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

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

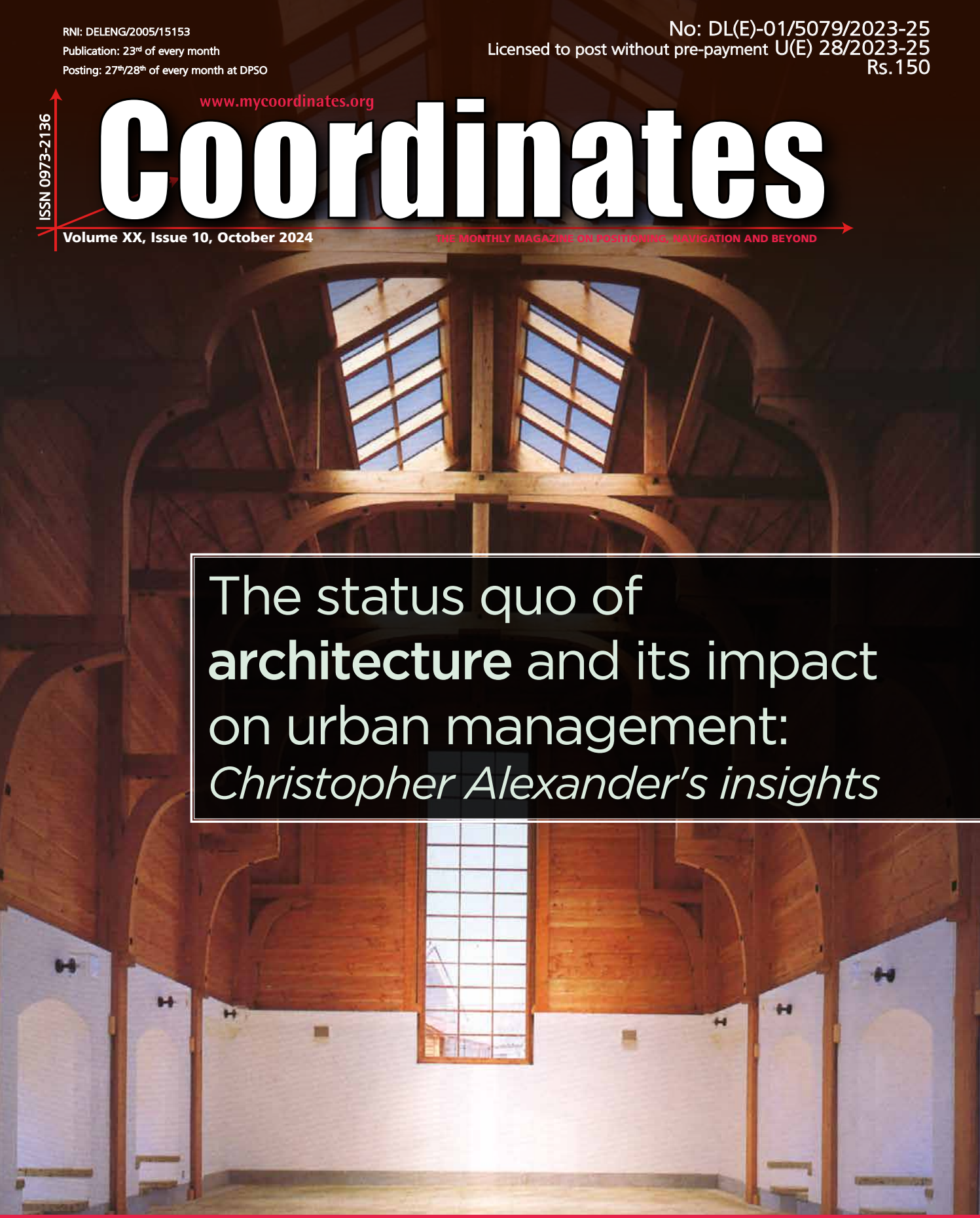
ISSN 0973-2136

www.mycoordinates.org

Coordinates

Volume XX, Issue 10, October 2024

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND



The status quo of **architecture** and its impact on urban management: *Christopher Alexander's insights*

Intelligent airborne monitoring of irregularly shaped man-made marine objects using statistical Machine Learning techniques

In Coordinates

10 years before...

mycoordinates.org/vol-X-issue-10-October-2014

Sea level change - An inconvenient fact or an irritating fiction?

Emeritus Professor John Hannah
University of Otago and Managing Director, Vision NZ Ltd, New Zealand

Claims that sea level has not risen significantly over the last 150 years and, indeed, should not be expected to do so over the next 100 years can be safely disregarded.

Mapping India on large scales – A quick and viable solution

Krishna Kumar Naithani, COWI India Pvt. Ltd Gurgaon, India

A simplified approach for GPS assisted densification of levelling network for high-accuracy large-scale mapping without a geoid

VGS based framework for disaster response

Arash Kaviani and Professor Abbas Rajabifard
Centre for SDIs and Land, Administration (CSDILA), Department of Infrastructure Engineering, The University of Melbourne, Australia

In this research, a new framework and a prototype system are introduced to leverage VGI for enabling VGS in order to help disaster management in response phase. Based on the proposed framework, a mobile application is designed and implemented which attempts to enable society to be involved in response phase of disaster management process alongside public and private disaster management agencies.

