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

www.mycoordinates.org

Coordinates

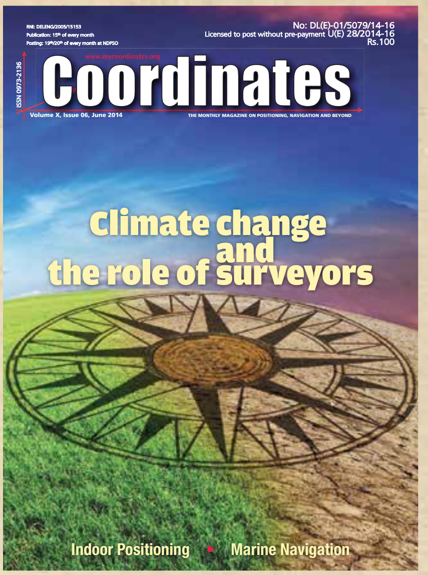
ISSN 0973-2136
Volume XX, Issue 6, June 2024
THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Renewable Power in Shared Spaces Empowered by LAS:
The Role of Energy Entitlement

Digital transformation in India

In Coordinates

10 years before...



mycoordinates.org/vol-X-issue-6-June-2014

Trends in indoor positioning

Jeong-Min Lim and Tae-Kyung Sung, Chungnam National University, Korea

Surging smartphone market and increased use of WiFi gives new opportunities to indoor positioning technology. The developer could use WiFi signal by measuring RSS or AOA. Some positioning techniques based on these measurement gives positioning result only in a small area. In this case, pedestrian dead-reckoning method can be used together in order to give seamless position in indoor environment.

Certification of a Galileo Test Range

Volker Logemann and Martin Grzebellus, NavCert GmbH Braunschweig, Germany

The Galileo Test Environment GATEis already ideally suited to test Galileo receivers in a real-life environment with multi-path and atmospheric conditions. It is unique and outperforms laboratory based simulators in this respect.

The consensus among climate researchers and politicians has never been greater

Dr Frank Friesecke, Director, STEG Academy, Germany

In my opinion, disaster risk management could (and should) be an urgent eld of application for a surveyor.

Implementing multipurpose cadastre in Malaysia

Hasan Jamil, Mohd Yunus Mohd Yusoff and Nur Zurairah Abdul Halim, Department of Survey and Mapping Malaysia, Wisma JUPEM, Kuala Lumpur, Malaysia

The MPC Pilot Project for the Federal Territory of Putrajaya has enabled JUPEM to understand the complexity in the implementation of the MPC for Malaysia. It is hoped that the ndings and recommendations based on the pilot project will enable the successful gradual implementation of the MPC for the whole country.

Climate change and the role of surveyors

Dr Isaac Boateng, School of Civil Engineering and Surveying, University of Portsmouth, UK

It is important to state that the issue of climate refugees is very complex and may require a huge effort and engagement of the international community. However, surveyors are used to dealing with complex problems and taking a lead role on this issue is not beyond their capacity.

Approaches to Resilient PNT

Dr Nick Ward, Research Director, General Lighthouse Authorities, UK & Ireland

Whilst everybody in the maritime sector agrees on the need for Resilient Positioning Navigation and Timing (PNT), the way to achieve is not so clear. The problem is analysed in this article and a method of assessing the various alternative solutions is proposed.

ION®
INSTITUTE OF NAVIGATION

ION GNSS+

September 16-20, 2024

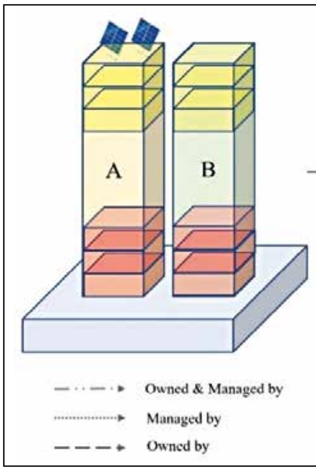
Exhibit Hall: September 17 and 18

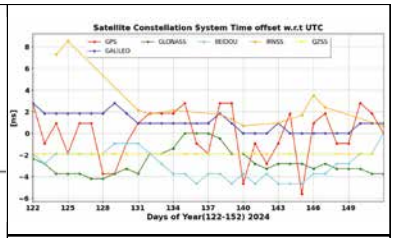
Hilton Baltimore Inner Harbor
Baltimore Inner Harbor, Maryland

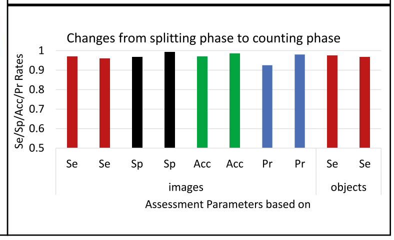
2024

REGISTER TODAY

ion.org/gnss







In this issue

Coordinates Volume 20, Issue 6, June 2024

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies
Abbas Rajabifard, Aravind Poshnath, Behzad Rismanchi, Darren Ansell, John McCarthy, Kaya Kuru, Narayan Dhital, Siva Kumar Rachapudi, Stephanie McGovern, and Stuart Clough; 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.

India: Navigating Satellite Launch Dilemma

The Indian Space Research Organisation (ISRO) Chairman recently reportedly highlighted that

India has surplus launch capability

Amid limited global demand.

Building low-cost rocket is not enough,

In the absence of a robust market.

There is a need to cultivate a domestic satellite industry,

Incentivize manufacturing,

Attract private investment,

To optimize space capabilities and its potential.

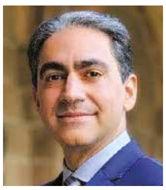
Resulting into boosting India's space ambitions.

Bal Krishna, Editor
bal@mycoordinates.org

Paving the Way for Renewable Power in Shared Spaces Empowered by Land Administration System: The Role of Energy Entitlement

Energy allocation demands an explicit approach with necessary legal and policy implications, acting as a ground for dispute resolutions

Aravind Poshnath
Doctoral Research Scholar in the Department of Infrastructure Engineering at the University of Melbourne



Dr Behzad Rismanchi
Senior Lecturer heading the Renewable Energy and Energy Efficiency Group at the Department of Infrastructure Engineering of the University of Melbourne

Prof Abbas Rajabifard
Discipline Leader of Geomatics at the Faculty of Engineering & IT, Associate Dean Sustainability, and the Director of the Centre for Spatial Data Infrastructures and Land Administration (CSDILA), The University of Melbourne

Introduction

As city populations surge, with projections indicating that two-thirds of the global populace will be urban dwellers by 2050, strategic management of resources and practical planning becomes paramount. Despite covering a mere 3% of the land area, cities contribute around 80% of the global GDP while generating 72% of greenhouse gases. The expanding trajectory of disasters complements these alarming statistics and is well acknowledged by the United Nations through the introduction of a distinct 'Sustainable Development Goal' (SDG 11), underscoring the urgency of enhancing urban living conditions. With the projected increase in city dwellings, a balanced focus on sustainability and resource utilisation is inevitable.

The global electricity grid predominantly relies on non-renewable, centralised energy sources. Incidents of natural disasters often trigger massive power blackouts, thereby affecting emergency services. Moreover, these grids are often not designed to handle abrupt spikes in energy demand during crises. Thus, researchers advocate decentralising energy to cater to multiple communities due to the detrimental effects of heavy reliance on a single energy system (Charani Shandiz et al., 2020). By extensively deploying renewable energy systems (RES), cities can fortify their energy resilience while bolstering sustainability.

Space limitations in cities caused by rapid urbanisation necessitate the development of multi-storeyed buildings for commercial, residential, or mixed-use purposes. These buildings may be individually owned by a person or a company, or collectively owned by numerous individuals, as often observed in residential buildings. The residential 'Multi-Owned Buildings' (MOBs) accommodate multicultural families, serving as a community. However, unlike the residents of detached homes, the residents in MOBs jointly share and own the building amenities. According to the 2016 census data (ABS, 2017), there is one occupied apartment in Australia for every five detached houses. The affordability of the apartments, compared to detached houses, coupled with the limited land stock, has also contributed to the growth of MOBs in major cities worldwide.

Challenges in Renewable Energy Adoption in MOBs

Unlike detached homes, the rooftops and other potential areas for RES installation are often recognised as common properties, collectively owned by all residents and managed by the 'Owners' Corporation' (OC), in which the apartment owners are members.

Such a management structure, known as 'Strata-title' in Australia, has been followed globally under various names, such as 'condominiums', 'freehold', and 'unit title'. Strata-title establishes the 'Rights, Responsibilities, and Restrictions' of the apartment owners in managing the properties while also granting each individual owner ownership of their unit, an ownership share of the common property as established in the 'plan of subdivision', and membership in the OC.

Due to the joint ownership of rooftops, any RES installation requires collective consensus, often discouraging individual initiatives. The issue is compounded by the presence of multiple owners' corporations, called 'limited' and 'unlimited' owners corporations. While the limited OC members possess exclusive rights over a particular common property, known as limited common property, all residents collectively own the unlimited common properties. Figure 2 illustrates the ownership conundrum in MOB management. Since the residents of Building B may not directly benefit from the solar panels installed in Building A, as it is a limited CP, they can still participate in decisions about the CP since the entire land parcel and building structure are under unlimited CP. However, the ownership shares of individual apartments, defined by their 'lot entitlement', will also influence the voting power of the owners, with greater lot entitlement resulting in a larger voting share.

Due to these complexities, installing a collectively-owned RES that shares generated energy among all residents is common in MOBs. However, there are a multitude of barriers that the OCs must address to obtain consent for installing the RES, as categorised by Poshnath et al. (2023).

- ***Strata-title barriers*** – This involves issues related to common property ownership and strata-title regulations, such as difficulty in obtaining collective consent, the lot entitlement of each apartment, the presence of multiple OCs and CPs, and the physical limitations of the buildings restricting feasible retrofits.
- ***Behavioural barriers*** – Accommodating multicultural families with diverse lifestyles can cause behavioural obstacles to the uptake of RES. Apartments, especially in major cities, could be rented out to tenants, and the owners may not receive any direct benefit from installing RES. Furthermore, the turnover rate of tenants is significant, necessitating frequent rearrangements. Additionally, the tendency to free-ride on the efforts of others, coupled with a lack of awareness about the benefits of RES and preconceived judgements, contributes to inhibiting installation.
- ***Financial barriers*** – Despite the decline, the cost of RES remains relatively high for a substantial population, causing challenges in raising the required capital. The lower feed-in tariffs for the exported energy, coupled with longer payback periods, discourage apartment residents from installing RES.
- ***Regulatory & Market barriers*** – Globally, several governments have introduced policies for RES adoption, such as solar incentives. However, the policies specifically for apartment buildings are rare. Moreover, the complexity of procuring approvals, the diverse technical requirements, and inconsistent policies obstruct the RES installation.

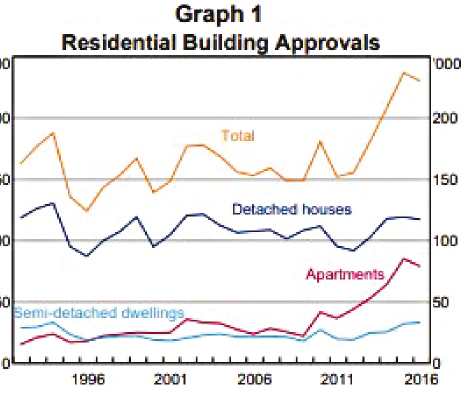


Figure 1: Residential building approvals in Australia over the years (Shoory, 2016)

Innovating Energy Allocation: The Concept of 'Energy Entitlement'

The allocation of renewable energy in MOBs has troubled stakeholders due to the inherent complexities pertaining to energy allocation, energy ownership, and the division of benefits and liabilities among residents. A standardised regulatory approach tailored for energy ownership is necessary to address the issue. This problem aims to be solved by introducing the concept of 'Energy Entitlement', which delineates the energy ownership each apartment owner can manage. Energy entitlement is founded on the principles of 'equitable' energy allocation, which incorporates the land administration principle while capturing the dynamic characteristics of energy management. Energy entitlement is poised to have policy implications and act as grounds for dispute resolutions, speeding up the renewable energy transition to attain net-zero objectives. The energy entitlement concept operates independently of the type of RES, whether solar panels, micro-wind turbines, or geothermal energy. Figure 3 illustrates the concept of energy entitlement in a MOB, which operates behind the meter and allows residents to maintain grid connections with their preferred electricity retailer, unlike embedded networks. Such a system allows for trading energy between the apartment units and the grid, unveiling opportunities for the owners to generate more revenue and thus reducing the payback period.

Disputes in strata buildings often arise from how common costs and benefits are allocated. Despite being prevalent, lot entitlement, founded on the market value of the property, is susceptible to the orientation of the apartment, the floor level of the unit, and rental potential. Since the literature and legislation are silent on the allocation of energy, any practised energy allocation model is based on the principles of common cost allocation, lacking consideration of the role of energy in strata. Thus, numerous disputes are expected to stem from the lack of legislative support for energy allocation.

The Subdivision Act (1988) suggests the allocation of common costs either equally or based on lot entitlement unless there are significant variations in lot size or number of occupants. Basing the allocation of energy on these models may have its disadvantages. For instance, equal allocation of energy may disproportionately benefit apartments with minimal energy usage, while energy-intensive units remain reliant on the grid. This may hinder the path towards net-zero energy status for the building. Moreover, if the building does not have the infrastructure to support energy trading, the surplus energy of energy-efficient users may be wasted. As discussed, lot entitlement is based on the market value of the property, which has an insignificant relationship to energy usage. The orientation towards specific cardinal directions may result in high energy demand for particular apartments, while their lot entitlement may be lower than a similar apartment with a different orientation. Thus, the units may not get the required energy to offset their additional energy demand, which is not a result of their actions.

While allocating energy based on the number of occupants residing in the unit may contribute positively towards attaining net zero, monitoring the occupancy is a hideous task. Being a static quantity and an indicator of energy demand, the allocation of energy based on the unit size could be a potential allocation model. However, external conditions may influence the energy demand of two identical apartments. Moreover, assuming double the energy demand for double the area in a residential building oversimplifies the intricacies of energy consumption. Thus, the choice of energy allocation model in a MOB plays a significant role in the effective functioning of the RES in MOBs. Exploring more potential allocation models that complement the MOB dynamics may prove essential. Moreover, it may be worthwhile to delve deep into the role of building typologies in the suitability of the allocation models. Identifying and integrating allocation models that align with the unique MOB characteristics is critical for determining energy entitlement and their sustainable operation.

Energy entitlement is poised to have policy implications and serve as a basis for dispute resolutions, speeding up the renewable energy transition to attain net-zero objectives.

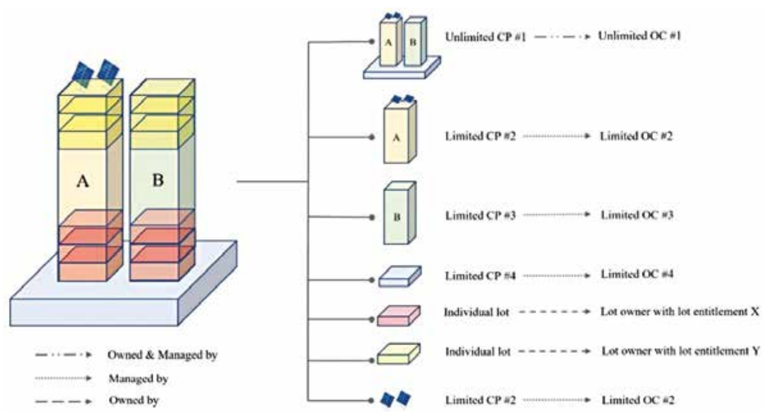


Figure 2: MOB Management (Poshnath et al., 2023)

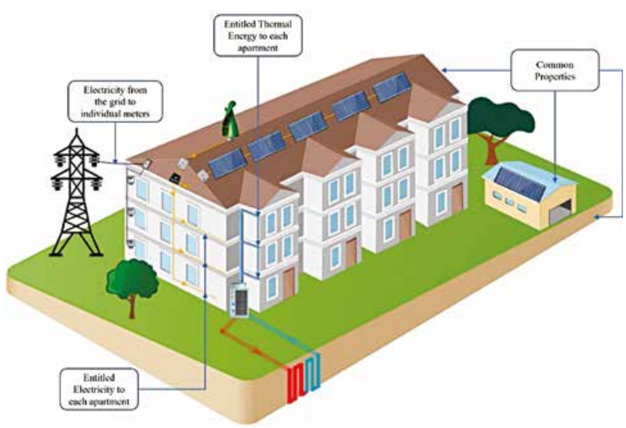


Figure 3: Graphical illustration of energy entitlement in MOBs (Poshnath et al., 2023)

Conclusion

The presence of around two and a half million strata titles or community buildings in Australia (Green & Newman, 2017) and more around the globe signifies the impending opportunity for the transition to net-zero communities. However, the adoption of renewable energy systems in strata buildings is insignificant compared to detached homes. The barriers to adoption range across various domains, from strata-title to social characteristics, underscoring the severity of the issue. The 'Energy Entitlement' is poised as a catalyst for renewable energy systems' adoption in MOBs by delineating the individual ownership of energy to each resident from a commonly-owned renewable energy system. The concept possesses the flexibility to extend across various multi-owned buildings as it operates independently of the type of RES. However, the practical implementation of energy entitlement mandates explicit guidelines on allocating energy from the jointly-owned system.

