively map and forecast flash floods in mountainous terrain.

The Map-5 suggests that while the normal rainfall pattern in areas more affected by disaster is slightly lower compared to the higher rainfall areas of the Kangra region, runoff appears to be the decisive factor in triggering flash floods in Kullu valley (see Map 5 & 6). The relationship between rainfall patterns and runoff appears strong, underscoring the importance of variables like rainfall intensity, slope, and elevation in flood-induced disasters. Graph-1 further illustrates this robust correlation between rainfall and runoff.

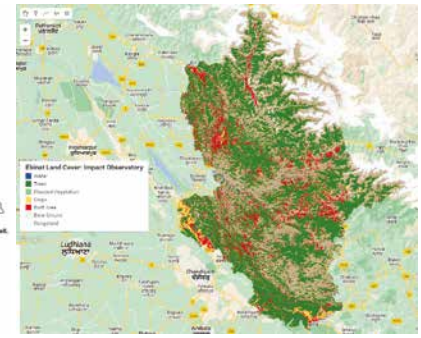
July 9th 2023 recorded 84.6 mm of precipitation cumulatively in five districts, followed by three more peaks that played havoc to the region and posed risks to life and property (see Graph-1).

Rainfall deviation from long term mean

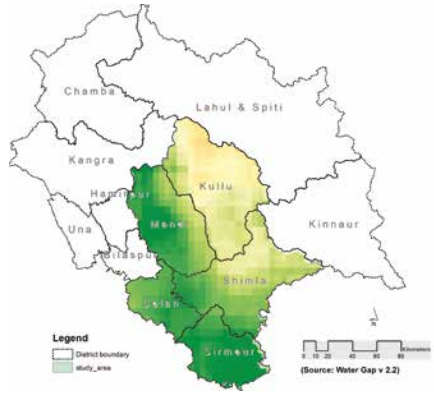
The average monthly rainfall for each month from 1987 to 2023 was calculated by summing up the rainfall for that month across all years and dividing it by the total number of years. Then, the percentage deviation for each month in 2023 was computed by comparing its rainfall with the respective average. Notably, rainfall decreased in February and March of 2023, while September 2023 saw a 100 percent positive deviation. On the whole, the monsoon rainfall showed an increase in 2023. Further intensity of rainfall also increased significantly.



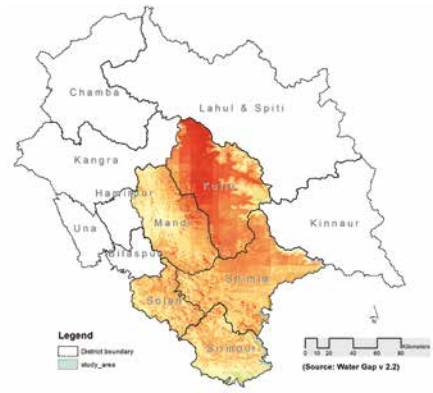
Map – 3: Population density as per WorldPop dataset for the year 2020



Map – 4: ESRI 2020 Global LULC dataset with a resolution of 10 meters



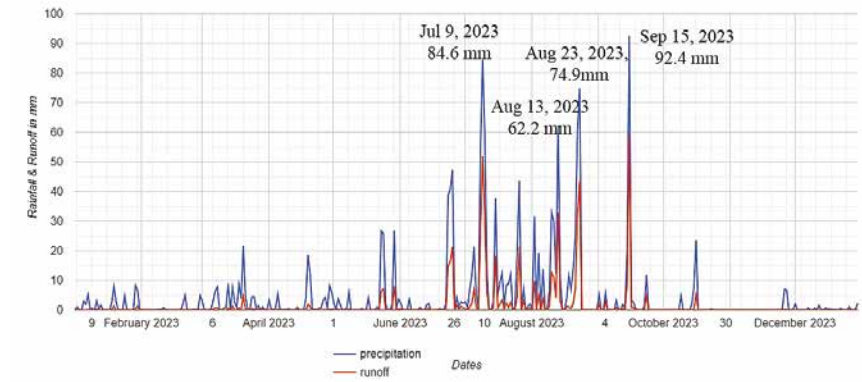
Map – 5: Rainfall intensity (Green reflecting high and yellow reflecting low)



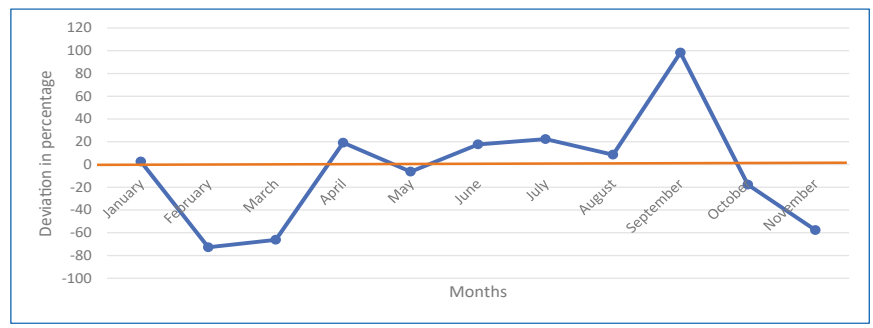
Map – 6: Runoff (Red very high and yellow very low)

(Source: Annual average rainfall for the year 2023 Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)

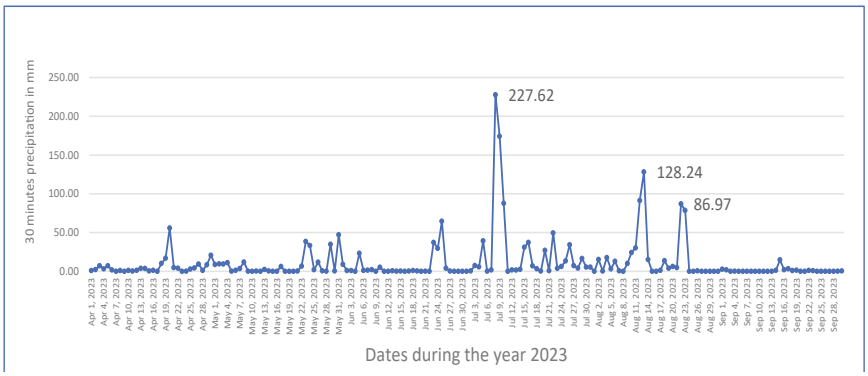
Graph-1: Rainfall runoff time series 2023 for five districts namely Kullu, Mandi, Shimla, Solan and Sirmaur



Graph-2: Precipitation deviation of 2023 from long term mean (1987-2023) in percentage



Graph – 3: Daily precipitation intensity estimation at Kullu, the most affected town



Chart– 4: Estimated 30 minutes precipitation at Shimla Town

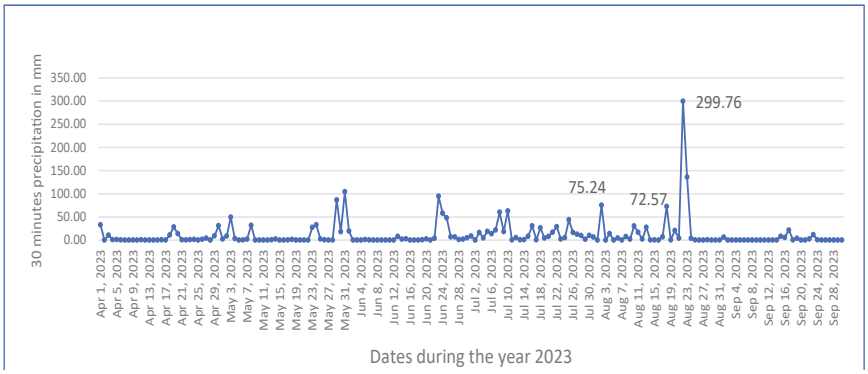


Chart – 5: Monthly Precipitation during last 3 years (mm)

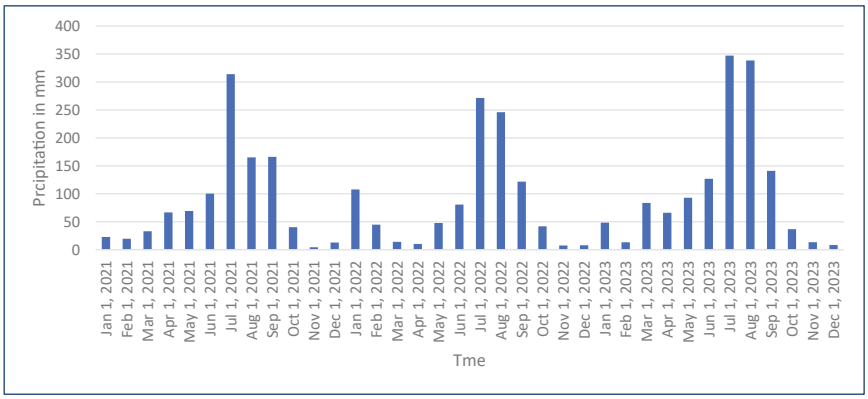
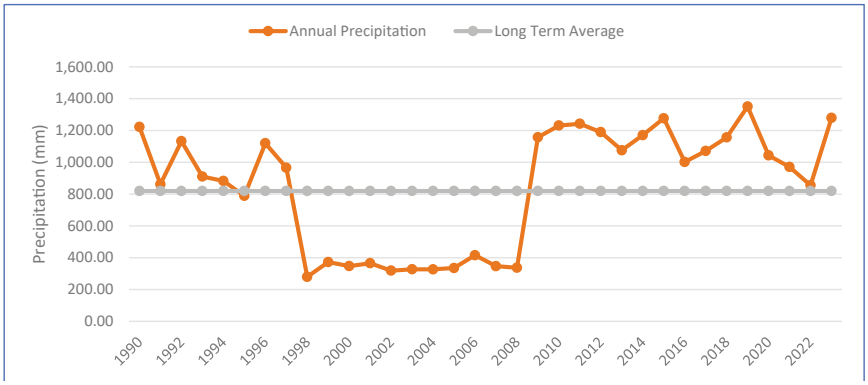


Chart – 6: Total Annual Precipitation from 1990 to 2023



Daily precipitation intensity

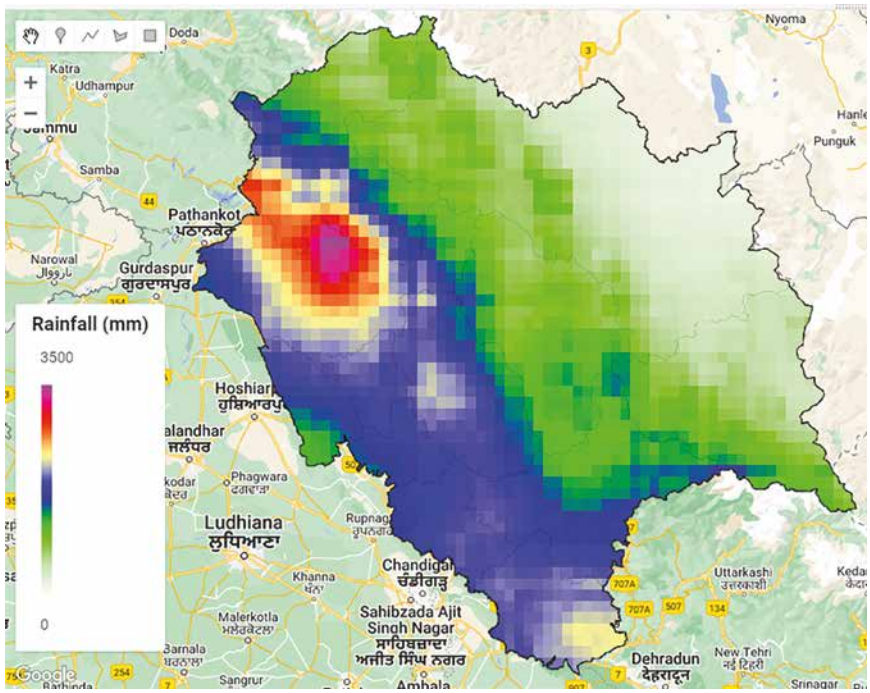
It appears that the 30-minute rainfall indicates a notably high intensity of rainfall in August 2023, leading to rapid runoff and flash flooding along the rivers and khads (see Graph – 3). It is noteworthy that human settlements in Himachal Pradesh are predominantly located along the valley, and this trend is steadily consolidating each year, contributing to an escalation in population density (see Map – 3). The rainfall intensity is plotted graphically for Kullu and Shimla separately, visualised at Graphs - 3 & 4).

The Graph -4 of Shimla illustrates the estimated 30-minute precipitation, computed using Google Earth Engine. This notable peak in precipitation occurred during August 2023 and led to significant losses due to numerous landslides and landslips (see Pic-2).

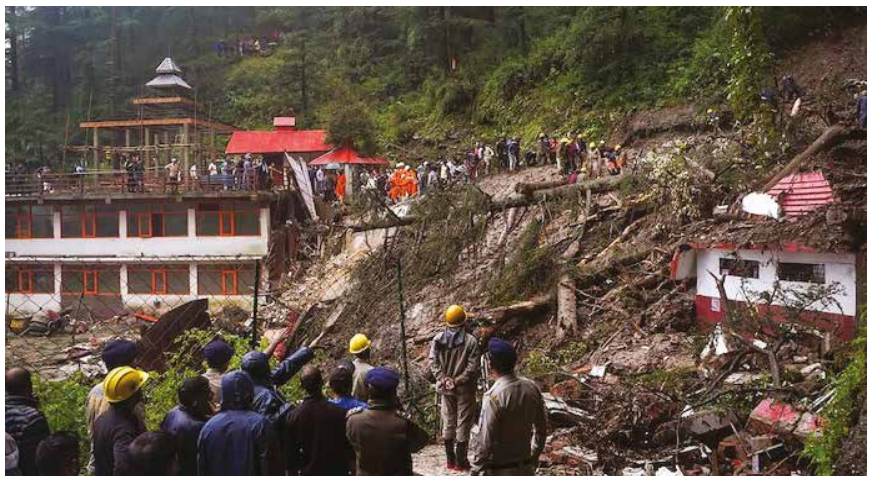
Precipitation estimation – methodology

Precipitation data for Kullu town is derived from the Global Precipitation Measurement (GPM) initiative. GPM is an international satellite mission designed to offer advanced observations of rain and snow across the globe every three hours. The Integrated Multi-Satellite Retrievals for GPM (IMERG) serves as the unified algorithm for estimating rainfall, amalgamating data from all passive-microwave instruments within the GPM Constellation.