The literature and legislation are silent on this matter, and the allocations, if any in practice, are based on the principles of common cost allocation, not aligning with the traits of energy, which are expected to generate disputes. Thus, energy allocation demands an explicit approach with necessary legal and policy implications, acting as a ground for dispute resolutions. Further development of 'energy entitlement' should encompass the policy and legal requisites, with the aid of novel technologies, to instil trust in the stakeholders transitioning to renewable energy.

References

Charani Shandiz, S., Foliente, G., Rismanchi, B., Wachtel, A., & Jeffers, R. F. (2020). Resilience framework and metrics for energy master planning of communities. *Energy*, *203*. https://doi.org/10.1016/j.energy.2020.117856

Green, J., & Newman, P. (2017). Planning and Governance for Decentralised Energy Assets in Medium-Density Housing: The WGV Gen Y Case Study. *Urban Policy and Research*, *36*(2), 201-214. https://doi.org/10.1080/08111146.2017.1295935

Poshnath, A., Rismanchi, B., & Rajabifard, A. (2023). Adoption of Renewable Energy Systems in common properties of multi-owned buildings: Introduction of 'Energy Entitlement'. *Energy Policy*, *174*. https://doi.org/10.1016/j.enpol.2023.113465

Shoory, M. (2016). The Growth of Apartment Construction in Australia.

Subdivision Act 1988 - Section 27F(4) inserted by No. 4/2021 s. 88(3). (1988).

Drone pilot can't offer mapping without North Carolina surveyor's license, court says

A North Carolina board that regulates land surveyors didn't violate a drone photography pilot's constitutional rights when it told him to stop advertising and offering aerial map services because he lacked a state license, according to a federal appeals court in the USA.

The panel of the 4th U.S. Circuit Court of Appeals, in upholding a trial court's decision, found the free-speech protections of Michael Jones and his 360 Virtual Drone Services business weren't violated by the state's requirement for a license to offer surveying services.

The litigation marked an emerging conflict between technology disrupting the hands-on regulated profession of surveying. A state license requires educational and technical experience, which can include examinations and apprenticeships.

The board wrote to Jones in June 2019 and ordered him to stop engaging in "mapping, surveying and photogrammetry; stating accuracy; providing location and dimension data; and producing orthomosaic maps, quantities and topographic information." Performing surveying work without a license can subject someone to civil and criminal liability.

By then, Jones had placed a disclaimer on his website saying the maps weren't meant to replace proper surveys needed for mortgages, title insurance and land-use applications. He stopped trying to develop his mapping business but remained interested in returning to the field in the future. So he sued board members in 2021 on First Amendment grounds.

U.S. District Judge Louise Flanagan sided with the board members last year, determining that the rules withstood scrutiny because they created a generally applicable licensing system that regulated primarily conduct rather than speech.

Circuit Judge Jim Wynn, writing an unanimous opinion by the three-member panel, said determining whether such a business prohibition crosses over to a significant speech restriction can be difficult.

"Even where a regulation is in fact aimed at professional conduct, States must still be able to articulate how the regulation is sufficiently drawn to promote a substantial state interest," Wynn said.

In this case, he wrote, it's important that people can rely on surveyors to provide accurate maps. And there's no evidence that the maps that Jones wants to create would constitute "unpopular or dissenting speech," according to Wynn.

"There is a public interest in ensuring there is an incentive for individuals to go through that rigorous process and become trained as surveyors," he wrote, adding the licensing law "protects consumers from potentially harmful economic and legal consequences that could flow from mistaken land measurements."

Sam Gedge, an attorney at the Institute for Justice firm representing Jones, said he and his client want to further appeal the case, whether through the full 4th Circuit, based in Richmond, Virginia, or at the U.S. Supreme Court.

The ruling says "the state can criminalize sharing certain types of photos without a government-issued license. And it does so on the theory that such a law somehow does not regulate 'speech,'" Gedge wrote in an email. "That reasoning is badly flawed. Taking photos and providing information to willing clients is speech, and it's fully protected by the First Amendment." *https://apnews.com*

Digital transformation in India

The digital transformation in India has had a significant impact on the geospatial sector

Dr Siva Kumar Rachapudi
Managing Director
SIBHU
siva@sibhu.space

Digital transformation (DT) is to use digital technologies in all processes, products and services of an organization. India made great strides in the recent times in DT as part of Digital India Initiative. Aadhaar and Digital Identities, Digital Payments and FinTech (BHIM, UPI), E-Governance and Digital Services (DigiLocker, Umang), Digital Infrastructure (BharatNet, GatiShakti), Smart Cities and Digital Urban Development, Digital Education and Skilling (SWAYAM e-Pathshala, National Digital Library), Digital Manufacturing and Industry 4.0 (Make in India, Samarth Udyog Bharat 4.0) Digital Agriculture and Rural Development (e-NAM (National Agriculture Market), Kisan Suvidha and Digital Healthcare (Ayushman Bharat) are some shining examples of the initiatives taken by government and some of them have attracted worldwide attention and adoption.

While digital transformation in India has made significant strides, challenges such as digital divide, cybersecurity concerns, and the need for digital literacy and skill development remain to be addressed. However, the overall trajectory indicates a strong commitment to leveraging digital technologies for economic growth, efficient governance, and inclusive development.

Geospatial sector

The digital transformation in India has also had a significant impact on the geospatial sector, which encompasses technologies like Geographic Information Systems (GIS), remote sensing, and satellite imagery. National Spatial Data Infrastructure (NSD)I, Digital India Land Records Modernisation Programme (DILRMP) are well deliberated initiatives. NSDI initiative started in the year 2000 helped in bringing all 17 agencies on a common platform agreeing to share the data as per NSDI standards. Standards for Metadata, Data Exchange and content for few themes were made and also formalized them through BIS. NSDI adapted GML and OGC standards in providing WMS and WFS through the National Geoportal. Though NSDI and DILRMP attained moderate success and programmes such as National GIS were nipped in the bud due to vested interests. Survey of India (SoI) has brought digital processes in various activities of geodesy.

Surveyors took the lead

It is not an exaggerated statement to say that Surveyors both in civil and military domain lead the digital transformation in India. When no other organization outside academic world even thought of computerization, survey agencies conceptualized the framework for digital processes. Since 1960s and 70s, SoI had been using medium and main frame computers for their geodetic and photogrammetric adjustment work, Using major computer centers (IBM 370 at IIT Madras, etc.), they formulated plans for total digital processes for various survey operations, though they had limited access to computers. Many officers went for studies in reputed institutions such as OSU Columbus, New Brunswick University Canada, University of Wisconsin Madison, Queensland Institute of Technology, Australia and most importantly ITC Enschede, The Netherlands.

Sometime in 1978-79 National Hydrographic Office (NHO), engaged in making navigational charts & maps, had to honour international commitment to share their charts inn digital format. For this purpose, they acquired an Auto-Chart system from M/s Systems House of Ottawa, Canada and an Auto- Map system for R&D directorate of SoI to explore possibility of computer assisted mapping to be tried in SoI. As SoI had no credible capability to maintain such systems, CMC was also involved. Accordingly, a team of officers of Indian Navy (NHO), Indian Army (SoI) and CMC engineers were sent to Canada for training in these systems. This is the first baby step towards digital transformation.

R&D Cell at Dehradun in 1980-81 received Auto-Map system which was configured around PDP11/32 computer with multiple terminals for digitization, editing and check plot on HP Calcom plotters. Also, there was a stand-alone Kongsburg A0 size plotter system with capabilities for fair mapping with scribing and photo plotting facilities.

The source codes were written using a modified Fortran IV language with modular and structured programming capabilities nicknamed FortranV.

This was the first time SoI had full access to a major computer H/W, system S/W and advanced graphics technology. The system helped to train and expose SoI officers at various levels in different stages of computer assisted digital cartography. Further, R&D had developed in-house to integrate photogrammetric output to Auto-Map system.

Military Survey of India (MSOI) have also started preparing ambitious proposals to modernize the total process of data acquisition, productization and dissemination. The proposals though initiated in early 80's, were approved in 1988 by the Cabinet Committee on Political Affairs paving the way for modernizing existing units and raising new units and equipment besides training personnel.

Meanwhile, considering the importance, the visionary leadership set up a Task Force to prepare a proposal for end-to-end digital technology for SoI to be considered by the government. The proposals prepared by MSOI were also studied and regular exchange of officers between SOI and MSOI helped the process.

After much deliberations and interaction with various regional directors that Task Force proposed the following:

Three sub-systems were to be set up, each at Southern, Eastern and Northern regions to generate digital cartographic data using digitized fair maps, stereo digitized and field verified latest data from off line platforms to be integrated, tested and certified for digital map making.

Two major systems were to be set up, net worked with the regional centers, one at Dehradun and the other at Hyderabad to centrally hold 3-D spatial data for digital mapping and sharing such data with other agencies.

There was provision for future integration of satellite image data for thematic map making as the technology developed.

Officers were to be trained in Indian and Foreign universities in systems s/w, h/w, computer graphics, spatial data base creation and maintenance.

Government accepted the proposal in 1983. To start with two Digital Mapping centers were set up, one at Dehradun and another at Hyderabad. The systems were similar to the sub-systems of regional centers limited to 2-D map digitization and fair mapping, thus truncating the original goal of end-to-end digital mapping. Officers were mostly trained abroad on imported systems. Also, some augmentation to R&D Cell systems were made to facilitate future research work. These centers were operational in 1987-89.

At the same time UNDP supported a project under which Modern Cartographic Centre came up in Dehradun which had end to end digital mapping equipment, tools and software. This was managed along with Government of India approved Digital Mapping Centres.

Digitisation of land records

Another pathbreaking initiative by SoI was in digitizing land records. Most of the legal cases in India pertain to land and reraising the importance, GOI directed SoI to depict individual village boundaries in 1:25,000 scale topographic maps for whole of India. It was envisaged that in digital environment village maps could be integrated with surrounding topographic details to help planners to work out various developmental projects.

In 1991-92, a pilot project for Odisha state to create a digital cadastre for district Angul of Odisha was taken up by R&D directorate of SoI. The project emphasised a thorough revision of Settlement survey using digital/ semi-digital method of different stages of re-settlement operations to create a clean digital cadastre for ease of future maintenance. It also gave rise to the concept of Geo-coded cadastral boundary and concept of digital Plot map for each land holding. Learnings from this project helped in streamlining procedures for digital land records which ultimately paved the way for nation wide Digital India Land Records Modernization Programme (DILRMP) by GOI.

Digital Cartographic Data Base (DCDB) and Digital Topographic Data Base (DTDB)

Being a mapping agency, SoI had the objective of creating a DCDB for the

> Surveyors both in civil and military domain lead the digital transformation in India. When no other organization outside academic world even thought of computerization, survey agencies conceptualized the framework for digital processes.

country to enable quick printing of maps to suit the requirements of users whereas MSOI set its sights on DTDB to provide requisite data, products, solutions and services to various weapons, equipment, delivery systems and surveillance systems. SOI concentrated on 2D DCDB.

Thus, SOI lead the digitization of maps on 1:50,000 scale, largest scale on which the country is covered. SoI completed this humungous task quickly adapting the fast-changing technologies from the laborious tablet digitisation, heads up digitisation, raster vector conversion, feature based digitization, digital photogrammetry, LIDAR, Drones, standardization, Continuously Operated Reference Stations (CORS) etc., SOI has also modified the objective and now creating a National Topographic Data Bade (NTDB). Establishment of National Geospatial Data Centre in 2003 enabled in maintaining a single repository of digital topographical data.

Not lagging behind, MSOI was the first to use digital photogrammetry, mobile printing and also first to create a comprehensive Geographic Information System (GIS) for a very large area by integrating graphics (point, line and polygon) with non-graphic attributes such as tables, photos , videos etc.,

Many other central and state organsiations took inspiration from these success stories and embarked upon their own digital programmes.

Way ahead

Still there is long way to go in achieving total digital transformation. SoI has a huge repository of data collected for over 257 years on various resolutions for which even metadata is not available thus duplicating efforts. A comprehensive metadata of all what SOI possesses will save efforts and time of the users. WMS and WFS for the whole country and nationwide CORS will enable users to make best use of available resources.

Remote sensing and drone mapping to be done in Udanti Sitanadi Tiger Reserve

Udanti Sitanadi Tiger Reserve in Chhattisgarh, India is set to launch a project using remote sensing and drone mapping technology to monitor the tiger corridor. The initiative aims to identify negative changes in land and water, combat encroachments, and enhance anti-poaching efforts along the 400 km stretch of the Indravati-Sitanadi-Udanti-Sunabeda Tiger Corridor.
The Udanti Sitanadi Tiger Reserve, located in Gariaband district around 170 km from Raipur, employs cloud computing and AI-based Google Earth Engine technology to monitor changes in land and water within the tiger corridor. The total cost of this project is just Rs 285,000. This monitoring will cover changes from 2010 to 2023. Mining, illegal tree felling, encroachments and other disturbances have nearly halted the migration of tigers from Maharashtra to Chhattisgarh and Odisha.

Satellite data will enable comparisons of land and water changes every five days. The Water Resources Department can also utilize this data. Through the Drone Mapping Portal, "Jungle Mein Mor Naacha Sabne Dekha", high-resolution imagery will be accessible to the public, allowing zooming in up to 5 centimetres over areas of 50-250 hectares. This offers greater detail than Google Earth's 65 cm resolution.

Tree plantation areas can be monitored for the number of plants, pits, and annual plant growth. Imagery from different years can be compared to assess changes. For example, the imagery from 2022, 2023, and 2024 of a 2022 plantation area can be analyzed.
https://timesofindia.indiatimes.com

ISRO announces Indo-French Thermal-Imaging Mission

ISRO has announced a joint Indo-French infrared earth observation satellite mission, TRISHNA (Thermal Infra-Red Imaging Satellite for High-Resolution Natural Resource Assessment), to monitor surface temperature and water management around the world.

The mission will study water presence and concentrations, as well as dynamics including melting glaciers, in various parts of the biosphere, quantifying water being used on land and how.
The satellite will also monitor thermal anomalies and spikes, emission of heat from land, surface energy, urban heat islands, and other global parameters.

In the process, the satellite will also study aerosols, water vapour, and clouds in the atmosphere around the world. It is currently tentatively set to launch in 2025 with an expected lifespan of 5 years.

ISRO also said the TRISHNA mission will address crucial water and food security challenges, focusing on anthropogenic or human-induced impacts of climate change.

Evapotranspiration monitoring includes soil evaporation and water transpiration from planets. This is an important metric to monitor agriculture, and data will help in maintaining soil moisture levels in the face of increasing droughts affecting Indian farmers.

GNSS Constellation Specific Monthly Analysis Summary: May 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 URA in the context of RAIM and Advanced RAIM (ARAIM).