This algorithm aims to intercalibrate, merge, and interpolate satellite microwave precipitation estimates alongside microwave-calibrated infrared (IR) satellite data, precipitation gauge analyses, and potentially other precipitation estimators. It operates multiple times for each observation period, initially providing a preliminary estimate and subsequently refining its estimates with incoming data. The final iteration incorporates monthly gauge data to produce research-grade products.



Map – 7: Annual average rainfall for the year 2023, Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)



(Pic-2: Rescue personnel search for victims after a temple collapsed in Shimla on 14 August 2023 Source: India Today)

Sar-flood mapping using a change detection approach

However, it is noteworthy that a single SENTINEL-1 satellite has a revisit time of once every 12 days, and the two-satellite constellation offers a 6-day exact repeat cycle, rendering it unsuitable for assessing instantaneous events such as flash floods. Additionally, each scene of Sentinel-1 provides varying resolutions (10, 25, or 40 meters), 4 band combinations (corresponding to scene polarization), and 3 instrument modes.

Google Earth Engine was employed to generate a flood extent map using SAR Sentinel-1 imagery, employing a change detection methodology comparing pre- and post-flood event images. Specifically, Sentinel-1 GRD (Ground Range Detected) imagery was utilized, which undergoes pre-processing steps including Thermal-Noise Removal, Radiometric calibration, and Terrain-correction, followed by the application of a Speckle filter.

The flood extent mapping was derived from the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER). The study area encompassed five districts within the State of Himachal Pradesh, chosen due to flood-related disasters observed in 2023. However, due to the mountainous terrain and narrow rivers, coupled with flash flood-prone valleys, accurately depicting inundated areas proved challenging. Moreover, the classification of snow-covered regions as flood-affected areas further complicates the analysis. Consequently, the utility of Sentinel-1 GRD imagery for this purpose appears limited. However, two maps have been generated using Google Earth Engine (GEE): one illustrating all flood extents recorded between July and September 2023, as depicted in Map 8, while Map 9 specifically highlights areas that experienced severe inundation, resulting in significant loss of life and property during the same period last year.

Hydrographic profile

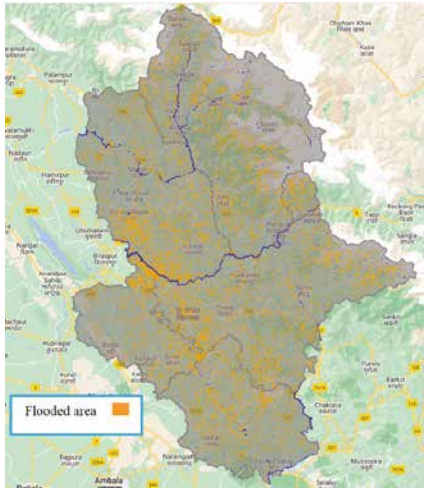
The present analysis utilizes the HydroRIVERS dataset, comprising a vectorized line network encompassing all global rivers with a catchment area of at least 10 km² or an average river flow of at least 0.1 m³/sec, or both. HydroRIVERS is derived from the gridded HydroSHEDS core layers at a 15 arc-second resolution.

Characteristics of River Discharge

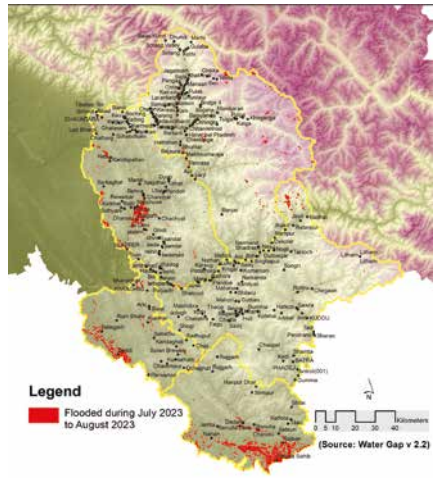
Estimates of discharge and runoff within HydroATLAS are derived from long-term (1971–2000) average "naturalized" values provided by the state-of-the-art global integrated water balance model, WaterGAP (Döll et al., 2003, model version 2.2 as of 2014).

Land Surface Runoff

Runoff, the result of precipitation flowing over the ground surface, has the potential to trigger flash floods by accumulating rapidly, overwhelming natural or man-made drainage systems. Increased runoff, often prompted by heavy rainfall



Map – 8: Sentinel-1 GRD imagery-based flood analysis initially

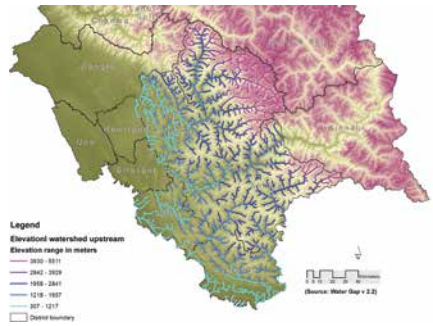


Map – 9: Sentinel-1 GRD imagery-based main flooded area

Map-10: Average annual discharge & river system

Map-11: Land Surface Runoff

Map-12: River area in ha in total watershed upstream of reach pour point



Map-13: River elevation in meters

Map -14: Annual average precipitation in total watershed upstream of reach pour point

Map – 15: Soil erosion as per RUSLE-based Global Soil Erosion Modelling platform

or rapid snowmelt, can elevate water levels in streams, rivers, and urban areas, precipitating flash floods with minimal warning. Consequently, there exists a direct correlation between runoff and the occurrence of flash floods, with heightened runoff levels amplifying both the risk and severity of flash flood events.

In regions like Kullu & Manali, characterized by steep slopes and narrow valleys, excessive runoff swiftly accumulate, precipitating flash flooding events that endanger human life, infrastructure, and the environment. It is imperative to implement effective runoff management strategies, including enhanced land-use planning, watershed management initiatives, and the establishment of early warning systems, to mitigate the adverse impact of flash floods in Kullu and other susceptible areas.

Summary

The study area encompasses diverse topographic features, ranging from plains to highly mountainous terrain. Despite the relatively low rainfall in the area, Kullu valley experienced significant property loss due to intense runoff from higher elevations. The unprecedented rainfall intensity resulted in widespread devastation and havoc throughout the valley. Continuous rainfall triggered intermittent landslides in various parts of the Study area, leading to substantial loss of human life, livestock, and property. Additionally, numerous landslips and landslides occurred in different locations during the last monsoon season.

The State Government has been diligently working to restore normalcy as swiftly as possible. Himachal Pradesh has a resilient history of rebounding from such disasters repeatedly over the years. Significant resources have been mobilized, resulting in the saving of numerous lives. However, these events offer valuable lessons for both the populace and the administration, fostering ongoing learning and adaptation.

The study area encompasses diverse topographic features, ranging from plains to highly mountainous terrain. Despite the relatively low rainfall in the area, Kullu valley experienced significant property loss due to intense runoff from higher elevations.

Disclaimer: All the satellite data or other data have been utilised without validation of data on ground. All geographic information has limitations due to the scale, resolution, date and interpretation of the original source materials. No liability concerning the content or the use thereof is assumed by the authors.

The opinions expressed in the paper are independent of the institutional affiliations of the authors and do not reflect the official views of the Government of Himachal Pradesh.

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NASA, FAA partner to develop new wildland fire technologies

NASA and the Federal Aviation Administration (FAA) have established a research transition team to guide the development of wildland fire technology.

Wildland fires are occurring more frequently and at a larger scale than in past decades, according to the U.S. Forest Service. Emergency responders will need a broader set of technologies to prevent, monitor, and fight these growing fires more effectively. Under this Wildland Fire Airspace Operations research transition team, NASA and the FAA will develop concepts and test new technologies to improve airspace integration.

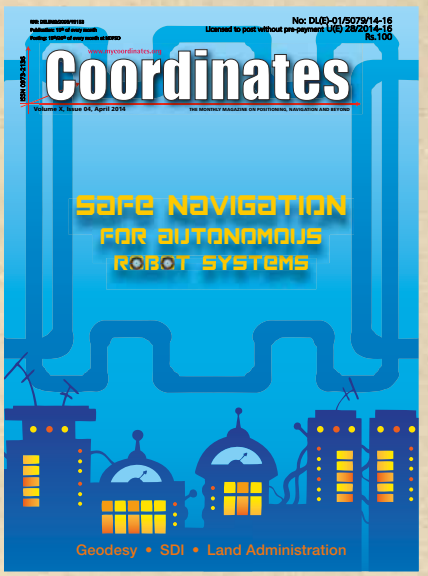
Current aerial firefighting operations are limited to times when aircraft have clear visibility – otherwise pilots run the risk of flying into terrain or colliding with other aircraft. Drones could overcome this limitation by enabling responders to remotely monitor and suppress these fires during nighttime and low visibility conditions, such as periods of heavy smoke. However, advanced airspace management technologies are needed to enable these uncrewed aircraft to stay safely separated and allow aircraft operators to maintain situational awareness during wildland fire management response operations.

Over the next four years, NASA's Advanced Capabilities for Emergency Response Operations (ACERO) project, in collaboration with the FAA, will work to develop new airspace access and traffic management concepts and technologies to support wildland fire operations. These advancements will help inform a concept of operations for the future of wildland fire management under development by NASA and other government agencies. The team will test and validate uncrewed aircraft technologies for use by commercial industry and government agencies, paving the way for integrating them into future wildland fire operations.

ACERO is led out of NASA's Ames Research Center in Silicon Valley under the agency's Aeronautics Research Mission Directorate. *www.nasa.gov*

In Coordinates

10 years before...



mycoordinates.org/vol-X-issue-4-March-2014

Safe Navigation for autonomous Robot systems

Oliver Kurz
Fraunhofer IIS, Germany
Manuel Stahl
Fraunhofer IIS, Germany
Doris Aschenbrenner
Zentrum für Telematik, Germany
Michael Fritscher
Zentrum für Telematik, Germany
Robin Hess
Julius Maximilian University of Wuerzburg, Germany
Klaus Schilling
Julius Maximilian University of Wuerzburg, Germany

The project SiNafaR (German acronym for "Sichere Navigation für autonome Robotikplattformen") aims for identifying requirements, legal aspects in Germany, and finding technological solutions for heterogeneous multiagent systems in the civilian sector, especially in the domain of security services covering large areas.

TUSAGA-Aktif and WEB-based online PPP Services: A case study in ÇORUM

Reha Metin ALKAN, İ Murat OZULU, Veli İLÇİ, F Engin TOMBU and Murat AHİN
Hitit University, Çorum, Turkey

This study aimed to assess the accuracy performance of the Network-RTK technique and web-based online PPP services. The test measurements showed that Network RTK-derived fixed coordinates agreed with the relative positioning solution at a few cm level accuracy in both position and height with a very short occupation time, i.e., couple of minutes.

Spatial Data Infrastructure in the Sultanate of Oman

Ahmed Hamood Mohammed Al-Wardi "PHd Student Candidate", Faculty of Geoinformation and Real Estate (FKSG), Universiti Teknologi Malaysia

Oman is one of the countries, during recent years that sought to adopt the National Spatial Data Infrastructure initiative project due to its tangent need to organize its data within a common frame. This frame fulfills its future ambitions and provides the base from which its long term strategies in all fields of development and fulfillment of requirements for environment management were launched.

Up-to-dateness in Land Administration: Setting the Record Straight

Ying Jing, Rohan Bennett and Jaap Zevenbergen
Faculty of Geo- Information Science and Earth Observation (ITC), Twente University, The Netherlands

A wide range of literature reveals that up-to-dateness in land administration is presented in terms of 'up-to-date', 'updating', 'upgrading', 'renewal', 'dynamism', 'changes', 'maintenance', and 'evolvement'. All these diversified interpretations of up-to-dateness could be equally regarded as the dynamism of land administration.

Georeferencing archive spy satellite images of Hungary

Gábor Bakó, Member, Szent István University's Institute of Botany and Ecophysiology, Hungary
Eszter Góber, Manager, Interspect Aerial Image Archive, Hungary

The Corona satellites were used for photographic surveillance beginning in June 1959 and ending in May 1972.

Mystery of declining monarch butterfly

A new study from the U.S. Geological Survey and partners in the U.S. and Mexico lends new insight into the puzzle of monarch butterfly population declines, showing that migration habitat in Texas and Mexico has largely remained intact over the period of decline.

The new findings indicate that changes to migration habitat are not likely to be a primary cause of population declines and that good migration habitat remains for monarchs, especially in Mexico.

The study drew on data and expertise from both the U.S and Mexico to help complete the picture of habitat change across the full life cycle of the eastern population of migratory monarchs.

"It's an important example of international scientific collaboration," said Jay Diffendorfer, USGS research ecologist and lead author.

Monarch butterflies are well-known for their impressive annual migration. Not all monarchs migrate, but for those that do, their journey can be as long as 3,000 miles, a vast distance for an insect that weighs only one-half of a gram. The eastern migratory population flies northward each spring from their wintering habitat in central Mexico, mating and laying eggs on milkweed in Texas before they die. Subsequent generations migrate into the central and eastern U.S. and southern Canada and continue breeding. In the fall, the last generation completes the annual cycle by foregoing breeding and flying south to the wintering grounds in Mexico, passing through Texas on the way.

Monarch butterfly populations in their wintering habitat in Mexico have sharply declined since the 1990s, with the second-lowest numbers recorded this past winter in an annual survey led by the World Wildlife Fund.

Diffendorfer was in Mexico when the latest monarch population numbers were published, and his observations in the field reflected the latest numbers. "It was shocking to be up there—you're at 10,000 feet in a beautiful fir forest —and there were almost no monarchs," he said. "It was pretty sobering to say the least."

The steep declines in the wintering population have been associated with a loss of milkweed across the midwestern U.S. as a result of the rapid adoption of herbicide-tolerant genetically modified corn and soybeans. The accompanying use of glyphosate herbicide essentially eliminated milkweed in and around agricultural fields in the Midwest.