Analyzed Parameters for May, 2024

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

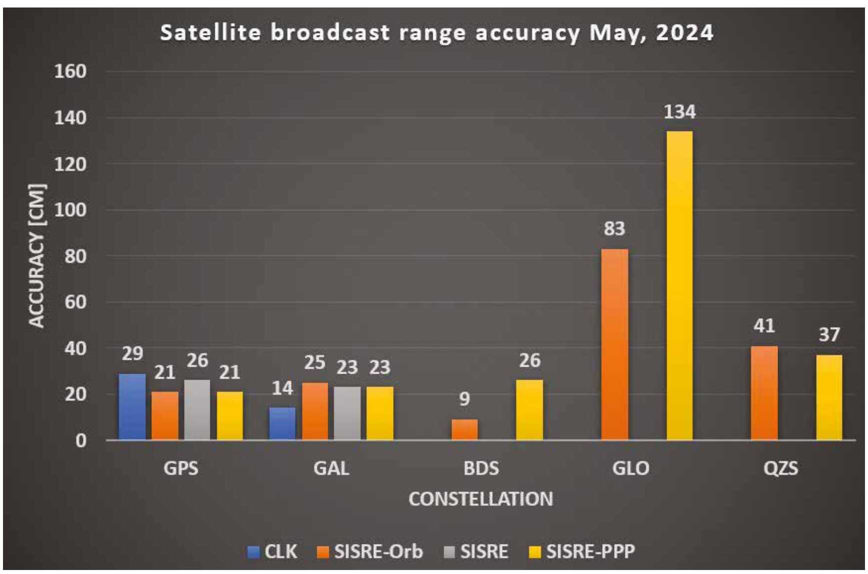
a. Satellite Broadcast Accuracy, measured in terms of **Signal-In-Space Range Error (SISRE) (Montenbruck et. al, 2010).**

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

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



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. URA for ARAIM: URA plays a important role in the realization of ARAIM. Together with the SISRE, it allows characterization of the system behavior and determination of service

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.

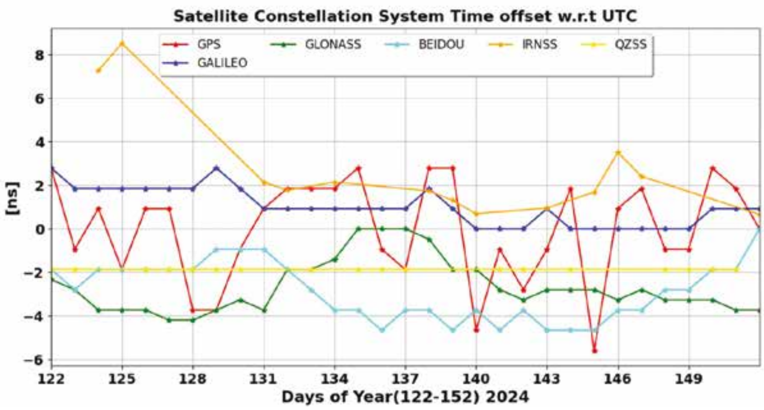
(c) Satellite Clock Jump per Mission Segment Upload

Const	Mean [ns]	Max [ns]	95_Percentile [ns]	99_Percentile [ns]	Remark (Best and Worst 95 %)
IRNSS	2.79	545.61	5.40	18.67	Best I03 (3.98 ns) Worst I09 (10.11 ns) Several moderate jumps for all satellites
GPS	34.23	137192.20	0.99	2.31	Best G14 (0.40 ns) Worst G01 (2.88 ns) G03, G04 have large jumps on day 123. G07 had very large jumps during days 146-150. G17 which was set unusable on day 138, also had large jumps
GAL	0.10	108.79	0.19	0.46	Best E07 (0.15 ns) Worst E19 (0.33 ns) E11 had a large jump on day 122

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

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	2955	51	1	-	-	-	-	-
I03	435	17	-	-	1	-	-	-
I06	535	2	-	-	2	-	1	-
I09	512	6	-	-	2	-	-	-
I10	522	4	-	-	1	-	-	-

(e) GNSS-UTC Offset



(f) URA Statistics and Applications in RAIM/ARAIM

ARAIM utilizes a variety of signals from multiple satellite constellations, which inherently increases the chance of satellite faults compared to the traditional GPS-only RAIM. An essential aspect of ARAIM is its capability to manage several satellite faults simultaneously, accomplished through the use of Integrity Support Messages (ISM). Consequently, it's vital for GNSS constellation service providers to work together closely and effectively to guarantee the reliability of ISM. Moreover, there may be varying perspectives among different providers regarding the choice of ISM parameter values. The ISM values have to be carefully evaluated based on the constellation performance data over a longer period of time. A basic overview on the applicability of broadcast URA to execute such evaluation is analyzed in the following paragraphs.

The main ISM of the ARAIM concept include α_{URA}, α_{URE}, b_{nom}, P_{sat}, and P_{const}. Here, P_{sat} describes the satellite faults that occur independently on a particular satellite and that do not affect the performance of the other satellites. For the constellation faults, P_{const} represents the probability of the fault arising from a common cause and affecting multiple satellites. These are mostly due to the faults at the ground control segment that can propagate to multiple satellites. The parameters α_{URE} and α_{URA} represent a multiplier to obtain the expected uncertainty on the SIS error and the integrity over bound of the uncertainty on the SIS error, respectively. The b_{nom} parameter includes slowly varying change such as signal deformations, antenna biases or quasi-static error sources (**Walter, et.al, 2019**). URA plays a crucial role in the implementation of RAIM and ARAIM. In the traditional RAIM, URA is used for fault detections and for a fault-free case, it represents the zero-mean overbounding Gaussian for both integrity and accuracy computation. Different to it, the ARAIM uses separate zero-mean overbounding Gaussian (together with a bias parameter) for integrity (using α_{URA} and b_{nom}, and accuracy (using α_{URE}). The traditional value, in the case of GPS, for P_{sat} is taken as10^{-4}/hour/sat (this is changed to 10^{-5}/hour/sat as per the current GPS SPS PS) which reflects the maximum probability with which the un-faulted errors can occur and still meet the requirements of the integrity. The faulted and un-faulted state are separated by this probability and for which the Gaussian

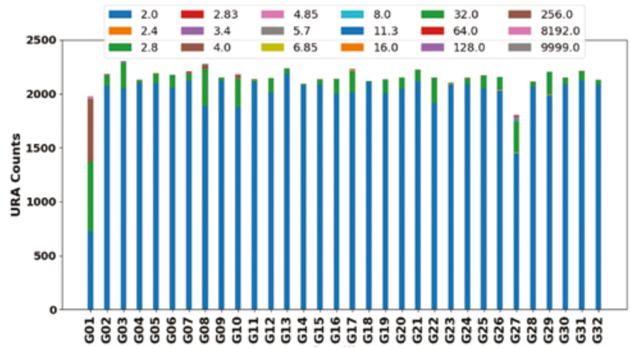


Figure (f) 1: The distribution of observed URA values for all GPS satellites in the broadcast message (01 January– 31 May, 2024). The nominal value of 2.0 m is well obtained for majority of the time and is followed by 2.8 m. G01 has the distinct distribution of 2.0 m, 2.8 m and 4.0 m. Latest generation of GPS satellites (Block III: 4, 11, 14, 18, 23, 28) have more consistent URA of 2.0 m.

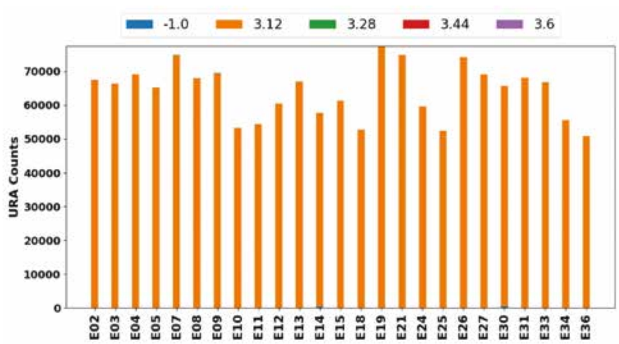


Figure (f) 2: The distribution of observed SISA (URA equivalent) values for all Galileo satellites in the broadcast message (01 January– 31 May, 2024). There are very few instances with higher values than the nominal 3.12 m. E14 and E30 broadcast few URA values which are unknown and unidentified. Note: both FNAV and INAV messages are considered.

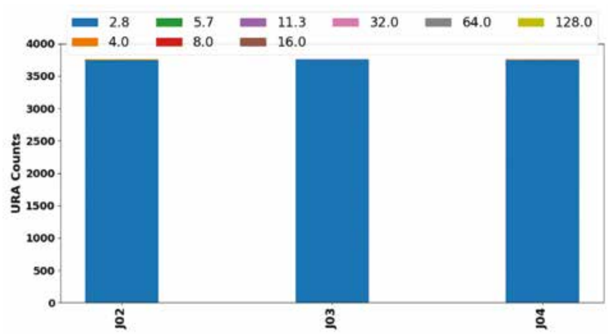


Figure (f) 3 : The distribution of observed URA values for all QZSS satellites in the broadcast message (01 January– 31 May, 2024). The satellites predominantly attain URA of 2.8 m.

inflation factor, K, is computed as 4.42 (this can be reduced to 4.17 with new $P_{sat} = 10^{-5}$). The conceptual computation of the K value is provided in the literature (**Walter, et.al, 2019**). The K factor along with the URA value for each satellite provides a threshold to compare against the corresponding SIS error (as similar to the SISRE computed in this monthly analysis). If the SIS error is above the threshold, then there is a faulted event not captured by the system. The historical data for each constellation can be used to compute the P_{sat} and P_{const} (as of now, it is10^{-8}) and 10^{-4}) for GPS and Galileo, respectively) based on the total faults detected over the given time period. The longer the time period, the better is the estimation of the probabilities. As such, both, SISE (similar to SISRE computed in this monthly analysis report but as instantaneous value and worst user location) and URA are very critical parameters for understanding the probabilities of fault events for each GNSS constellation. In this monthly issue, only an overview of the URA distribution for each constellation is provided. It can be observed in figures (f (1)- f (4)) that each constellation has satellites with varying URA values other than the designated standard accuracy. This indicates that there could be a potential fault even when the satellite is set to healthy and the broadcast validity is ok, and if the existing empirical analysis for past years (**Alonso, et.al, 2019, 2020**) is considered, for GPS and Galileo, the probability of single satellite fault is better than 10^{-5})/hour/ sat. This corresponds to the K factor of 4.17. For other constellations, similar approach can be used to compute the probabilities for the service commitment. This is also a testament to the necessity of analyzing the behavior of URA together with the SISE (in this analysis only 5 months data is seen but in the mentioned literature, they give analysis of longer time period).

The target of the ARAIM concept is to enable aviation integrity services from RNP 0.3 (H-RAIM) upto LPV-200 (V-RAIM). Rather than broadcast the conservative URA as is the case in RAIM, the ARAIM concept expects, in addition to handling fault cases with P_{sat} and P_{const}, relaxing the URA values by providing a bias term and the multiplier terms to separately bound the SIS accuracy and integrity. In doing so, the availability and integrity can be maintained to meet the required specifications of from RNP 0.3 up to LPV-200. The deployment of initial ARAIM is planned for 2025.

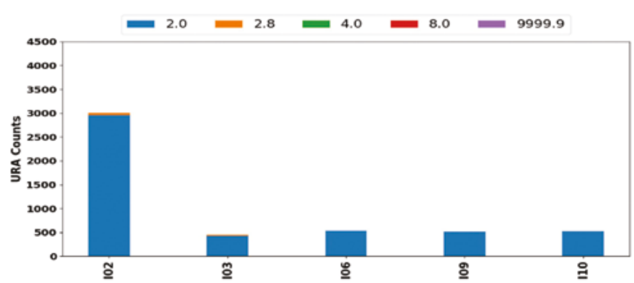


Figure (f) 4: The distribution of observed URA values for all IRNSS satellites in the broadcast message (01 January– 31 May, 2024). There are varying URA values observed but predominantly 2.0 m is attained by all satellites. Only I02 satellite broadcast with higher update rate (as read from the IGS RINEX 3.04 Navigation Messages).

For Beidou, all satellites consistently broadcast URA value of 2.0 m 100 % of the time and as such, the plot was not deemed necessary. For Glonass, the URA value is not available in the RINEX broadcast message file. There will be an attempt in the future to combine the URA overview provided in this month's issue with the SISE analysis and empirically derive the probability of satellite fault and constellation fault.

Monthly Performance Remarks:

1. Satellite Clock and Orbit Accuracy:

- For GPS, the satellite clock and orbit accuracy shows similar performance as in April 2024. There were couple of satellite outages and NANU and removed from the analysis. As in previous months, GPS PRN 17 had couple of unusable status on day 138. G07 had bad clocks during day 146 – 150.
- For Galileo, all parameters showed consistent performances. E11 had relatively large clock jump between consecutive batches of upload on day 122.
- For GLONASS, the performance looked similar to the past months. There were couple of satellites unusable which were removed in the analysis.
- For BDS and QZSS, the performance looks very much the same as in the past. For QZSS, there were couple of advisories to not use specific satellites. Example, J02 was not available on day 122. There were days with better orbit quality and some days with degraded performance. BDS has announced routine maintenance activities in its constellation from 31st May, 2024.
- For IRNSS, the notable difference in this month's performance is the URA for all satellites. There were not a varying confidence in the range accuracy as in the previous months.

2. UTC Prediction (GNSS-UTC):

- Not much difference in comparison to the last month analysis but Glonass showed slightly consistent values.

References

Alonso M, Sanz J, Juan J, Garcia, A, Casado G (2020) Galileo Broadcast Ephemeris and Clock Errors Analysis: 1 January 2017 to 31 July 2020, MDPI

Alonso M (2022) Galileo Broadcast Ephemeris and Clock Errors, and Observed Fault Probabilities for ARAIM, Ph.D Thesis, UPC

Cao X, Zhang S, Kuang K, Liu T (2018) The impact of eclipsing GNSS satellites on the precise point positioning, Remote Sensing 10(1):94

Dhital N (2024) GNSS constellation specific monthly analysis summary, Coordinates, Vol XX, Issue 1, 2, 3, 4

Hauschlid A, Montenbruck O (2020) Precise real-time navigation of LEO satellites using GNSS broadcast ephemerides, ION

Guo F, Zhang X, Wang J (2015) Timing group delay and differential code bias corrections for BeiDou positioning, J Geod,

IERS C04 (2024) https://hpiers.obspm.fr/iers/eop/eopc04/eopc04.1962-now

IGS (2021) RINEX Version 4.00 https://files.igs.org/pub/data/format/rinex_4.00.pdf

Li M, Wang Y, Li W (2023) performance evaluation of real-time orbit determination for LUTAN-01B satellite using broadcast earth orientation parameters and multi-GNSS combination, GPS Solutions, Vol 28, article number 52

Li W, Chen G (2023) Evaluation of GPS and BDS-3 broadcast earth rotation parameters: a contribution to the ephemeris rotation error Montenbruck O, Steigenberger P, Hauschlid A (2014) Broadcast versus precise ephemerides: a multi-GNSS perspective, GPS Solutions

Liu T, Chen H, Jiang Weiping (2022) Assessing the exchanging satellite attitude quaternions from CNES/CLS and their application in the deep eclipse season, GPS Solutions 26(1)

Montenbruck O, Steigenberger P, Hauschlid A (2014) Broadcast versus precise ephemerides: a multi-GNSS perspective, GPS Solutions

Montenbruck O, Hauschlid A (2014 a) Differential Code Bias Estimation using Multi-GNSS Observations and Global Ionosphere Maps, ION

Steigenberger P, Montenbruck O, Bradke M, Ramatschi M (2022) Evaluation of earth rotation parameters from modernized GNSS navigation messages, GPS Solutions 26(2)

Sylvain L, Banville S, Geng J, Strasser S (2021) Exchanging satellite attitude quaternions for improved GNSS data processing consistency, Vol 68, Issue 6, pages 2441-2452

Walter T, Blanch J, Gunning K (2019) Standards for ARAIM ISM Data Analysis, ION

Wang N, Li Z, Montenbruck O, Tang C (2019) Quality assessment of GPS, Galileo and BeiDou-2/3 satellite broadcast group delays, Advances in Space Research

Note: References in this list might also include references provided to previous issues.

Data sources:

https://cddis.nasa.gov (Daily BRDC); http://ftp.aiub.unibe.ch/CODE_MGEX/CODE/ (Precise Products); BKG "SSRC00BKG" stream; IERS C04 ERP files

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

WILDetect: An intelligent platform to perform airborne wildlife census automatically in the marine ecosystem

A new non-parametric approach, WILDetect, has been built using an ensemble of supervised Machine Learning (ML) and Reinforcement Learning (RL) techniques. Readers may recall that the first part of the paper was published in May' 24 issue of Coordinates magazine. *We present here the concluding part*

Kaya Kuru
Corresponding author
School of Engineering, University of Central Lancashire, Fylde Rd, Preston, Lancashire, PR12HE, UK

Stuart Clough
APEM Inc., 2603 NW 13th Street, 402, Gainesville, FL 32609-2835, USA[1]

Darren Ansell
School of Engineering, University of Central Lancashire, Fylde Rd, Preston, Lancashire, PR12HE, UK

John McCarthy
APEM Ltd., The Embankment Business Park, Stockport, SK4 3GN, UK[2]

Stephanie McGovern
APEM Ltd., The Embankment Business Park, Stockport, SK4 3GN, UK

5. Implementation of the methodology in splitting and counting (A.4) using the recursive RL technique

Objects can appear in different regions of the image and in different scales. In order to solve this problem, the sliding window method (Fig. 3) is used (Forsyth & Ponce, 2012). It consists of a detection window that slides over an image extracting regions and classifying them. A Gaussian pyramid (Witkin, 1984) (Fig. 3) is also applied to the image to perform a scale search to detect similar objects in different sizes.