However, there remains disagreement about the causes of monarch population declines, and some scientists have suggested that fewer monarchs are surviving the long fall migration to Mexico. While the loss of milkweed and other changes to monarch summer breeding habitat have been studied extensively, little research has investigated how land use and land cover change may have affected milkweed and nectar availability in migratory habitat in Mexico and Texas.

The researchers found little evidence of major changes to migratory habitat from 2001 to 2020, estimating only a 2.9% decline in milkweed in Texas, and little to no change in Mexico. Fall and spring nectar resources declined <1% in both regions. Overall, they found that monarch habitat in Mexico and Texas appears relatively more intact than in the midwestern, agricultural landscapes of the U.S.

These findings indicate that habitat loss in the migratory region studied is not likely to be a major cause of monarch butterfly declines, weakening support for the idea that monarchs are not surviving fall migration.

"If there had been big scale changes like we've seen in the Midwest, we would have picked that up," says Diffendorfer. "The hypothesis that losses are happening during migration could still be correct, but it's not because of the types of habitat change we measured."

Despite the low numbers this year, the study highlights how much intact monarch habitat still remains in Mexico and Texas.

"This study provides baseline information to reinforce conservation actions from a Mexican perspective," said Víctor Sánchez-Cordero, Professor at the Instituto de Biología, Universidad Nacional Autónoma de México and co-author on the study. "It justifies the idea of expanding conservation efforts throughout the monarch migratory route in Mexico, which has seen little land use change for some decades. For example, a conservation area network can connect decreed protected areas with newly identified priority areas for conserving the migration corridor for monarchs in Mexico during their fall and spring journey." The study was published in Nature Scientific Reports on March 20.

Digital twin technology in Pune

Genesys International announced that Pune city in India will now adopt the Digital twin map stack of Genesys. A 3D Digital Twin will be seamlessly integrated with a Command and Control Centre, incorporating various IoT sensors. This integration will provide real-time data insights and actionable intelligence to the authorities, enabling them to make informed decisions swiftly and effectively. The scope of work for this project encompasses a wide range of applications including Disaster Management, Fire Rescue, Traffic Management, and Property Tax revenue enhancement. By leveraging advanced geospatial technology. *www.igenesys.com*

NV5 acquires GIS Solution

NV5 Global, Inc. has reached an agreement to acquire GIS Solutions, Inc. provider of enterprise GIS technologies and services including GIS application development, cloud-based database design, data science, and project management. *nv5.com*

Gatwick Airport establishes new geospatial platform

Esri UK has announced that London Gatwick has created a new geospatial platform using Esri's ArcGIS to support multiple operational areas at the airport, including engineering and environmental services. The geospatial platform contains critical infrastructure information spanning the 70-year history of the airport, including BIM, CAD, utilities, environmental, aerial photography and legacy data.

Ocean floor a 'reservoir' for plastic pollution

New research from CSIRO, Australia's national science agency, and the University of Toronto in Canada, estimates up to 11 million tonnes of plastic pollution is sitting on the ocean floor.

Every minute, a garbage truck's worth of plastic enters the ocean. With plastic use expected to double by 2040, understanding how and where it travels is crucial to protecting marine ecosystems and wildlife.

Dr Denise Hardesty, Senior Research Scientist with CSIRO, said this is the first estimate of how much plastic waste ends up on the ocean floor, where it accumulates before being broken down into smaller pieces and mixed into ocean sediment.

Scientific data was used to build two predictive models to estimate the amount and distribution of plastic on the ocean floor - one based on data from remote operated vehicles (ROVs) and the other from bottom trawls.

Using ROV data, 3 to 11 million metric tonnes of plastic pollution is estimated to reside on the ocean floor. The ROV results also reveal that plastic mass clusters around continents - approximately half (46 per cent) of the predicted plastic mass on the global ocean floor resides above 200 m depth. The ocean depths, from 200 m to as deep as 11,000 m contains the remainder of predicted plastic mass (54 per cent). *www.csiro.au*

Melting ice, an expanding phenomenon

Arctic hydrography has undergone major transformations over the past two decades, with a marked decrease in sea ice extent and an increase in liquid freshwater content due mainly to melting glaciers and sea ice.

The new study, recently published in the journal Ocean Science, has integrated surface salinity measurements from the SMOS satellite to assess the Beaufort Sea freshwater content between the years 2011 and 2019 and compare it with estimates from in situ data. The results show an underestimation of freshwater content considering only the numerical model data, with the bias being reduced by 70% by incorporating the satellite measurements.

"Our research demonstrates the critical role that remote sensing of salinity plays in improving our ability to monitor Arctic freshwater content and understand the key processes that influence global climate systems," states Eva de Andrés of the Polytechnic University of Madrid (UPM).

However, the implications of the study extend beyond the Arctic, with possible repercussions on the global circulation system that regulates the Earth's climate. Improved understanding of salinity variations and their relationship with freshwater content will allow better prediction and mitigation of the effects of climate change at both regional and global scales," concludes the scientific team. *www.icm.csic.es*

World's Highest Res EO Satellite

SI Imaging Services (SIIS) in collaboration with its parent company Satrec Initiative, is preparing for the launch of a 100% commercial optical satellite with ultra-high resolution.

SIIS aims to innovate the domestic and international satellite data market by venturing into ultra-high-resolution (30cm) SpaceEye-T imagery in 2025, in addition to providing KOMPSAT imagery. *www.si-imaging.com*

ICEYE signs deal with CDC

ICEYE has announced a new contract with the Centers for Disease Control and Prevention (CDC), which provides the federal agency with access to ICEYE Flood Insights for events across the United States and its territories.

It will deliver flood impact data and analysis to teams at CDC's Geospatial Research, Analysis, and Services Program (GRASP). GRASP is CDC's leading geospatial unit, partnering with groups across the agency to analyze, visualize, and map complex data sets — leveraging GIS expertise to explore the link between location and public health. *www.iceye.com*

NOAA awards Small Business Innovation Research Program Grant to Hydrosat

Hydrosat has been awarded a grant from the United States National Oceanic and Atmospheric Administration (NOAA) Small Business Innovation Research (SBIR) program. It funds the development of innovative solutions that demonstrate excellent commercial potential.

Hydrosat collects, processes, and analyzes thermal infrared satellite images to provide a leading indicator for water stress, and provides irrigation and water management solutions to growers to help them farm more efficiently. *www.hydrosat.com*

Planet Insights Platform

Planet Labs announced Planet Insights Platform, the all-in-one place for creating Earth insights. It is a milestone in the journey to unify Planet's product portfolio and the power of Sentinel Hub, which Planet acquired last year. *www.planet.com*

China launches new remote sensing satellite

China successfully launched a new remote sensing satellite from the Xichang Satellite Launch Center in southwest China's Sichuan Province on April 3, 2024. A

Long March-2D rocket, carrying the Yaogan-42 01 satellite, blasted off at 6:56 a.m. Beijing Time and sent the satellite into its designated orbit. *news.cgtn.com*

SLU, TGI researchers use remote sensing to study permafrost

Saint Louis University is one of five universities working together to study permafrost using hyperspectral remote sensing, as part of a grant funded by the Department of Defense (DoD) as part of its Multidisciplinary University Research Initiative (MURI) program.

The project, Interdisciplinary Material Science for the Hyperspectral Remote Sensing of Permafrost (I'M SHARP), will explore the physical and chemical properties of permafrost using remote sensing. The permafrost properties will be reviewed under current and potential environmental conditions.

The DoD awarded the highly competitive five-year, $7.5 million overall MURI grants to 30 teams at 73 academic institutions earlier this month after the Army Research Office, Air Force Office of Scientific Research, and Office of Naval Research solicited proposals in areas of strategic importance to the Department. *www.slu.edu*

Unlocking clearer views of our world's water: A Landsat legacy

Satellite remote sensing is vital for monitoring marine and freshwater ecosystems, leveraging missions like SeaWiFS, MODIS, MERIS, Landsat, and Sentinel to track water parameters such as chlorophyll, sediment, and temperature. The dynamic nature of water bodies demands high-frequency observations for accuracy, with limitations highlighted by factors like clouds and sunlight.

Despite its longer revisit cycle, Landsat's observations are invaluable for inland and coastal waters, emphasizing the need for more frequent data to monitor the dynamic changes in aquatic ecosystems effectively.

In a recent study published in the Journal of Remote Sensing, advancements in analyzing water environments via Landsat missions are revealed. For the first time, this research offers a global assessment of cloud-free observations (NCOs) from Landsat, emphasizing its critical contribution to environmental and hydrological studies, marking a significant leap in our capability to monitor and understand water bodies on a global scale.

The study embarked on an ambitious journey to unravel the intricacies of NCOs via the Landsat missions. By meticulously analyzing over 4.8 million Landsat images spanning from Landsat 5 through Landsat 8, they uncovered striking spatial and temporal variations in cloud-free data across the globe.

Their research illustrated Landsat-8's superior performance, offering nearly double the mean annual NCOs compared to its predecessors. This leap in data quality is particularly pronounced in areas with orbital overlaps, especially above the 45°N latitude, where observation quality is significantly enhanced.

Furthermore, this work delves into the vital role of these overlaps in augmenting the quantity and quality of observations, presenting a game-changer in how we monitor and understand the dynamics of the Earth's water environments.

The study's lead researcher emphasized, "Our analysis not only showcases Landsat-8's superior capability in providing nearly twice as many mean annual NCOs as its predecessors but also highlights the importance of adjacent orbit overlaps in improving observation quality, particularly above 45°N latitude."

The findings hold profound implications for enhancing the accuracy of long-term environmental change detection and monitoring. By leveraging improved NCOs, researchers and policymakers can make more informed decisions, particularly in managing water resources and addressing ecological challenges. *https://phys.org*

SPH Engineering launches Drone Show Software 4.3

SPH Engineering released its latest Drone Show Software update, version 4.3. This update introduces cutting-edge features to streamline preflight processes, enhance map visualization and sharing capabilities, and improve operational efficiency for drone professionals worldwide. *https://www.droneshowsoftware.com*

Remote sensing data can reduce the bias in Arctic melt estimates by up to 70%

As the effects of climate change continue to reshape the Arctic landscape, a new study led by the Institut de Ciències del Mar (ICM-CSIC) in Barcelona in collaboration with the Nansen Environmental and Remote Sensing Center (NERSC) in Norway has revealed that data collected by satellites help reduce the bias of melt estimates made from numerical models by up to 70%.

Specifically, the paper discusses salinity measurements taken by the 'SMOS' (Soil Moisture and Ocean Salinity) satellite, which has been sending data to the European Space Agency (ESA) antennas since 2009 to calculate ocean salinity and land moisture, key to better understand ocean circulation and the water cycle, deepening hurricane or fire prevention, and improving snowmelt estimates.

"By integrating satellite-derived surface salinity measurements with data from the TOPAZ Arctic numerical model, we were able to significantly improve our estimate of freshwater content and better monitor changes in the Beaufort Sea, a critical area within the Arctic affected by rapid environmental changes," explains the ICM-CSIC researcher Marta Umbert, leading author of the study.

This highlights the ability of satellite data to contribute to the monitoring of freshwater dynamics in cold regions such as the Arctic, with significant implications for the understanding of global climate systems.

New International Office of RIEGL in Germany

RIEGL is strengthening its presence in the German market with the establishment of the new RIEGL Deutschland (Germany) office based in Gilching near Munich. With headquarters located in Austria and the U.S., along with offices worldwide, this is just another logical step to meet the constantly growing demand for LiDAR technologies in applications for surveying, construction, and the infrastructure segment.

Xona Space Systems, Aerospacelab partnership

Aerospacelab and Xona Space Systems have announced their partnership to promote PNT.

Under the terms of the agreement, Aerospacelab will leverage its Versatile Satellite Platform (VSP) capabilities to design, manufacture, and launch Xona Space Systems' upcoming navigation satellite, assist Xona Space Systems in obtaining the necessary operator license, and support launch operations for two years. Xona Space Systems will provide the PNT payload for integration into Aerospacelab's platform. *www.aerospacelab.com*

SparkFun releases Iridium antenna

SparkFun Electronics has released the 2J7426MPz by 2J antenna, a high-performance magnetic mount antenna designed to communicate with the Iridium satellite communication system. The antenna housing is waterproof to IP69 standards and designed to operate in extremely harsh environments, including those with frequent exposure to water, dust and debris. *www.sparkfun.com*

Quectel unveils 5G and GNSS antennas

Quectel Wireless Solutions has made further additions to its comprehensive range of antennas for IoT devices and deployments. The latest launches include the YEMN016AA and YEMN017AA5G 5-in-1 combo antennas, the YECN001J1A and YECT000WBA external 5G antennas and the YEGB000Q1A and YEGN000Q1A active GNSS L1 and L5 antennas.

The YEGB000Q1A and YEGN000Q1A active GNSS L1 and L5 antennas are designed to precisely tap into L1 and L5 frequency bands. Quectel's GNSS antennas are part of a broader release that includes the YEMN016AA and YEMN017AA 5G 5-in-1 combination antennas, which also feature GNSS capabilities. *www.quectel.com*

Inertial Labs enhances INS solutions

Inertial Labs has announced an under-development valuable addition of our INS-aiding data ecosystem to the FT743-D-SM wind/air speed sensor from FT Technologies. This Acoustic Resonance, air speed sensor, enables multi-rotor UAVs to estimate their horizontal air speed better, enhancing position estimation accuracy in GNSS-denied environments.

The FT743-D-SM air speed sensor adopts a digital anemometer-based solution by being able to estimate air speed incoming from any direction using an innovative Acoustic Resonance-based technology, which is immune to vibration and external acoustic noise. *inertiallabs.com*

Abracon releases new GNSS RF Antennas

Abracon has announced their new line of high-accuracy, high-precision GNSS antennas. These GNSS antennas can support full band including all L1/L2/L5 + L band data correction services. They are designed with multi-band and multi-constellation support, ensuring compatibility across a wide range of applications. *abracon.com*

Saildrone launches the first unmanned surface vehicle

Saildrone has launched the first aluminum Surveyor unmanned surface vehicle (USV). Primarily designed for ocean mapping and maritime domain awareness, the USV is powered by wind, solar, and a diesel generator for long-range, long-endurance missions in the open ocean.