A multi-threaded approach was established to speed up the calculations and reduce the processing time. In this multi-threaded approach, jobs are distributed among the resources in the same network, partic- ularly among the multi-core processors, with one job for each core. The user can choose one of the two processing options, either multi-threaded where powerful computing resources can be deployed to perform many tasks at once, or sequentially where operations are performed in order and results can be followed by the user per image. The multi-threaded option reduces the processing time significantly based on the power of the resources used. Some of the resources in use can be stopped to be used for other purposes, and vice versa, new resources can be incorporated into the system while the splitting or counting process is ongoing, using a novel flexible cloud computing approach built in this study.

It is worth noting that datasets are imbalanced -i.e., not uniform within surveys most of the time as mentioned earlier regarding the larger number of negative images (negative class) compared to a smaller number of positive images (positive class). This imbalance is mitigated using an ensemble of ML and RL techniques within the research in two phases of automated data analysis. The selection of the best detectors in the splitting phase is based on the features of the background to discard most of the negative images while aiming to place all the positive images in the positive folder whereas it is based on the features of the targeted objects in the counting phase to count all the objects in the images placed in the positive folder while aiming to discard all the remaining negative images placed in the positive folder during the splitting phase. Four values are measured to assess the obtained results, namely,

$$Sensitivity = Se = TruePositiveRate(TPR) = TP/(TP + FN),$$
$$Specificity = Sp = TrueNegativeRate(TNR) = TN/(TN + FP),$$
$$Accuracy = Acc = (TP + TN)/(P + N) = (TP + TN)/(TP + TN + FP + FN), Precision = Pr = TP/(TP + \mathbf{FP}) \quad (1)$$

The first three values — *Se*, *Sp*, and *Acc* — are explained in Section 6 in detail based on the data analysis of the particular approaches. Pr is mainly employed to identify the class imbalance problem and assess how imbalanced data in favour of "negative images" that may lead to large FPs is influencing the results. More specifically, this assessment helps to understand (i) if the high values of *Se*, *Sp* and *Acc* are biased and most importantly (ii) if the two phases of using an ensemble of learning techniques help alleviate the bias regarding the improvement in Pr through obtaining the final counting results. The low values of Se, e.g., < 0.80, require the implementation of cost-sensitive analy- sis (CSA), as we conducted in our previous research in Kuru et al. (2013) to get more reliable improved results. In CSA, classes have different costs associated with them using weights with respect to the number of instances; the classes with fewer instances, i.e., under- represented classes (positive cases in this research) are assigned higher costs (i.e., adding cost-sensitivity, e.g., P:N = 10:1) to reduce the number of false predictions, particularly in favour of the class with less number of instances, and consequently increase the reliability of the results related to that class by assigning different penalties to misclassification of samples (Kuru et al., 2013) in which there is a trade-off between *Se* and *Pr*.

5.1. Implementation of the platform in splitting

Most of the time, more than 95% of images in a survey contain no targeted objects, and therefore this phase of the implementation aims to separate out the images with no targeted objects in a reduced overall processing time. Strictly speaking, the main objective of this phase is to perform the best splitting between negative and positive images based on the parameters specified in Section 4.2.3. The negative images are placed in the negative folder and the positive images are placed in the positive folder. Then, the images in the positive directory are analysed in detail to locate all targeted objects, which is explained in Section 5.2. The methodology selects a set of detectors for each feature extraction technique to deploy during the splitting process based on the particular characteristics and specific patterns of the images in surveys. This step is explained in Section 5.1.1. Then, how the splitting is performed is explored using these selected detectors in Section 5.1.2.

5.1.1. Pattern recognition and specification of the best feature extraction detectors for splitting using RL (A.4.1)

The methodology chooses the best detectors regarding separating negative images from positive images successfully based on the texture patterns and characteristics of the images in the surveys using the user- model- data interaction as illustrated in Fig. 3, A.4.1. The components of the recursive RL algorithm employed in this phase are demonstrated in a broader perspective in Fig. 11 and the main steps are explained as follows.

First, a very small subset of the negative images (i.e., 5–10) representing the whole of the negative images (i.e. background) in the survey is selected by the user. The characteristics of this very small set play an important role in determining the best convenient detectors. Therefore, the user is expected to choose blank images that have diverse background textures in the survey. For instance, at least a blank image taken from each camera mounted on the aeroplane and blank images taken from different time intervals should be placed in this set in order to represent the background characteristics of the whole survey. Alternatively, processing of the images from different cameras or in different time intervals – subsets of surveys – can be conducted separately, which can increase the efficacy of the platform further.

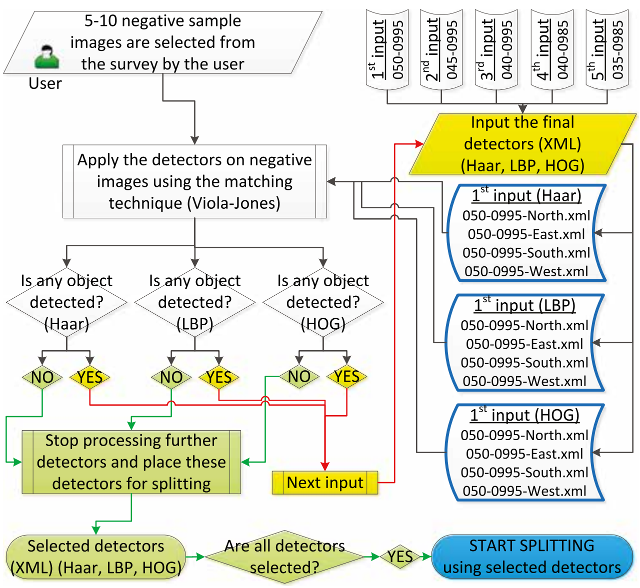


Fig. 11. Use of Reinforcement Learning (RL) for selecting the best detectors for splitting.

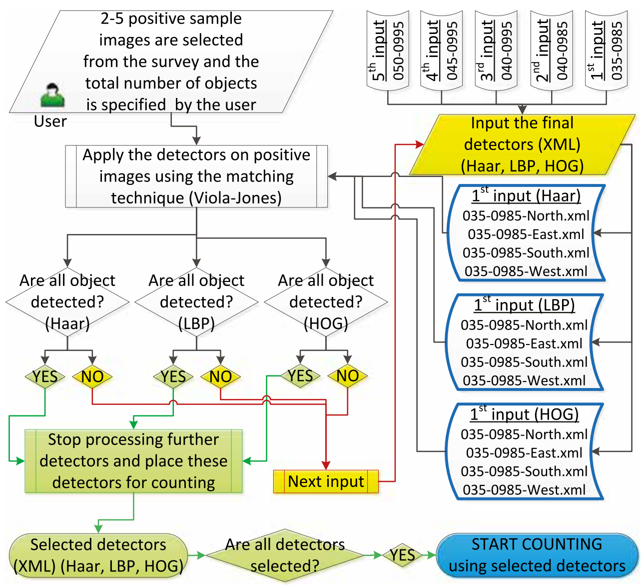


Fig. 12. Use of Reinforcement Learning (RL) for selecting best detectors for counting.

Second, the blank images selected by the user are processed by the approach to determine the best detectors for each technique based on the observed *Sp* (i.e., TN/(TN+FP)) values. In this process, a screening test is performed with preferably higher *Sp* values to increase the chance of placing images with no targeted object in the negative folder. In other words, the FP cases are reduced to a minimum resulting in very high *Sp* values with an ability to correctly place the negative images in the negative folder and this means that if an image is tagged as negative, it is a high probability that there is no object in that image. The RL algorithm makes the detectors run on the sample negative images fed by the user using the Viola–Jones matching technique to single out the successful detectors for splitting based on the characteristics of the background texture. This process starts from the detectors with the highest threshold values (i.e., 050–0995 in Table 2) that may result in many FPs reducing *Sp* whereas the background has a complicated texture. However, no FP may be obtained if the background has a clear texture. This iterative process using predetermined nominated detectors (Fig. 9) proceeds (Fig. 11) until no FP is obtained per detector where *Sp* is 1. In other words, the process stops per detector where *Sp* is 1 and the detector is selected at this stage in which a satisfactory pattern is observed and learned by the system. Otherwise, the last detectors with the smallest threshold values are processed where the *Sp* may be slightly smaller than 1 and they are selected for splitting.

Finally, the methodology determines the most suitable detectors for each technique (i.e., Haar, LBP, HOG) through the detector sets trained previously as depicted in Table 2 that are above the green line in Fig. 9. The results of the RL process for the 13 surveys regarding the selection of the detectors for splitting are explained in Section 6.1.

5.1.2. Object recognition and splitting (A.4.2.Phase1)

The detectors determined by the RL approach at the start of the splitting process as explained in Section 5.1.1 are utilised in this phase. The methodology makes these detectors run on all the images using the Viola–Jones matching technique and the images are placed in the negative directory if they are specified as negative; in other words, these are the images in which no object is detected by any of these detectors. The images are readily placed into the positive directory when an object is detected by any detector without screening the image for other objects using the remaining detectors. The main aim is to increase *Sp* by reducing FPs with respect to each technique, but to increase *Se* using 3 techniques at the same time by reducing FNs regarding the number of positive images (see Fig. 10). The higher the number of objects in an image, the more likely that the image will be put into the positive directory. The splitting phase was evaluated on several surveys (Fig. 4III) and the results (Table 3) are explained in Section 6.1.

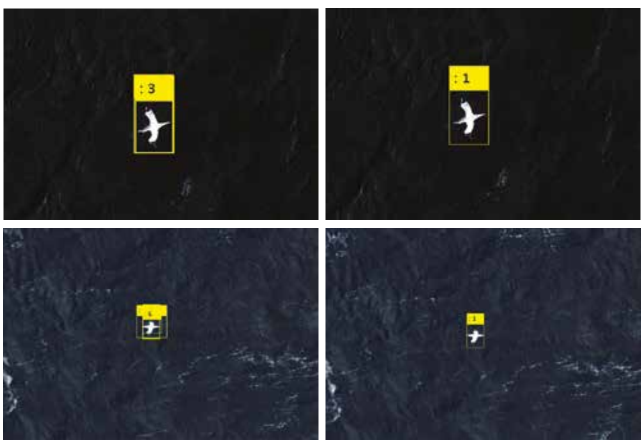


Fig. 13. Two magnified gannet objects detected by several detectors (left) and counted only once (right).

5.2. Implementation of the platform in counting objects

In the splitting phase, the application places any image into the positive directory when an object is detected without screening the image for other objects using the remaining detectors. In this way, the processing time of the splitting is reduced significantly. On the other hand, the aim of the counting phase is to detect every targeted object in images placed in the

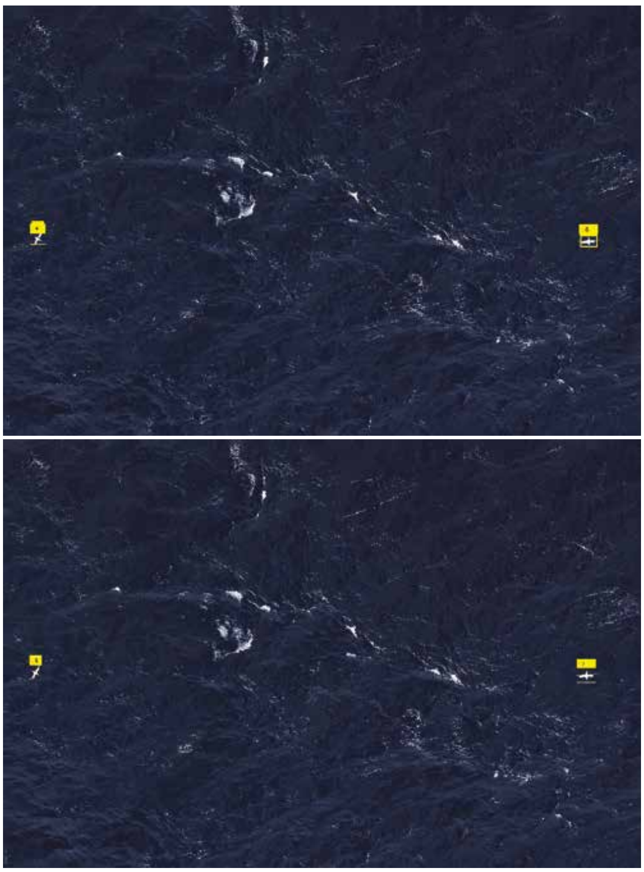


Fig. 14. Gannets detected by the convenient detectors: Multiple gannet objects detected by several detectors (top) and counted only once (bottom).

Table 3 Accuracy rates of the snag dataset based on the trained files of 4 different parameters for splitting images into positive and negative categories: all snags are recognised successfully by the training parameters, FAR = 0.50 and TPR = 0.995 with the combination of 3 techniques.

									Selected parameters for three techniques					
									Haar		LBP		HOG	
Surveys	NegativeImages	PositiveImages	GannetsTot	#	TP	TN	Se	Sp	FAR	TPR	FAR	TPR	FAR	TPR
Survey	1	100	31	31	30	99	0.968	0.990	0.350	0.985	0.400	0.995	0.350	0.985
Survey	2	100	7	7	7	93	1.000	0.930	0.350	0.985	0.350	0.985	0.350	0.985
Survey	3	100	3	3	3	97	1.000	0.970	0.350	0.985	0.400	0.995	0.400	0.985
Survey	4	100	2	2	2	92	1.000	0.920	0.350	0.985	0.350	0.985	0.350	0.985
Survey	5	100	1	1	1	99	1.000	0.990	0.500	0.995	0.500	0.995	0.500	0.995
Survey	6	100	2	2	2	99	1.000	0.990	0.350	0.985	0.400	0.995	0.400	0.985
Survey	7	100	10	10	9	99	0.900	0.990	0.350	0.985	0.400	0.995	0.400	0.985
Survey	8	100	3	3	3	100	1.000	1.000	0.400	0.995	0.400	0.995	0.500	0.985
Survey	9	100	1	1	1	99	1.000	0.990	0.500	0.995	0.500	0.995	0.500	0.995
Survey	10	100	1	1	1	97	1.000	0.970	0.400	0.995	0.400	0.995	0.350	0.985
Survey	11	100	10	10	10	98	1.000	0.980	0.350	0.985	0.400	0.995	0.450	0.995
Survey	12	100	3	3	3	99	1.000	0.990	0.400	0.995	0.500	0.995	0.400	0.995
Survey	13	500	202	256	196	484	0.970	0.968	0.350	0.985	0.350	0.985	0.400	0.995
Split Avg							**0.988**	**0.975**						

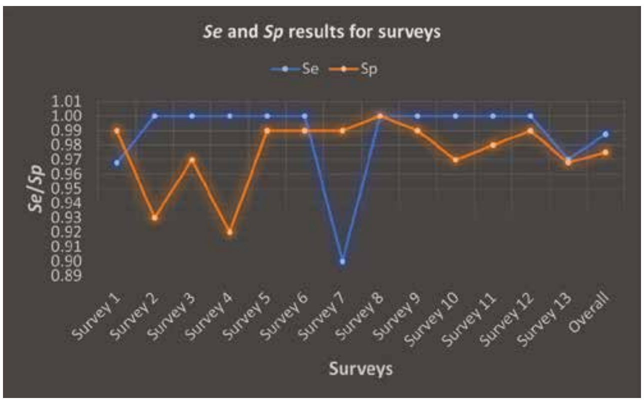


Fig. 15. Visualisation of Se and Sp results of the surveys in Table 3 for splitting images into positive and negative categories.

(a) Example 1: the object with very difficult background texture; Bottom centre.

(b) Example 2: the object during diving in exactly different shape; at the middle left.

Fig. 16. Examples of gannet objects in whole images not detected by the trained classifiers.

positive directory. New detectors are selected to complete this task using a similar recursive RL approach explored above, but differently as explained in Section 5.2.1 in order not to miss any targeted object in the positive images.