The Surveyor carries the latest multibeam sonar equipment for seafloor mapping to depths of 11,000 meters (36,000 feet) and purpose-built defense and security payloads for accurate, dynamic, and confident decisions and responses to the full spectrum of maritime threats and challenges. Upcoming Navy missions will focus on the ability of the Surveyor to deliver both surface and undersea intelligence for a range of high-priority applications, including anti-submarine warfare (ASW). *www.saildrone.com*

CMC Electronics and Hexagon partner for GNSS innovation

CMC Electronics and Hexagon's Autonomy & Positioning division make a significant advancement in the field ofGNSS) positioning technology for aviation with the development of a leading-edge multi-constellation, multi-frequency (MCMF) GNSS platform. Merging CMC's certification expertise with industry-leading digital signal processing from Hexagon | NovAtel this new MCMF GNSS platform provided by CMC is engineered to tackle tomorrow's challenges. With a focus on enhanced detection of spoofing and jamming, lighter weight and a smaller form factor, this innovative solution will shape the trajectory of GNSS technology for the future. *cmcelectronics.ca*

EpiSci, Northrop Grumman collaboration

Northrop Grumman Corporation is collaborating with EpiSci to further develop advanced, trusted autonomous tactical solutions for the United States and its allies.

EpiSci's TacticalAI software will integrate into Northrop Grumman's aeronautics system architecture to accelerate the delivery of advanced autonomous solutions.

Using the U.S. government's open-architecture design, Northrop Grumman's autonomy solutions are able to incorporate third-party collaborative platform technologies that allow uncrewed aircraft systems to adapt to changing mission requirements and provide flexibility to military commanders in complex environments. *northropgrumman.com*

Zighra awarded contract with Canadian Coast Guard

Zighra has announced a new contract with the Canadian Coast Guard for its GenesysInsights platform. It will enhance the safety and security of Canada's maritime territories by providing a previously unattainable level of analysis. It offers unparalleled automated threat detection and comprehensive situational awareness in maritime environments. The platform synthesises information from GNSS signals and terrestrial and space-based AIS data helping to significantly contribute to the Canadian Coast Guard's capabilities in detecting and responding to maritime threats. This initiative is part of the Innovative Solutions Canada program. *zighra.com*

Geneq unveils the SXblue GLOBE

Geneq Inc has introduced SXblue GLOBE, the pinnacle of innovation in GNSS positioning and GIS technology. Carrying a 448 channel GNSS board, it ensures unparalleled accuracy and integrity in positioning, even in the most demanding environments. It incorporates an advanced anti-jamming and interference monitoring system, safeguarding against disruptions and ensuring uninterrupted operation in any scenario. *www.sxbluegps.com*

Kongsberg Discovery launches hydrographic surveying solution

Kongsberg Discovery has released the Seapath 385 navigation system. It is designed to enhance precision in hydrographic surveying by using advanced navigation algorithms and integrating a range of satellite signals, including GPS, GLONASS, Galileo, Beidou and QZSS, alongside geostationary satellite signals.

The system combines raw inertial sensor data from Kongsberg Discovery's proprietary high-performance motion gyro compass (MGC) or motion reference unit (MRU) with GNSS data and corrections from real-time kinematics (RTK), precise-point positioning (PPP) or Differential Global Navigation Satellite System (DGNSS). *www.kongsberg.com*

Telit Cinterion unveils high-precision GNSS IoT Module

Telit Cinterion has launched SE868K5-RTK module, a high-precision GNSS receiver. Designed for seamless operation near cellular or other radios, it ensures optimal immunity. At 11×11 mm, the module's compact form factor offers adaptability in size-constrained scenarios and easy migration within the scalable xE868 family. It is a multifrequency and multiconstellation positioning receiver module fortified by RTK capabilities that enhances positioning accuracy. *www.telit.com*

Swift Navigation and Telit Cinterion partnership

Swift Navigation and Telit Cinterion recently unveiled their joint solution to empower ultra-low power consumption devices, such as wearables, robotic lawn mowers, and vehicle tracking devices with precise GNSS positioning. *www.swiftnav.com*

Topcon and Bentley strategic agreement

Topcon Positioning Systems has announced strategic agreements with Bentley Systems and Worldsensing to integrate its advanced GNSS technology into the companies' innovative software and connectivity solutions.

As part of its agreement with Bentley Systems, Topcon will provide access to its powerful web-based GNSS processing engine. Bentley has integrated this technology into their advanced iTwin IoT monitoring solution.

Worldsensing has integrated the Topcon AGM-1 GNSS receiver with its Thread X3 broadband product. The result is a new Accurate Positioning System to monitor geohazards such as rock falls and landslides in pit mines, rail embankments and other ground structures. *bentley.com*

Iridium Agrees To Buy GNSS Protector Satelles

Satellite network operator Iridium Communications will pay about $115 million to acquire the remaining 80 percent of Satelles, a provider of "secure satellite-based time and location services that complement and protect GPS and other GNSS-reliant systems." Iridium had previously invested in Satelles and owned about 20 percent of it.

While Satelles focuses primarily on providing its satellite time and location (STL) services for digital infrastructure companies, there are potential applications for aviation. Satelles offers smaller form factor devices that can be integrated with data processing and storage servers to provide critical positioning, navigation, and timing (PNT) data.

STL could help mitigate GNSS jamming and spoofing, with dedicated STL receivers incorporated into aircraft avionics.

Enhancing timing synchronisation for enterprise applications

The HUBER+SUHNER GNSS and Power-over-Fiber solution eliminates the need for a separate energy source to power the active antenna for applications that use GNSS for navigation, positioning, timing and geodesy. This avoids voltage spikes, minimises spoofing risk, and enables separate antenna positions for reliable signal transmission.

The latest version has been enhanced to meet the needs of companies, banks etc. which require precise time synchronisation. To achieve this, all the nodes in the database cluster must

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https://locate.geospatialcouncil.org.au

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Ottawa, Canada
https://geoignite.ca

FIG Working Week 2024
19 - 24 May
Accra, Ghana
www.fig.net/fig2024/Welcome.htm

National Surveyors' Conference
21 –24 May 2024
Cardigan, PE Canada
https://www.acls-aatc.ca/nsc-2024

June 2024

GEO Business 2024
05 - 06 June
London, UK
https://www.geobusinessshow.com

Training on Glacier studies and Remote sensing
18-28, June 2024
Indian Institute of Science,
Bengaluru, India
https://iisc.ac.in

July 2024

Esri User Conference
15 - 19 July 2024
San Diego, CA, USA
www.esri.com

August 2024

International Geographical Congress 2024
24 - 30 August
Dublin, Ireland
https://igc2024dublin.org

September 2024

ION GNSS +
16-20 September
Baltimore, USA
https://www.ion.org/gnss/index.cfm

2024 GEO Symposium and Open Data & Open Knowledge Workshop
23 - 26 September 2024.
Hangzhou, China
https://earthobservations.org/events

November 2024

Trimble Dimensions
11-13, November 2024
Las Vegas, USA
www.trimble.com

GeoWorld
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www.geoworldevent.com

be consistent to ensure the secure transfer of data between data centers and from the cloud to the edge.

Synchronising clocks via GNSS provides high accuracy and stability over long distances, with precise time calculation for every location on earth. It provides the most accurate time reference for Precision Time Protocol (PTP) and Network Time Protocol (NTP), two of the most common methods for setting network devices' clocks.

Using fiber optics for synchronisation minimises the risk of errors compared to traditional reference methods.

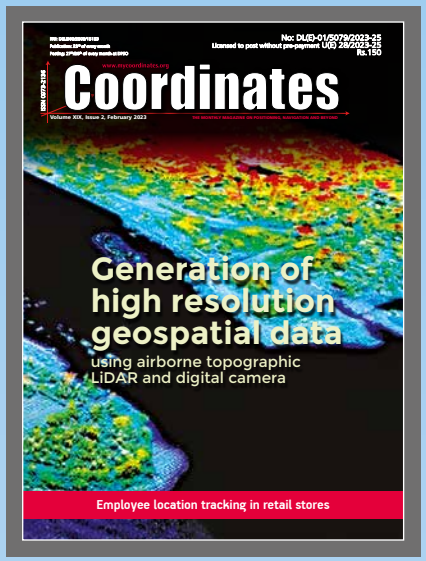
Cognni revolutionizes data mapping

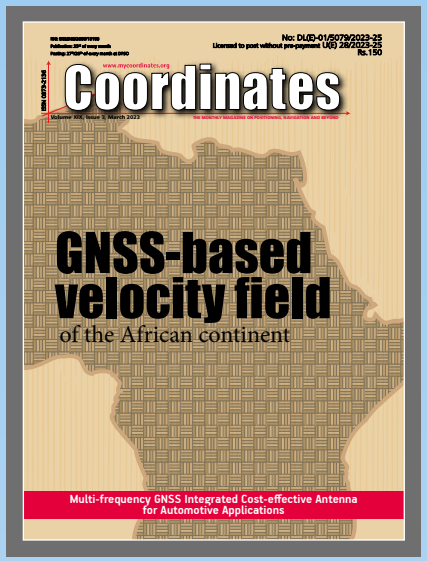
Cognni Ltd has launched of its Data At-Rest discovery and classification solution. It is a zero-effort solution that leverages Cognni's proprietary AI technology to autonomously scan, map, and classify data stored in databases, files, and cloud services. This solution provides actionable insights and recommendations, as well as assigns sensitivity labels and information types to each data element, mitigating data risks and ensuring compliance with data privacy regulations. *www.cognni.ai*

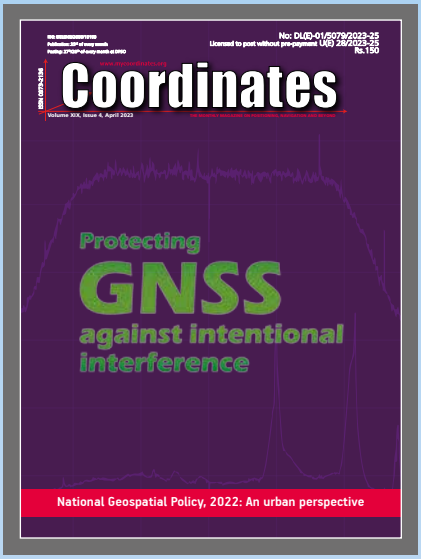
FrontierSI urges action on resilient PNT infrastructure

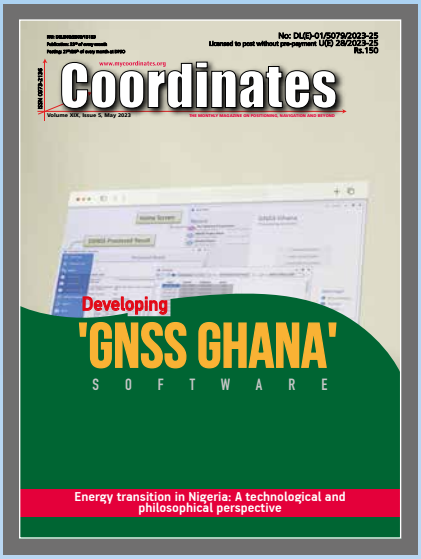
FrontierSI unveils a review of government policy to strengthen Australia's Positioning, Navigation, and Timing (PNT) infrastructure with a new white paper and technical report. In an era defined by digital dependency and cyber threats, ensuring the resilience of PNT technology is imperative to maintain uninterrupted access and safeguard our nation's future.

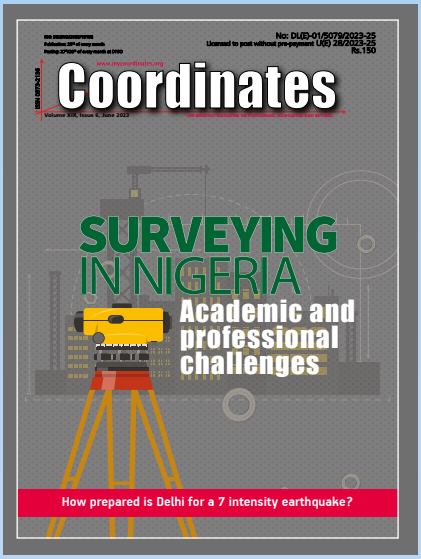
Recent technological glitches and malicious cyber activities have highlighted vulnerabilities within Australia's PNT ecosystem. When satellite signals falter, industries such as agriculture and maritime feel the sting, emphasising weaknesses that demand attention. *frontiersi.com.au*

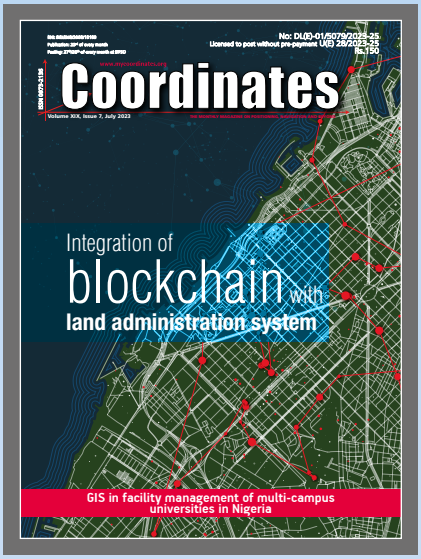


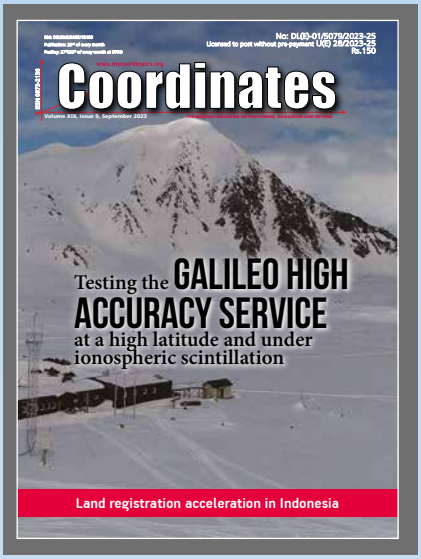












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