5.2.1. Pattern recognition and specification of the best feature extraction detectors for counting using RL (A.4.1)

The methodology chooses the best detectors regarding counting ob- jects in the images placed in the positive folder based on the particular patterns and characteristics of the objects in those images as illustrated in Fig. 3, A.4.1. The main objective of this phase is to detect and count all the targeted objects successfully. The components of the recursive RL algorithm employed in this phase are demonstrated in Fig. 12 and the main steps are explained as follows.

First, a very small subset of the positive images (i.e., 2–5) in the survey are selected and all the objects in these images are outlined with a bounding box along with the targeted object counts per image by the user upon the interface provided in the application during the selection of a subset of the negative samples at the start of the survey analysis as mentioned in Section 5.1. In other words, the detectors for both splitting and counting are designated by the recursive RL approach before the survey analysis starts. In this way, the methodology carries out the counting process automatically after the splitting phase is completed.

Second, these selected positive images are processed with respect to the user-specified objects by the RL approach to determine the best de- tectors for each technique based on the observed *Se* (i.e., TP/(TP+FN)) values. In this step, an object recognition test is performed with preferably higher *Se* values to increase the chance of detecting a targeted object in the positive folder. In other words, the FN cases are reduced substantially with respect to the targeted objects, preferably to zero, resulting in very high *Se* values with an ability to correctly detect the objects in the images. The RL algorithm makes the detectors run on the sample positive images using the Viola–Jones matching technique to single out the successful detectors for counting by referencing the users' object inputs from the selected positive images. This time, different from the splitting phase, the process starts from the detectors with the lowest threshold values (i.e., 035–0985 in Fig. 9) that may result in many FNs which may reduce *Se*. This iterative process proceeds until no FN is obtained per detector where *Se* is 1. In other words, the process stops per detector where *Se* is 1 and the detector is selected at this stage in which a satisfactory pattern is observed and learned by the system. Otherwise, the last detectors with the highest threshold values are processed where the *Se* may be slightly smaller than 1 and they are selected for counting. Additionally, the last detector with the highest threshold values may result in several FP where the images have complex backgrounds, which may reduce *Sp* of the system at this stage. But, the objective is to detect all targeted objects successfully with a high *Se*, preferably 1, as specified earlier even though compromising *Sp* slightly. The use of multiple designated detectors at a time in a collective way aims to ensure a high *Se* — one of the other two detectors can detect an object if it is missed by a detector.

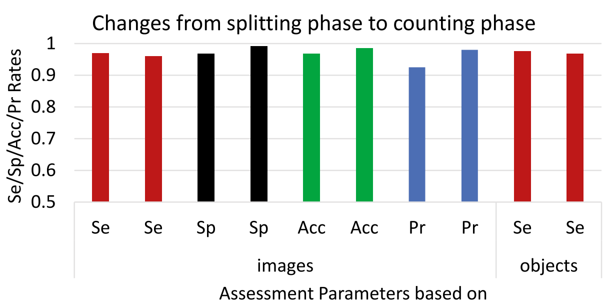


Fig. 17. Performance of the counting phase with respect to splitting regarding Survey 13 presented in Table 3.

Finally, the methodology places the most convenient detectors for each technique (i.e., Haar, LBP, HOG) through the detector sets trained previously as depicted in Table 2 that are above the green line in Fig. 9. The results of the RL process for the last survey (Table 3) regarding the selection of the detectors for counting are explained in Section 6.2 (Fig. 4III).

5.2.2. Object recognition and counting of objects in surveys (A.4.2.Phase2)

In this phase, the aim is to detect all targeted objects in the positive images with an increased Se by giving several FPs if necessary, in order not to miss any targeted objects. Every image in the positive directory is processed by the Viola–Jones technique using each designated detector and objects are tagged wherever they are detected and coordinates for one or more rectangular ROI (coloured bounding box around the recognised object (e.g., Fig. 13)) are returned. These coordinates are mainly utilised for both counting each detected object once using the non-maximum suppression technique (Fig. 3), as explained in the following paragraph, and cropping the tagged objects automatically for further analysis.

Due to the fact that detection windows overlap each other, the same object can be counted more than once. The main reason for this is that 12 detectors are applied for detecting objects in any direction, which may detect and specify an object several times. For instance, a gannet object is detected by 3 detectors and consequently counted 3 times and likewise, another gannet object is detected by 5 detectors and counted 5 times in Fig. 13(left). The non-maximum suppression technique, in which windows with a local maximum classifier response suppress nearby windows (Forsyth & Ponce, 2012), is employed to count the same object only once as shown in Fig. 13(right). Two gannets are located by the detectors several times and they are counted as 2 objects in a whole image in Fig. 14 using the non-maximum suppression technique.

6. Results for splitting and counting

6.1. Results for phase 1: splitting

The methodology was evaluated on each of the 13 surveys (Fig. 4III) in which gannet objects exist to observe the success rates of splitting.

The number of gannets and the negative images along with the success rates are presented in Table 3 and Fig. 15 with respect to the surveys. The detectors selected by the system for each feature extraction tech- nique are shown in the column titled "selected parameters for three techniques" of Table 3 regarding each survey. For instance, the values FAR = 0.350 and TPR = 0.985 for survey 1 correspond to the four detectors, namely, 0.35–0.985-North.xml, 0.35–0.985-East.xml, 0.35– 0.985-South.xml, and 0.35–0.985-West.xml determined for the Haar technique.

The large images with gannets that were not detected as positive are presented in our technical report — MarineObjects_Gannet_Supplement_4.pdf in the supplementary materials. Additionally, the blank images with no gannets that were detected as positive are pre- sented in our technical report — MarineObjects_Gannet_Supplement_ 5.pdf as well. The average *Se* of the system concerning the *Se* results of 13 surveys based on the number of images (i.e., the column titled *Se* in Table 3) is 0.988. The average *Sp* of the system concerning the *Sp* results of 13 surveys based on the number of images (i.e., the column titled *Sp* in Table 3) is 0.975.

Se – correctly-detected-positive-images/all-positive-images – shows the power of the techniques used in the paper in giving assurance that if an image is tagged as a positive image, with at least one bird, that image most probably comprises at least one bird with a belief, an average confidence level of 0.988. In other words, we can conclude that there is a chance that this image does not comprise a bird with an average confidence level of 0.012, which is significantly low in a sense of showing high confidence when a decision is given about an image that is determined as "positive". How the splitting process is implemented successfully can be noticed in Table 3 in the column "TP" compared to the column "Positive Images". Almost all positive images with birds are placed in the positive folder for further processing (e.g., counting). This success is clearer in Survey 13 with many negative images and positive images with multiple targeted objects. On the other hand, *Sp* – correctly-detected-negative-images/all-negative-images – shows the power of the techniques in giving assurance that if an image is tagged as a negative image, that image most probably comprises no bird with a belief, an average confidence level of 0.975. In other words, we can conclude that there is a chance that this image is not a bird-free image with an average confidence level of 0.025, which is significantly low in a sense of showing high confidence when a decision is given about an image that is determined as "negative".

6.2. Results for phase 2: counting

The last survey – Survey 13 – in Table 3 was used to evaluate the viability of the object recognition and counting phase (Fig. 4III). The reason for selecting this survey is that it is the largest survey and has multiple gannets in some of the images, which can help quantify the obtained results more realistically with less bias. The detectors with the parameters of 0.40–0.995, 0.45–0.995, and 0.40–0.985 were selected respectively for Haar, LBP, and HOG techniques by the recursive RL technique. These parameters are bigger than the parameters selected by the RL algorithm in phase 1 (i.e., splitting with 0.35–0.985, 0.35– 0.985, and 0.40–0.995) as explained in Section 5.2.1. This shows that different detectors may be chosen for different purposes (i.e., splitting and counting) by the same recursive RL technique using two different approaches to realise the two different objectives, higher *Sp* with a high level of splitting and higher *Se* with a high level of object detection respectively. 248 objects out of 256 objects in 202 images were tagged as positive successfully resulting in a *Se* value of 0.968 which is 0.976 during the splitting phase regarding the number of objects. 6 objects are missed during the splitting phase within 6 different positive images (Table 3) and 2 objects within 2 different images are missed here during the counting phase. The two objects not detected by the application are shown in Fig. 16. The difference in *Se*, i.e., 0.08 (0.976–0.968), is not found to be significant ($p > 0.01$ using the statistical paired t-test). *Se* – correctly-detected-positive-objects/all-positive-objects – shows the power of the techniques used in the paper in giving assurance that if an object is tagged as a positive gannet, that object most probably is a gannet with a belief, a confidence level of 0.968. In other words, we can conclude that there is a chance that this object is not a gannet with a confidence level of 0.032, which is significantly low in a sense of showing high confidence when a decision is given about an object that is determined as "positive".

On the other hand, it could be highly informative to compare the results between the splitting and counting phases based on the number of images rather than the number of objects for assessing how the counting phase is performing in further splitting, particularly, in handling the imbalanced data. 194 images out of 202 images were tagged as positive successfully resulting in a *Se* value of 0.960 which is 0.970 during the splitting phase. 6 positive images are missed during the splitting phase (Table 3) and 2 positive images are missed here during the counting phase. The difference in *Se*, is not found to be significant ($p > 0.01$, i.e., 0.1578). There were 4 FPs where waves were shaped similarly to the shape of gannets in the snags included in the training process. 496 out of 500 negative images are detected correctly as TN after the counting process whereas it is 484 during the splitting phase for survey 13 (Table 3). This results in a *Sp* value of 0.992 whereas it is 0.968 during the splitting phase based on the number of images. The difference, 0.024 (0.992–0.968), was found to be statistically significant ($p < 0.01$, i.e., 0.0005015) considering the number of negative images, i.e., 500, using the statistical paired t-test. The reduction of FP regarding the increased *Sp* is highly important, particularly for the surveys that are comprised of a great majority of bird-free negative images (e.g., >%95) leading to imbalanced data distribution and bias on the obtained results as elaborated above in Section 5. Moreover, *Pr* is increased slightly from the splitting *Pr*, 0.925 (TP / (TP + FP) = 196 / (196 + 16) = 0.925), to the counting *Pr*, 0.980 (196 / (196 + 4)) based on the number of images, which is statistically significant ($p < 0.01$). Finally, overall *Acc* rises from 0.969 ((196 + 484) / (202 + 500)) to 0.985 ((196 + 496) / (202 + 500)) based on the number of images, which is statistically significant ($p < 0.01$) as well. The results are presented in Fig. 17 for better visualisation. To summarise, the techniques used during the counting phase provide (i) a successful way of object detection leading to counting objects correctly, and (ii) further successful splitting leading to discarding the FP images substantially as well. The high value of *Pr* indicates that there is still a large room to perform CSA by which *Se* can be increased while compromising *Pr* slightly if *Se*, resulting from the minority positive class, is not deemed as satisfactory

(<%95 for our research) due to the imbalanced data class distribution that may cause unreliable results. These outcomes demonstrate that the two phases of using ensemble techniques proposed in this study can work successfully in performing the offshore bird censuses even without needing to perform CSA (Section 5) and most importantly, the proposed approaches can be generalised to the automated counting of broader species.

A comprehensive field test with a completely new survey has not yet been completed. The system was validated by two field experts from APEM using a completely new evaluation dataset with a decent number of example species (i.e., 20 positive images with 21 gannets and 500 negative images (Fig. 4IV) taken from other recent surveys at the end of the project at the UCLan Intelligent Systems Laboratory before a comprehensive field survey is conducted using the established system in this study. There was a single juvenile gannet in this dataset and this was not detected as positive where all other gannets (i.e., 21) were detected correctly without missing a single one and without producing any FP by excluding other types of flying birds such as terns (i.e., 2 terns) and shearwaters (i.e., 11 shearwaters) as TN. The reason for not detecting this juvenile gannet is that the features of the juvenile gannets seem significantly different from their mature ones, e.g., first-year juvenile gannets are almost black, and subsequent sub-adult plumages show increasing amounts of white (SeabirdCentre, 2017). It is noteworthy to mention that there were no juvenile gannets either in our training nugget dataset or in our surveys. We suggest the construction of new classifiers specific to juvenile gannets to increase the chance of their detection. The correct labelling of the other images with other types of species (e.g., terns and shearwaters) as TN indicates that the classifiers established for gannets perform perfectly for detecting gannets as anticipated, and particular classifiers need to be established for the other species as mentioned in Sections 4.2.1–4.2.3 to identify them. This outcome confirms that the designed techniques in this research enable the automated classification of multispecies and counting them since every targeted species has its particular classifiers.

7. Discussion

Prevention of regional and global extinction of species during industrial developments and environmental changes (e.g., climate change, habitat loss with rapid urbanisation and coastal disturbance, toxic pesticide use) is a social responsibility from a conservationist point of view. In this sense, a species whose population is in decline needs to be identified urgently and should be protected with higher priority before it is too late. Data science is considered by Gibert et al. (2018) as the multidisciplinary field that combines data analysis with data processing methods and domain expertise, transforming data into understandable and actionable knowledge relevant to informed decision-making. Interdisciplinary efforts will help precipitate the shift towards increased use of computer-automated aerial photographic species census techniques (Chabot & Francis, 2016). Within this context, this study by bringing domain expertise and data scientists together in a fruitful collaborative team aims to develop a novel environmental platform for monitoring the marine ecosystem and performing bio censuses in an automated manner at regular intervals to track changes in a particular species population. Birds are sensitive indicators of biological richness, environmental health, ecosystem integrity, and environmental trends and fulfil many key ecological functions; they contribute to our understanding of natural processes (Bibby et al., 1998; Burger & Gochfeld, 2004; Morelli, 2015). Extinction of the passenger pigeon (Ectopistes migratorius), once likely the most numerous bird on the planet, provides a poignant reminder that even abundant species can go extinct rapidly (Rosenberg et al., 2019). Continuously, automated monitoring of species is of paramount importance which requires the use of advanced tools equipped with effective intelligent surveillance techniques. In this sense, a new non-parametric platform composed of an ensemble of supervised ML and RL techniques, WILDetect, is built to segment, split and count maritime species, in particular, birds for performing automated censuses in a highly dynamic maritime environment. Typically, parameter selection to mitigate the variations in datasets and obtain the best possible outcome in an intelligent autonomous system are carried out by users based on several predictions and trials and the success rates of the systems are highly associated with the wisdom of this assumption and implementation of trials correctly, which is a non-trivial task, specifically for ordinary users. Furthermore, there is no single best approach that suits every type of problem space based on the changing characteristics of datasets (e.g., quantity, quality, attributes) and many other environmental dynamics (e.g., different seasons and time zones, different weather conditions, different settings and types of image-capturing technologies). It can be concluded based on the preliminary tests, as elaborated in Section 4.1, and the current research attempts in the literature to count species and classify multispecies, as elaborated in Sections Section 2, that (i) there is no computer-automated study that analyses datasets of small species acquired from the photogrammetry settings using small aeroplanes to survey very large areas in shorter times compared to the other on-ground, ships or UAS platforms, (ii) The most popular learning technique, the so-called DNN, yield the precision values ranging from 60% to 97.66% for bird detection using the aforementioned platforms, (iii) Large data samples with distinctive features (e.g., species that contrast distinctively from image backgrounds) may result in high accuracy rates in using DNN, (iv) The inner states of the DNN approaches are accepted as black boxes by the research community and these approaches do not let the researchers intervene in their inner states which may help increase their efficacy if they do not produce desired outcomes, (v) The misclassification of multispecies is high using DNN and clustering techniques if data instances in different groups resemble each other too closely as seen in bird species. In the proposed intelligent platform – within a dynamic approach that adjust its parameters according to the features of targeted objects, their background and the targeted accuracy rate – the best possible parameters, resulting in the best outcome, are chosen by the platform itself through the automated selection of pre-trained models, in which the parameters are instilled, using the user-model-data interaction solution that is implemented within a new recursive RL technique for mitigating the highly dynamic characteristics of the maritime ecosystem as well as the concerns mentioned with the aforementioned approaches. Additionally, the use of multiple trained models at a time, focusing on different features, ensures a high accuracy rate where one of the other two detectors/models can detect an object if it is missed by the other detector/model in use as elaborated in Section 4.2.2.

The validation of the platform, as summarised in Fig. 4, has been performed on several aerial maritime domains resulting in successful empirical evidence for the viability of the model. During the splitting phase, a positive image is most likely to be placed in a positive folder if there are several targeted objects in that image. Strictly speaking, there is a very high probability that one of the objects in an image will be detected by at least one of the three techniques using 12 detectors regarding the orientation of the objects during the splitting phase. Therefore, the more targeted objects in images, the higher the success rate of splitting. We would like to emphasise that the success rates are very high even though there is mostly only one gannet object in images in the surveys in this study (Table 3 and Fig. 15). The main reason for not detecting 2 of the gannet objects depicted in Fig. 16 in the second phase (i.e., recognition and counting) is that one of them does not look like the shape of a gannet in the training set, because, it is in the diving position, while the other one was not detected because of the very complex background texture behind the gannet. The training snag set should have more similar object types to be able to represent the real-world better and in this way, these types of objects are not missed by the trained detectors.

The trained files established for the gannets do not detect other types of birds as TP, such as common gulls, shearwaters, or terns. Therefore, if the objective is to count other types of birds as well, all bird types should be trained independently as explained in Section 4.2.2 to increase the accuracy of the system. In this way, the classification of other bird species becomes possible using the specific classifiers trained for these types of species. The methodology developed for the detection, splitting, and counting of birds, particularly gannets, in large-scale aerial images may be used for the UK marine gannet census since the most important nesting ground for northern gannets is in the UK with about half of the world's population (55.6%) (JNCC, 2015). Furthermore, multiple types of species of interest can be classified and counted at once using the methodology (as concluded in Section 6.2) with the multiple classifiers that can be obtained as explained in Section 4. It is worth mentioning that the methodology can be expandable with more feature extraction techniques in addition to the feature extraction techniques (i.e., Haar, LBP, and HOG) that we employ in this study.

Given the current pace of global environmental change, quantifying change in species abundances is essential to assess ecosystem impacts. Evaluating the magnitude of declines requires effective long-term monitoring of population sizes and trends, data that are rarely available for most species (Rosenberg et al., 2019). Models perform better as they are attributed to the results of more realistic/recent-data analysis on particular domains. With the proposed platform, current labour-intensive and costly censuses of species conducted in longer time intervals can be replaced with cost-effective and more robustly automated computerised systems and can be repeated in an automated manner at regular intervals. Hence, cycles of the census can be conducted more frequently in shorter intervals over time, and incorporation of near-real-time results along with the prior results (e.g., population fluctuations) attributed to shorter intervals into these models paves the way for developing more effective ecological environmental models with realistic data trends and future projections. This, in turn, can boost the decision-making and prediction abilities of these data-driven simulation models, particularly, about the ecological footprint of human activities on the environment, specifically, on areas/offshores that are being turned into industrial zones, for both assessing the likely impact of the industrial developments on nature (e.g., habitat associations) and constraining/alleviating their potential damaging effects.

8. Conclusions and future work

Advanced tools, enabling effective monitoring of species, are needed to observe and predict the likely effects of environmental changes on species, mostly caused by indispensable industrial developments to take urgent proper actions, e.g., rebuilding natural habitats to maintain/increase species counts. Birds have been demonstrated to serve as good indicators of biodiversity and environmental change and as such can be used to make strategic conservation planning decisions for the wider environment (Bibby et al., 1998). Based on the literature reviewed in Chabot and Francis (2016), a major shift to computer- automated aerial photographic bird censusing is not yet underway and investigators are encouraged to study for potential approaches to automate animal detection and enumeration in aerial images. In this study, a novel supervised ML platform supported by a new recursive RL approach using several off-the-shelf feature extraction techniques and a matching algorithm were developed to conduct marine bird censuses in an automated manner. In the proposed approach, the uncertainties within a highly dynamic maritime environment and inconsistencies/variations in the characteristics of datasets attributed to the diverse sets of image-capturing technologies used in the maritime ecosystem have been mitigated using the recursive RL technique with the user-model-data interaction. In this technique, the most available parameters based on the characteristics of the dataset to be analysed are selected within the platform by the direction of the user at the start of the analysis to result in the best possible outcome. In this way, the developed approach adapts itself to the characteristics of the dataset concerning targeted objects and background and the environmental dynamics, which leads to resulting a desired solution to the current problem space in hand. The methodology has been evaluated and validated by field experts using several surveys and datasets that are independent of the dataset used in the training phase as outlined in Fig. 4. Experimental results on many aerial surveys demonstrate that the proposed methodology is effective and efficient in the detection and segmentation of targeted objects in the maritime ecosystem. The efficacy of the proposed approach can be increased as the techniques are trained with larger datasets for particular species.

The outcome of the study is expected to benefit the entire environmental modelling community. In particular, the proposed techniques can shed light on similar object detection implementations in finding the best possible parameters for analysis in an automated manner by employing the user-model-data interaction solution. Moreover, the platform can be employed to detect all types of birds after these species are pre-processed and trained, as mentioned in Sections 4.2.1–4.2.3. The outcomes elaborated in Section 6 demonstrate that the proposed approaches can be generalised to the automated counting of a broader number of species in a given area and these automated approaches can help track population changes of particular species at different specific locations on a regular basis with a true picture. Strictly speaking, it can be primarily deployed by environmentalists, researchers, authorities, and policymakers to monitor the marine ecosystem for fulfilling their goals effectively.

Within a holistic view, we aim to study other bird species and other marine species (e.g., turtles) as well as man-made maritime objects (Kuru et al., 2022) to be able to observe the bio marine ecosystem with the possible environmental footprint in the short, mid, and long-term. Moreover, the automatic classification of maritime ecosystems based on a variety of species will be in our future plans to support all types of environmental models with near-real-time information with multiple species.

9. Limitations of the study

The established environmental platform can work for other bird species, but using the specific detectors that can be trained for each species as explained in Sections 4.2.1 and 4.2.2. The higher the quality of the datasets representing the real environment, the higher the accuracy rates. We aim to share our results with other papers about our ongoing research on multispecies census of other species such as shearwaters, terns, gulls, scooters, fulmars.

CRediT authorship contribution statement

Kaya Kuru: Conceptualization, Methodology, Software, Writing – original draft. Stuart Clough: Validation, Resources, Data curation. Darren Ansell: Investigation, Project administration. John McCarthy: Validation, Resources, Data curation. Stephanie McGovern: Valida- tion, Resources, Data curation.

Declaration of competing interest

The authors declare that they have no known competing finan- cial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

We would like to thank APEM Ltd for providing the maritime aerial surveys used in this study. Anyone who wants to use any of the images either in this manuscript or in our technical reports in the supplementary materials should request permission from APEM Ltd, which retains the copyright and intellectual property contained within. The authors would like to thank the anonymous reviewers for their constructive comments which doubtlessly improved the quality of the paper significantly.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.eswa.2023.120574.

Endnotes

[5] MATLAB and Simulink are registered trademarks of the MathWorks, Inc. See www.mathworks.com/trademarks.

[6] https://uk.mathworks.com/help/vision/ug/train- a- cascade- object- detector.html.

References

Akçay, H. G., Kabasakal, B., Aksu, D., Demir, N., Öz, M., & Erdoğan, A. (2020). Automated bird counting with deep learning for regional bird distribution mapping. *Animals, 10*(7), http://dx.doi.org/10.3390/ani10071207, URL: https://www.mdpi. com/2076- 2615/10/7/1207.

Alqaysi, H., Fedorov, I., Qureshi, F. Z., & O'Nils, M. (2021). A temporal boosted YOLO-based model for birds detection around wind farms. *Journal of Imaging,* 7(11), http://dx.doi.org/10.3390/jimaging7110227, URL: https://www.mdpi.com/2313- 433X/7/11/227.

Bibby, C., Jones, M., & Marsden, S. (1998). *Expedition field techniques: Bird surveys*. London: Royal Geographical Society.

BOEM (2022). Ocean wind 1 offshore wind farm draft environmental impact statement. URL: https://www.boem.gov/sites/default/files/documents/renewable-energy/state- activities/OceanWind1- DEIS.pdf.

Borowicz, A., Le, H., Humphries, G., Nehls, G., Höschle, C., Kosarev, V., & Lynch, H. J. (2019). Aerial-trained deep learning networks for surveying cetaceans from satellite imagery. *PLOS ONE, 14*(10), Article e0212532. http://dx.doi.org/10.1371/journal. pone.0212532.

Burger, J., & Gochfeld, M. (2004). Marine birds as sentinels of environmental pollution. *EcoHealth, 1*(3), http://dx.doi.org/10.1007/s10393-004-0096-4.

Chabot, D., Dillon, C., & Francis, C. M. (2018). An approach for using off-the-shelf object-based image analysis software to detect and count birds in large volumes of aerial imagery. *Avian Conservation and Ecology, 13*(1), http://dx.doi.org/10.5751/ ace- 01205- 130115.

Chabot, D., & Francis, C. M. (2016). Computer-automated bird detection and counts in high-resolution aerial images: a review. *Journal of Field Ornithology, 87*(4), 343– 359. http://dx.doi.org/10.1111/jofo.12171, URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/jofo.12171.

Clements, N., & Robinson, W. (2022). A re-survey of winter bird communities in the Oregon Coast Range, USA, initially surveyed in 1968–1970. *Biodiersity Data Journal*, http://dx.doi.org/10.3897/arphapreprints.e91575.

Cruz, J. E. C., Shiguemori, E. H., & Guimaraes, L. N. F. (2015). A comparison of Haar-like, LBP and HOG approaches to concrete and asphalt runway detection in high resolution imagery. *The Journal of Computational Interdisciplinary Sciences, 6*(3), 121–136.

Dalal, N., & Triggs, B. (2005). Histograms of oriented gradients for human detection. *In Proceedings of the 2005 IEEE computer society conference on computer vision and pattern recognition (CVPR'05) - Volume 1 - Volume 01* CVPR '05, (pp. 886–893). Washington, DC, USA: IEEE Computer Society, http://dx.doi.org/10.1109/CVPR. 2005.177.

Davis, K. L., Silverman, E. D., Sussman, A. L., Wilson, R. R., & Zipkin, E. F. (2022). Errors in aerial survey count data: Identifying pitfalls and solutions. *Ecology and Evolution, 12*(3), http://dx.doi.org/10.1002/ece3.8733.

Delhez, A. (2022). *Multiple flying bird and bird keypoint detection toolbox for processing bird videos* (Master's thesis), Belgium: University of Louvain.

Dujon, A. M., Ierodiaconou, D., Geeson, J. J., Arnould, J. P. Y., Allan, B. M., Katse- lidis, K. A., & Schofield, G. (2021). Machine learning to detect marine animals in UAV imagery: effect of morphology, spacing, behaviour and habitat. *Remote Sensing in Ecology and Conservation, 7*(3), 341–354. http://dx.doi.org/10.1002/rse2.205, URL: https://zslpublications.onlinelibrary.wiley.com/doi/abs/10.1002/rse2.205.

Forsyth, D., & Ponce, J. (2012). *Computer vision* (2nd ed.). London: Pearson.

Gibert, K., Horsburgh, J. S., Athanasiadis, I. N., & Holmes, G. (2018). Environmen- tal data science. *Environmental Modelling & Software, 106*, 4–12. http://dx.doi.org/10.1016/j.envsoft.2018.04.005, URL: http://www.sciencedirect.com/science/ article/pii/S1364815218301269. Special Issue on Environmental Data Science. Applications to Air quality and Water cycle.

Groom, G., Stjernholm, M., Nielsen, R. D., Fleetwood, A., & Petersen, I. K. (2013). Remote sensing image data and automated analysis to describe marine bird distributions and abundances. *Ecological Informatics, 14*, 2–8. http://dx.doi.org/10. 1016/j.ecoinf.2012.12.001, URL: https://www.sciencedirect.com/science/article/ pii/S1574954112001185. The analysis and application of spatial ecological data to support the conservation of biodiversity.

Hayes, M. C., Gray, P. C., Harris, G., Sedgwick, W. C., Crawford, V. D., Chazal, N., Crofts, S., & Johnston, D. W. (2021). Drones and deep learning produce accurate and efficient monitoring of large-scale seabird colonies. *Ornithological Applications, 123*(3), http://dx.doi.org/10.1093/ornithapp/duab022.

Hollings, T., Burgman, M., van Andel, M., Gilbert, M., Robinson, T., & Robinson, A. (2018). How do you find the green sheep? A critical review of the use of remotely sensed imagery to detect and count animals. *Methods in Ecology and Evolution, 9*(4), 881–892. http://dx.doi.org/10.1111/2041-210X.12973, URL: https: //besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/2041- 210X.12973.

Hong, S.-J., Han, Y., Kim, S.-Y., Lee, A.-Y., & Kim, G. (2019). Application of deep- learning methods to bird detection using unmanned aerial vehicle imagery. *Sensors, 19*(7), http://dx.doi.org/10.3390/s19071651, URL: https://www.mdpi.com/1424- 8220/19/7/1651.

Jaderberg, M., Czarnecki, W. M., Dunning, I., Marris, L., Lever, G., Castañeda, A. G., Beattie, C., Rabinowitz, N. C., Morcos, A. S., Ruderman, A., Sonnerat, N., Green, T., Deason, L., Leibo, J. Z., Silver, D., Hassabis, D., Kavukcuoglu, K., & Graepel, T. (2019). Human-level performance in 3D multiplayer games with population-based reinforcement learning. *Science, 364*(6443), 859–865. http://dx.doi.org/10.1126/ science.aau6249.

Jayadevan, P., Nameer, P. P. O., Jha, A., Aravind, A., Dilip, K. G., Karuthedathu, D., Tom, G., Mavelikara, H., Mannar, H., Palot, M., Johnson, J., Raveendran, J., Rodrigues, M., Mujeeb, M., Namassivayan, L., Payyeri, N., Nesrudheen, P., Narayanan, S. P., Prasanth, S., & Yathumon, M. A. (2022). Kerala Bird Atlas 2015– 20: features, outcomes and implications of a citizen-science project. *Current Science, 122*, 298–309. http://dx.doi.org/10.18520/cs/v122/i3/298-309.

JNCC (2015). Northern Gannet Morus bassanus. URL: http://jncc.defra.gov.uk/page- 2875.

JNCC (2022). Seabirds count – the fourth breeding seabird census. URL: https://jncc. gov.uk/our- work/seabirds- count/.

Johnston, D. W. (2019). Unoccupied aircraft systems in marine science and conserva- tion. *Annual Review of Marine Science, 11*(1), 439–463. http://dx.doi.org/10.1146/annurev-marine-010318-095323, PMID: 30020850.

Kellenberger, B., Veen, T., Folmer, E., & Tuia, D. (2021). 21 000 Birds in 4.5 h: efficient large-scale seabird detection with machine learning. *Remote Sensing in Ecology and Conservation, 7*(3), 445–460. http://dx.doi.org/10.1002/rse2.200, URL: https://zslpublications.onlinelibrary.wiley.com/doi/abs/10.1002/rse2.200.

Kuru, K., Clough, S., Ansell, D., McCarthy, J., & McGovern, S. (2022). Intelligent airborne monitoring of irregularly shaped man-made objects in the marine ecosys- tem using statistical machine learning techniques. *SSRN Electronic Journal*, http: //dx.doi.org/10.2139/ssrn.4283676.

Kuru, K., Girgin, S., Arda, K., & Bozlar, U. (2013). A novel report generation approach for medical applications: The SISDS methodology and its applications. *International Journal of Medical Informatics, 82*(5), 435–447. http://dx.doi.org/10. 1016/j.ijmedinf.2012.05.019, URL: https://www.sciencedirect.com/science/article/ pii/S138650561200113X.

Kuru, K., & Khan, W. (2018). Novel hybrid object-based non-parametric clustering approach for grouping similar objects in specific visual domains. *Applied Soft Computing, 62*, 667–701. http://dx.doi.org/10.1016/j.asoc.2017.11.007.

Kuru, K., & Yetgin, H. (2019). Transformation to advanced mechatronics systems within new industrial revolution: A novel framework in automation of everything (AoE). *IEEE Access, 7*, 41395–41415. http://dx.doi.org/10.1109/ACCESS.2019.2907809.

Li, Y., Yang, J., & Wen, J. (2021). Entropy-based redundancy analysis and information screening. *Digital Communications and Networks*, http://dx.doi.org/10.1016/j.dcan. 2021.12.001.

Li, Y., Yang, J., Zhang, Z., Wen, J., & Kumar, P. (2023). Healthcare data quality assessment for cybersecurity intelligence. *IEEE Transactions on Industrial Informatics, 19*(1), 841–848. http://dx.doi.org/10.1109/TII.2022.3190405.

McConnell, R. (1986). Method of and apparatus for pattern recognition. URL: http: //www.google.co.uk/patents/US4567610. US Patent 4, 567, 610.

Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A. A., Veness, J., Bellemare, M. G., Graves, A., Riedmiller, M., Fidjeland, A. K., Ostrovski, G., Petersen, S., Beattie, C., Sadik, A., Antonoglou, I., King, H., Kumaran, D., Wierstra, D., Legg, S., & Hassabis, D. (2015). Human-level control through deep reinforcement learning. *Nature, 518*(7540), 529–533. http://dx.doi.org/10.1038/nature14236.

Moravčík, M., Schmid, M., Burch, N., Lisý, V., Morrill, D., Bard, N., Davis, T., Waugh, K., Johanson, M., & Bowling, M. (2017). DeepStack: Expert-level artificial intelligence in heads-up no-limit poker. *Science, 356*(6337), 508–513. http://dx.doi.org/10.1126/science.aam6960.

Morelli, F. (2015). Indicator species for avian biodiversity hotspots: Combination of specialists and generalists is necessary in less natural environments. *Journal for Nature Conservation, 27*, 54–62. http://dx.doi.org/10.1016/j.jnc.2015.06.006, URL: https://www.sciencedirect.com/science/article/pii/S1617138115300078.

Murray, S., Harris, M. P., & Wanless, S. (2014). An aerial survey of Northern Gannets Morus bassanus on Scar Rocks, southwest Scotland, in 2014. *Seabird, 27*(1), 104–109.

Murray, S., Harris, M. P., & Wanless, S. (2015). The status of the gannet in Scotland in 2013-14. *Scottish Birds, 35*(1), 3–18.

Murray, S., Smith, I., & Smith, A. (2014). Gannet and Guillemot breeding on Rockall, North Atlantic. *Scottish Birds, 34*(1), 13–15.

Ojala, T., Pietikainen, M., & Harwood, D. (1994). Performance evaluation of texture measures with classification based on Kullback discrimination of distributions. In *Proceedings of 12th international conference on pattern recognition, Vol. 1* (pp. 582–585). http://dx.doi.org/10.1109/ICPR.1994.576366.

Ojala, T., Pietikainen, M., & Maenpaa, T. (2002). Multiresolution gray-scale and rotation invariant texture classification with local binary patterns. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 24*(7), 971–987. http://dx.doi.org/10. 1109/ TPAMI.2002.1017623.

Paleczny, M., Hammill, E., Karpouzi, V., & Pauly, D. (2015). Population trend of the world's monitored seabirds, 1950–2010. *PLOS ONE, 10*(6), Article e0129342. http://dx.doi.org/10.1371/ journal.pone.0129342.

Papageorgiou, C. P., Oren, M., & Poggio, T. (1998). A general framework for object detection. In *Sixth international conference on computer vision (IEEE Cat. No.98CH36271)* (pp. 555–562). http://dx.doi.org/10.1109/ ICCV.1998.710772.

Reyes, E. (2014). *A comparison of image processing techniques for bird detection* (Master's thesis), the Faculty of California Polytechnic State University.

Rosenberg, K. V., Dokter, A. M., Blancher, P. J., Sauer, J. R., Smith, A. C., Smith, P. A., Stanton, J. C., Panjabi, A., Helft, L., Parr, M., & Marra, P. P. (2019). Decline of the North American avifauna. *Science, 366*(6461), 120–124. http://dx.doi.org/10. 1126/science.aaw1313, URL: https://www.science.org/ doi/abs/10.1126/science. aaw1313. arXiv:https://www.science.org/doi/ pdf/10.1126/science.aaw1313.

RSBP (2015). Gannet. URL: https://www.rspb.org.uk/ birds- and- wildlife/wildlife-guides/bird- a- z/gannet/.

SeabirdCentre (2017). Gannet. URL: https://seabird.org/wildlife/ seabirds/gannet/12/ 26/47.

Shi, Y., Shen, C., Fang, H., & Li, H. (2017). Advanced control in marine mechatronic systems: A survey. IEEE/ASME *Transactions on Mechatronics, 22*(3), 1121–1131. http://dx.doi.org/10.1109/ TMECH.2017.2660528.

Silver, D., Huang, A., Maddison, C. J., Guez, A., Sifre, L., van den Driessche, G., Schrittwieser, J., Antonoglou, I., Panneershelvam, V., Lanctot, M., Dieleman, S., Grewe, D., Nham, J., Kalchbrenner, N., Sutskever, I., Lillicrap, T., Leach, M., Kavukcuoglu, K., Graepel, T., & Hassabis, D. (2016). Mastering the game of Go with deep neural networks and tree search. *Nature, 529*(7587), 484–489. http: // dx.doi.org/10.1038/nature16961.

Silver, D., Hubert, T., Schrittwieser, J., Antonoglou, I., Lai, M., Guez, A., Lanctot, M., Sifre, L., Kumaran, D., Graepel, T., Lillicrap, T. P., Simonyan, K., & Hassabis, D. (2017). Mastering chess and shogi by self-play with a general reinforcement learning algorithm. ArXiv, abs/1712.01815.

Silver, D., Hubert, T., Schrittwieser, J., Antonoglou, I., Lai, M., Guez, A., Lanctot, M., Sifre, L., Kumaran, D., Graepel, T., Lillicrap, T., Simonyan, K., & Hassabis, D. (2018). A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play. *Science, 362*(6419), 1140–1144. http://dx.doi.org/10.1126/ science.aar6404, arXiv:https://www.science.org/ doi/pdf/10.1126/science.aar6404.

Silver, D., Schrittwieser, J., Simonyan, K., Antonoglou, I., Huang, A., Guez, A., Hubert, T., Baker, L., Lai, M., Bolton, A., Chen, Y., Lillicrap, T., Hui, F., Sifre, L., van den Driessche, G., Graepel, T., & Hassabis, D. (2017). Mastering the game of Go without human knowledge. *Nature, 550*(7676), 354–359. http://dx.doi.org/10. 1038/nature24270.

Smyser, T. J., Guenzel, R. J., Jacques, C. N., & Garton, E. O. (2016). Double-observer evaluation of pronghorn aerial line-transect surveys. *Wildlife Research, 43*(6), 474. http:// dx.doi.org/10.1071/wr16006.

Stefano, L. D., Mattoccia, S., & Mola, M. (2003). An efficient algorithm for exhaustive template matching based on normalized cross correlation. In *12th international conference on image analysis and processing, 2003. Proceedings* (pp. 322–327). Mantova, Italy: IEEE.

Thompson, D. (2021). Seabird survey methods for offshore installations: Black-legged kittiwakes. URL: https://assets.publishing.service. gov.uk/government/uploads/ system/uploads/attachment_ data/file/974338/Kittiwake_ survey_advice_v2.1.pdf.

Trefný, J., & Matas, J. (2010). Extended set of local binary patterns for rapid object detection. In *Computer vision winter workshop 2010*. Czech Society for Cybernetics and Informatics.

Vállez, N., Deniz, O., & Bueno, G. (2015). Sample selection for training cas- cade detectors. *PLOS ONE, 10*(7), 1–16. http://dx.doi.org/10.1371/ journal.pone. 0133059.

Viola, P., & Jones, M. (2001). Rapid object detection using a boosted cascade of simple features. In *Proceedings of the 2001 IEEE computer society conference on computer vision and pattern recognition.* CVPR 2001, Vol. 1 (pp. I–511–I–518). http://dx.doi.org/10.1109/CVPR.2001.990517.

Wang, L., & He, D.-C. (1990). Texture classification using texture spectrum. Pattern Recognition, 23(8), 905–910.

Wang, D., Shao, Q., & Yue, H. (2019). Surveying wild animals from satellites, manned aircraft and unmanned aerial systems (UASs): A review. *Remote Sensing, 11*(11), http://dx.doi.org/10.3390/rs11111308, URL: https://www.mdpi.com/2072-4292/ 11/11/1308.

'Witkin, A. (1984). Scale-space filtering: A new approach to multi-scale description. In *ICASSP '84. IEEE international conference on acoustics, speech, and signal processing, Vol. 9* (pp. 150–153). http://dx.doi.org/10.1109/ICASSP.1984.1172729.

Yang, Z. (2010). Fast template matching based on normalized cross correlation with centroid bounding. In *2010 international conference on measuring technology and mechatronics automation, Vol. 3* ICMTMA, (pp. 224–227). Changsha, China: IEEE. Zhang, L., Chu, R., Xiang, S., & Liao, S. (2007). Lecture notes in computer science, Facts and fallacies: A book of definitive mistakes and misguided predictions in advances in biometrics. Berlin Heidelberg: Springer.

The paper is republished with authors' consent.

Water ice possibility in Moon's polar craters

The Indian Space Research Organisation (ISRO), in a study, has enhanced the possibility of water ice in the polar craters of the Moon. Data revealed that the amount of subsurface ice in the first couple of metres is about 5 to 8 times larger than the one at the surface in both poles (North and South). This crucial information will aid drilling on the Moon to sample or excavate that ice on future missions, and the long-term presence of humans. Not only this, based on the depth of the water ice, it can help select future landing and sampling sites for Moon missions.

The study, on the 'Reachability and Genesis of Water Ice on the Moon' is being carried out by scientists of the Space Applications Centre (SAC) from ISRO, in collaboration with researchers at IIT Kanpur, University of Southern California, Jet Propulsion Laboratory, and IIT (ISM) Dhanbad.

The study also revealed that the extent of water ice in the northern polar region is twice that in the southern polar region. Confirming the hypothesis made during the Chandrayaan mission in 2008, the primary source of subsurface water ice was suspected to be in the lunar poles. This result was found by utilizing polarimetric radar data from the Chandrayaan-2 Dual-frequency Synthetic Aperture Radar instrument.

Another interesting point made by the study is that water in the craters was "outgassed during volcanism in the Imbrian period". On the lunar geologic timescale, the Imbrian period was 3.85 to 3.80 billion years ago, during which intense volcanic activity took place. "The results also conclude that distribution of water ice is likely governed by Mare volcanism (intense bombarding by asteroid-sized bodies) and preferential impact cratering," noted ISRO's study.

The space agency said this will help with future in-situ volatile exploration plans on the Moon. The researchers used seven instruments, comprising a radar, laser, optical, neutron spectrometer, ultra-violet spectrometer, and thermal radiometer on board the Lunar Reconnaissance Orbiter to understand the origin and distribution of water ice on the Moon. *www.newindianexpress.com*

Study indicates 2023 Uttarakhand landslide occurred due to tectonic and human activities

What caused the landslide at Joshimath in Uttarakhand, India towards the fag end of 2022 and early 2023?

The answers to this question were unlocked by two geophysicists from the Space Application Centre-Indian Space Research Organisation (SAC-ISRO) and the Cochin University of Science and Technology (Cusat). The research study, which was a collaborative work led by Dr Sreejith K M of SAC ISRO and Dr Sunil P S of the Department of Marine Geology and Geophysics, Cusat, found an alarming increase in the velocity of landslides in the Himalayan region.

According to Dr Sunil, during the reserach, the team used the Interferometric Synthetic Aperture Radar (a radar technique used in geodesy and remote sensing), Global Positioning System (GPS) and rainfall measurements to understand the geometry of the motion of the Joshimath landslide.

During the research, the geophysicists found that the Himalayan landslides occurred due to tectonic, hydrological and human activities.

"The trigger for our research was the catastrophic landslides that shook Joshimath, a densely populated Himalaya town during December 2022 and January 2023. Around 700 buildings got damaged," said Dr Sunil.

Explaining more about the research and the landslide phenomenon, Dr Sunil said, "While the low amplitude annual landslide motions are modulated by seasonal precipitation, acceleration phases are triggered by extreme rain events. Our analysis revealed episodes of cascading motions triggered by extreme rain events resulting in an overall increase in landslide velocity from 22 mm per year during 2004-2010 to 325 mm per year during 2022-23."

The researchers estimated the landslide depth and hydraulic diffusivity using a 1-D pore-water diffusion model (in this model, diffusion is assumed to take place in the liquid-filled pores).

"Our study reveals the importance of systematic monitoring of ground deformation and weather parameters for landslide hazard mitigation," Dr. Sunil added.

The study also found another active landslide 6 km southwest of Joshimath town that has been moving at a speed of approximately 75 mm per year since mid-2018. *www.newindianexpress.com*

Arahas joins UNIDO's AIM Global Program

Arahas has secured a spot in AIM Global, the Global Alliance on Artificial Intelligence for Industry and Manufacturing, a program run by United Nations Industrial Development Organization (UNIDO). This strategic collaboration is committed to advancing a safe, sustainable, and inclusive use of Artificial Intelligence in industry and manufacturing, th company said in a statement on Thursday.

GHMC begins GIS mapping of properties

Greater Hyderabad Municipal Corporation (GHMC) has begun GIS based survey and mapping of properties and utilities. It is depending on drone-based GIS aerial survey which will be supplemented with door-to-door surveys also. The survey will create detailed and accurate maps of all properties and utilities and integrate datasets across various departments of govt. A unique identification (UID) number will be generated for easy identification of location of properties for door to door garbage collection, emergency and disaster management as well as community engagement.

GHMC also said that the data collected will be treated with the utmost confidentiality and will be used solely for the purpose of enhancing urban management and service delivery. *https://timesofindia.indiatimes.com*

Central Bureau of Narcotics in India to implement GIS mapping

The Central Bureau of Narcotics is planning to conduct a GIS mapping survey to monitor opium cultivation, with the aim of combating illegal trade in the commodity within the country. The bureau intends to issue a new request for proposal to engage a managed service provider to carry out the survey and implement the GIS platform by the end of June or July. The previous request for proposal (RFP), issued in February, was cancelled due to a lack of adequate response. There have been reports of farmers engaging in opium cultivation alongside other crops, particularly in regions such as the Northeast, Rajasthan, and Bihar. *https://economictimes.indiatimes.com*

AfriGIS develops verified geospatial data for Africa

AfriGIS offers verified and validated geospatial data on administrative boundaries linked to postal codes throughout Africa. It has developed a polygon dataset (a collection of shapes defined by closed lines that represent geographical areas) for 21,600 localities (towns), including 475,000 sub-localities (suburbs), over the past three years. *www.afrigis.co.za*

AWS launches GenAI service in APAC region

Amazon Web Services (AWS has announced the general availability of Amazon Bedrock, its fully-managed generative artificial intelligence (GenAI) service, in its Asia Pacific (Mumbai) region. It was globally launched through select regions in 2023.

European GNSS Independent ATM Surveillance Satellite Constellation

The present invention provides a method for space-based air traffic surveillance. The GNSS independence distinguishes the proposed solution from the Automatic Dependent Surveillance-Broadcast (ADS-B) which is reporting the aircraft position based on the GNSS information. It uses uses MODE-S squitter radio signals that are recurrently transmitted by the aircraft and which contain a static 24-bit aircraft unique identifier (known as ICAO aircraft address) and other known bits (such as parity bits for the static address). This static content of the MODE-S signals is particularly important as it allows (satellite) receivers to significantly improve the signal detection as well as timing and carrier frequency estimation of the incoming signal, hence improving the accuracy of post-processing algorithms for geo-locating the aircraft.

The aircraft position is computed in real-time by applying known techniques such as multi-lateration techniques relying on Time difference of arrival (TDOA) or Frequency difference of Arrival (FDOA). Multiple satellites will receive each aircraft MODES-S squitter (broadcasting) signals either with some time delays or with relevant frequency difference due to Doppler, proportional to the distance of aircraft from each satellite, making it possible to calculate aircraft position geometrically, simply based on the difference in the time of arrival or the frequency Doppler shift of the signal received by multiple satellites.

In order to determine the position of the aircraft, at least four independent observations of the same MODE-S signal is required. However, a higher number of observations (if available) can be used to improve the accuracy of the position and resolve the dilution of precision caused by the geometrical location of satellites with respect to the target aircraft. *www.esa.int*

ESA selects Syntony receivers for LEO-PNT constellation demonstration

The European Space Agency (ESA) has selected Syntony GNSS to supply user demonstration receivers for its low-Earth orbit positioning, navigation and timing (LEO-PNT) project.

Led by Thales Alenia Space and funded by ESA, the first European LEO-PNT project aims to enhance PNT services from LEO. This initiative is expected to improve the accuracy and reliability of navigation systems. Syntony will provide its ground receivers, compatible with the new LEO/PNT signals, as well as with GPS and Galileo systems. *syntony-gnss.com*

NHAI seeks global partners for GNSS-based toll collection system

Indian Highways Management Co. Ltd (IHMCL), which operates under the National Highways Authority of India (NHAI), has called for expressions of interest (EOI) to develop and implement a GNSS-based electronic toll collection (ETC) system.

Initially, NHAI plans to integrate the GNSS-based ETC system with the existing FASTag ecosystem through a hybrid model, with both RFID-based and GNSS-based ETC operating simultaneously.

Subsequently, dedicated GNSS lanes will be introduced at toll plazas, allowing vehicles with GNSS-based ETC to pass freely. Eventually, all lanes will convert to GNSS lanes, according to the statement. The invitation includes a detailed implementation plan and suggestions will be accepted till 22 July.

A GNSS-based ETC system is expected to streamline vehicle movement on National Highways, offering benefits such as barrier-free tolling, hassle-free riding experience, and distance-based charges, where users pay only for the stretch they ply on. This system aims to reduce toll collection inefficiencies, plug leakages and curb toll evasion. *www.livemint.com*

Remote sensing to measure water from snowpack and glaciers

Researchers at the Hakai Cryosphere Node are revolutionizing the way we measure snow and are gaining a better understanding of how wildfires influence the melting of the province's glaciers.

The Hakai Cryosphere Node is a collaboration between the University of Northern British Columbia (UNBC), Vancouver Island University (VIU) and the Hakai Institute. The Hakai Cryosphere Node is located at UNBC and led by Geography Professor Dr. Brian Menounos, and Dr. Bill Floyd, a Research Hydrologist with the BC Ministry of Forests and a VIU Geography Adjunct Professor.

The researchers have been working on this project since 2018 when the Tula Foundation funded the Hakai Cryosphere Charter. It funded a five-year project to understand the role seasonal snow cover and glaciers play in the hydrology of key watersheds along BC's Central and Southern Coast.

Researchers are using a plane equipped with LiDAR. The plane flies over watershed areas to get two sets of measurements. The plane is used when there is no snow, a bare Earth measurement, and again for a second measurement when there is snow on the ground. Researchers can subtract them from each other and get an estimate of snow depth.

The LiDAR information is combined with traditional snow-measuring methods that have been used for the past 100 years. These measuring techniques involve people going out into the snowpacks and using a snow tube to measure snow depth and density. *www.unbc.ca*

China launches four high-resolution remote sensing satellites

China sent a new set of four Beijing-3 optical remote sensing satellites - Beijing-3C into orbit on May 19, 2024. These are likely to enter roughly circular, 600-kilometer-altitude sun-synchronous orbits.The satellites were launched for Twenty First Century Aerospace Technology Co. Ltd. (21AT) of Beijing. The satellites were built by CASC's China Academy of Space Technology (CAST). *spacenews.com*

Euro 15M for inflatable heat shield development

A European consortium, led by Spanish mission and system integrator Elecnor Deimos ("Deimos"), is working to develop an inflatable heat shield (IHS) for recovering rocket stages from space. This system could also protect cargo during re-entry and may be used for Mars missions.

ICARUS ("Inflatable Concept Aeroshell for the Recovery of a re-Usable launcher Stage") has received euro 10 million in funding from the European Commission (EC) under the Horizon Europe programme (grant nr. 101134997). This project follows EFESTO-1 (euro 3 million) and EFESTO-2 (euro 2 million), funded by Horizon 2020 and Horizon Europe, respectively. *spacewatch.global*

Developing a Space-based Air Traffic Surveillance Service

Thales, Spire Global, and European Satellite Services Provider (ESSP) have signed a Memorandum of Cooperation with the goal of introducing a range of innovative global satellite-based surveillance services to the air traffic management (ATM) industry and broader aviation market. These services will be powered by a specialized constellation of over 100 satellites collecting Automatic Dependent Surveillance-Broadcast (ADS-B) messages broadcast from aircraft and transmitting the data back to Earth in real time.

Spire will develop the space segment, including system design, building the satellites and payloads, ground control and data collection. Thales will provision the ground air traffic management system and the service supervision infrastructure. ESSP will manage the certification and the delivery of the service for air traffic surveillance purposes and perform H24 operation and supervision, ensuring the compliance with real-time, safety-critical requirements imposed to ATC. *www.thalesgroup.com*

Drone survey at NMDC Diamond Mining Project, Panna

Drone service provider IG Drones has secured a substantial work order for conducting a comprehensive drone survey based on Photogrammetry and LiDAR at the Diamond Mining Project in Panna, Madhya Pradesh, India. This contract, awarded by National Mineral Development Corporation (NMDC), spans three financial years, covering 2024-25, 2025-26, and 2026-27. Complying with Ministry of Mines guidelines, NMDC has mandated a drone survey of the entire lease area for the preparation of digital elevation models (DEM), digital surface models (DSM), and survey-based ortho mosaic images. *https://economictimes.indiatimes.com*

AvironiX Drones Receives Patent for Amphibian UAV

AvironiX Drones has announced that the Indian Patent Office has granted a patent to their groundbreaking "Amphibian Unmanned Aerial Vehicle for MultiTerrain Applications." This unique drone, developed in collaboration with Vel Tech Technical University as part of a GITA Funded Indo-Korea joint research project, is a world-first hovercraft drone capable of navigating on water, land, and air. The Amphibian UAV has already demonstrated its versatility and utility in various applications, including bathymetry and turbidity mapping, as well as water quality sample collection. *https://botsanddrones.in*

Largest Drone Spray Project

Indian Farmers Fertiliser Cooperative (IFFCO) has partnered with Drone Destination to execute India's largest drone-spray services project. The agreement, signed between the two entities, aims to cover approximately 30 lakh acres of farmland across 12 states in India.

Under this Memorandum of Agreement (MOA), drones will be utilized to spray IFFCO's Nano fertilisers, including Nano Urea and Nano DAP, as well as other products across the designated farm lands. The states benefiting from this project include Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Telangana, Uttar Pradesh, and Uttarakhand. *https://botsanddrones.in*

Wingtra launches WingtraCLOUD

Wingtra has launches WingtraCLOUD, which promises to simplify data collection and streamline the onboarding of surveyors and pilots, delivering clear business advantages. This new drone data planning and collaboration solution is set to address some of the most significant challenges faced by customers today. *wingtra.com*

Dedrone launches next gen solution

Dedrone has launched its latest airspace security solution, DedroneOnTheMove (DedroneOTM). It was developed in partnership with several Dedrone customers, partners and world-renowned defence suppliers like Supacat. It is equipped with Counter Uncrewed Aerial Systems (cUAS) command and control (C2) sensor-fusion platform for 360-degree drone detection, *www.dedrone.com*

First FAA waiver for BVLOS commercial operations

Iridium partner American Aerospace Technologies, Inc. (AATI) was granted a first-of-its-kind waiver from the U.S. Federal Aviation Administration (FAA) to conduct UAS surveillance of critical infrastructure in the San Joaquin Valley on behalf of a multinational oil and gas company. This waiver may serve as a tipping point for wider adoption of safe and scalable UAS operations in the National Airspace System (NAS).

Enabled by Iridium's L-Band satellite connectivity, AATI's AiRanger is supporting remote aerial surveillance for the energy corporation's pipeline and production facilities. Iridium's low-latency network is providing BVLOS connectivity, including remote Command and Control (C2) and Detect and Avoid (DAA) capabilities. *www.iridium.com*

FAA approves Amazon Prime Air BVLOS UAV deliveries

The Federal Aviation Administration (FAA) has granted Amazon Prime Air permission to operate UAVs beyond visual line of sight (BVLOS).

Prime Air's BVLOS operations rely on detect-and-avoid technology, which allows UAVs to autonomously navigate obstacles for safe flight operations. Amazon provided the FAA with detailed engineering data and conducted flight demonstrations, which included real-world scenarios involving planes and hot air balloons, to validate the system's safety.

RapidFlight awarded $10M for autonomous aircraft development

RapidFlight has been awarded a $10 million contract from the United States Department of the Air Force (DAF) under the AFWERX Autonomy Prime program. Under the contract, RapidFlight will develop and produce the SPX, a customizable, autonomous fixed-wing aircraft system.

Drogo Drones to foray into survey, mapping, emergency medical services

Drone service provider, Drogo Drones, is pursuing multiple expansion plans, including a foray into survey, mapping, transportation of products as well as emergency medical services. It had recently entered into an agreement with fertilizer cooperative IFFCO for spraying insecticides on 30 lakh acres across several States, including in Andhra Pradesh, Telangana, Maharashtra and Tamil Nadu. Drogo has received permission from the Director General of Civil Aviation (DGCA) for its Krishi 3 drone that provides services in the agricultural sector.

Positioning solution for BMW 7 series

GMV has has integrated its safe, high-precision and reliable positioning technology as a - key component of the BMW Personal Pilot L3 function, the new feature available for order in the new BMW 7 Series. SAE Level 3 automated driving represents a significant advancement in autonomous vehicle technology. The vehicle automatedly manages specific driving tasks within defined conditions, requiring human intervention only when the system encounters challenges beyond its capabilities. GMV's proprietary positioning solution consists of two components: the onboard Safe Positioning Engine software and a Safe GNSS Correction Service. *www.gmv.com*

Swift Navigation and Locosys partnership

Swift Navigation has announced that Locosys has joined its ecosystem partner program. The partnership will help to unlock the next generation of location-based applications by providing enhanced accuracy, reliability, and performance across industrial segments. As industries increasingly adopt IoT to bolster productivity and safety, precise positioning emerges as a critical enabler. Two elements are critical to enable precise positioning: a robust GNSS receiver and a wide coverage corrections service. *swiftnav.com*

Vexcel Open Day India:

Vexcel Imaging, in partnership with Hindustan Assistant & Logistic Group (HALG), have announced the Vexcel Open Day India, taking place from October 7 to 9, 2024, in Bangalore.

This event aims to provide private companies and government agencies from the Indian subcontinent and Southern Asia with insights into Vexcel's extensive experience, as well as that of its customers and partners. Attendees will explore the capabilities of aerial surveys for mapping large areas and creating 3D city models using advanced photogrammetry and LiDAR technologies. International speakers who have undergone similar transformations will share their career paths, experiences, and the challenges they have overcome. Additionally, the Indian Institute of Science in Bangalore will present their scientific perspective and partner with us on this event. Attendance is free of charge. Registration is now open, and interested participants can sign up via vexcel imaging website *vexcel-imaging.com*

Dual-frequency navigation warfare simulator by Safran

Safran Federal Systems has launched the BroadSim Duo, its dual-frequency GNSS simulator designed specifically for testing military receivers in an unclassified environment.

The new product integrates dual-frequency capabilities within a single compact GPS Military signal testing unit. Key features include: Dual-Frequency Capability, Compact and Affordable, Advanced Technology, Skydel Simulation Environment Integration. *www.safranfederalsystems.com*

altGNSSSM GEO SecureTimeSM services by Viavi Solutions

Viavi Solutions Inc. has launched its altGNSSSM GEO SecureTimeSM services that deliver nanoseconds-accurate UTC timing via L-Band and Ku-Band satellite signals for critical infrastructure including 5G networks, transportation, data centers, smart grid, high-frequency trading, military and first responder communications, and satellite terminals. altGNSS GEO service is extremely difficult to jam or spoof and leads the industry with the broadest global coverage, further improving resistance to attacks on the rise. *www.viavisolutions.com*

ANELLO Photonics and Key Dollar Cab partnership

ANELLO Photonics and Key Dollar Cab have announced their strategic collaboration and partnership to bring ANELLO's advanced optical gyroscope technology to agriculture applications focusing on enhancing positioning accuracy in orchards and other High Value Crop environments with limited GPS availability. Optical gyroscope technology offers several advantages over traditional positioning systems, including improved accuracy, reliability, and robustness in challenging Agriculture environments such as orchards with dense foliage. *www.anellophotonics.com*

NAVSYS secures AFRL contract for complementary PNT solution

NAVSYS Corporation has secured a $4.4 million contract from the Rapid Architecture Prototyping and Integration Development (RAPID) Laboratory of the Air Force Research Laboratory (AFRL). The contract is part of AFRL's Commercial Alternative PNT for RAPID (CAPR) program, which aims to provide the Department of Defense improved access to reliable and resilient PNT services, particularly in situations where GPS is unavailable or compromised.

The contract involves developing and maturing NAVSYS' PNT as a Service (PNTaaS) system architecture. This technology uses existing SATCOM signals for PNT services, utilizing broadband signals outside of the L-band frequencies, which are often subject to jamming. The system employs multiple frequency allocations, including C-band, Ku-band and K-band, to offer high resilience and performance equivalent to GPS. *navsys.com*

BAE Systems unveils NavStorm™- M

At the Joint Navigation Conference in Cincinnati, BAE Systems unveiled NavStorm™- M, a gun-hardened integrated anti-jamming and GPS receiver for artillery, bombs, missiles, and unmanned systems. It features a layered protection approach using beamforming, anti-spoofing, resiliency, and software assurance. It is a next-generation Assured-Positioning, Navigation and Timing (A-PNT) device featuring M-Code GPS technology that

SUBSCRIPTION FORM

YES! I want my Coordinates

I would like to subscribe for (tick one)

☐ 1 year
12 issues
Rs.1800/US$140

☐ 2 years
24 issues
Rs.3400/US$200

☐ 3 years
36 issues
Rs.4900/US$300

SUPER saver

*

First name ....

Last name ....

Designation ....

Organization ....

Address ....

....

City .... Pincode ....

State .... Country ....

Phone ....

Fax ....

Email ....

I enclose cheque no. ....

drawn on ....

date .... towards subscription

charges for Coordinates magazine

in favour of **'Coordinates Media Pvt. Ltd.'**

Sign .... Date ....

Mail this form with payment to:

Coordinates
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.

If you'd like an invoice before sending your payment, you may either send us this completed subscription form or send us a request for an invoice at iwant@mycoordinates.org

* Postage and handling charges extra.

MARK YOUR CALENDAR

July 2024

IGS 2024 Workshop
1-5 July in 2024
Bern, Switzerland
https://igs.org

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

August 2024

ICRSG 2024
21-23 August
Singapore
https://www.icrsg.org

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

Intergeo 2024
24-26, September
Stuttgart, Germany
https://www.intergeo.de

12th International FIG Workshop on the Land Administration Domain Model & 3D Land Administration
24-26 September 2024
Kuching, Malaysia
https://gdmc.nl/3DCadastres/workshop2024

October 2024

4th International Conference on Environmental Management (ICEM 2024)
4-7 October
Hyderabad India
https://icem2024jntuh.orgm

Vexcel Open Day India
7-9 October, 2024
Bengaluru, India
https://www.vexcel-imaging.com

November 2024

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

GeoWorld
26-28 November 2024
Dubai, UAE
www.geoworldevent.com

supports warfighters through successful mission completion. *www.baesystems.com*

ComNav unveils M100X GNSS receiver

ComNav Technology Ltd. launched its latest development, the M100X GNSS Receiver. This device is built with the Quantum-III SoC Chip, providing full-constellation and multi-frequency capabilities. It features GNSS+INS integration, a cutting-edge algorithm that significantly boosts its reliability and performance, thereby enhancing functionality in challenging environments. *www.comnavtech.com*

SparkFun launches RTK technology

SparkFun Electronics has launched the RTK Torch, designed for high-precision geolocation and GIS needs. It has tri-band reception, tilt compensation and millimeter accuracy. It can provide millimeter-grade measurements. Users can connect a phone to the device over Bluetooth and receive the NMEA output and work with most GIS software. *www.sparkfun.com*

Mosaic Mobile mapping system with integrated Inertial Labs INS

Mosaic has introduced the Meridian mobile mapping. The system integrates the Mosaic X camera with Inertial Labs INS/lidar to improve mapping accuracy. The Meridian system offers a 74MP native resolution and 13.5K resolution panoramas using precisely synchronized camera modules. The design minimizes image overlap to offer clearer and more consistent panoramas. The integrated INS system has a vertical accuracy of 2 to 3 cm and a precision of 2 to 4 cm. *inertiallabs.com*

GeoMax introduces Zenith60 Pro GNSS smart antenna

GeoMax Positioning has unveiled the Zenith60 Pro GNSS smart antenna, designed for surveyors and construction professionals. It is a real-time kinematics (RTK) rover that features calibrated free tilt compensation to measure otherwise inaccessible points. The antenna is suited for harsh climates, urban areas, dense canopy coverage or other challenging terrains.


SBG SYSTEMS
0.05°
ATTITUDE
0.02°
HEADING
1 cm
POSITION
The Smallest Dual Frequency & Dual Antenna INS/GNSS
» RTK Centimetric Position
» Quad Constellations
» Post-processing Software
NEW ELLIPSE-D
Ellipse-D
RTK Dual Antenna
Ellipse-N
RTK Single Antenna
OEM
RTK Best-in-class SWaP-C
Visit our website: www.sbg-systems.com