Best practices in surveying

Dr Frank Derby
Associate Professor of Surveying, The Pennsylvania State University, USA

There are no universal rules that dene the best practices for land surveying because whereas surveying principles are the same, regulations vary and therefore equipment and methodologies vary in various jurisdictions. Besides, evolving technology is providing opportunities for surveyors to perform the same tasks with different equipment. The best practice is for the surveyor to adopt the methods that will enable him to provide the service effectively within stipulate accuracies by applying professionalism and ethics throughout the process.

Sea level changes in the 19-20th and 21st centuries

Nils-Axel Mörner
Paleogeophysics & Geodynamics, Sweden

The present global eustatic changes have to be conned to rates between +2.0 and 0.0 mm/yr, with a preference to the lower half of this zone; i.e. +1.0 to 0.0 mm/yr. In view of this, it is the high- values of the IPCC models and satellite altimetry that have to be “safely disregarded” Therefore, my best estimate of the amount of sea level change by year 2100 is +5 ±15 cm, which is nothing to worry about.

GIS mapping to determine river pollution

Mujtaba Baqar
College of Earth & Environmental Sciences, University of the Punjab, Lahore, Pakistan

Muhammad Arslan
Department of Earth Sciences, King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Dammam, Saudi Arabia

Asim Mahmood
College of Earth & Environmental Sciences, University of the Punjab, Lahore, Pakistan

The study focuses on the incorporation of GIS mapping to indicate the status of pollution in the sketch of River Ravi downstream to the wastewater outfalls in Pakistan

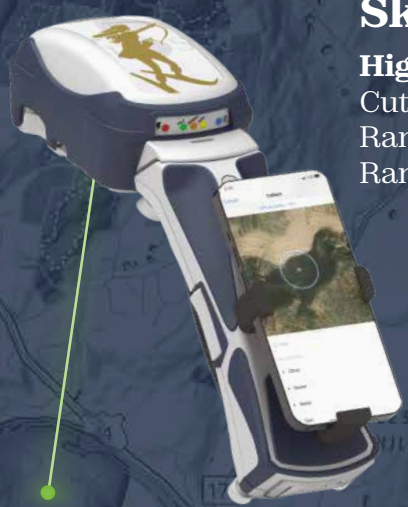
EOS Positioning Systems

The Skadi Series™

High-Accuracy GNSS Receivers for ArcGIS® Apps

Skadi Tilt Compensation™

No more bubbling up!
Increase your productivity,
by reducing your time on each point.



Skadi Smart Handle™

High Accuracy meets high portability
Cutting-edge sensors put an Invisible Range Pole™ and an Extensible Virtual Range Pole™ in your hand.

Skadi 100™

Skadi 200™

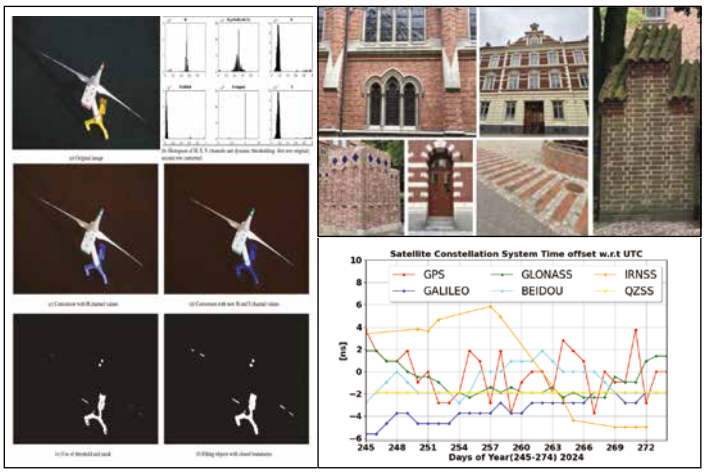
Skadi 300™

Skadi Gold™

esri Partner Network Gold

www.eos-gnss.com

Made in Canada



In this issue

Coordinates Volume 20, Issue 10, October 2024

Articles

Columns

Cover picture: "Eishin Campus Central Building Interior"

The Eishin Campus was built in Saitama prefecture outside of Tokyo, Japan, using Christopher Alexander's methods. Image Used with the permission of the Christopher Alexander & Center for Environmental Structure Archive (christopher-alexander-ces-archive.org)

This issue has been made possible by the support and good wishes of the following individuals and companies
Bin Jiang, Darren Ansell, John McCarthy, Kaya Kuru, Narayan Dhital, Stephanie McGovern and Stuart Clough; Eos Positioning Systems, 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.

A technological triumph

On October 15, 2024.

The successful mid-air capture of Super Heavy booster of Starship rocket,

Using innovative robotic arms at its Boca Chica launch site in Texas,

Takes us closure towards the goal of fully reusable rocket systems.

This achievement of SpaceX has the potential,

To transform many ambitious dreams into tangible realities,

Such as travel to Moon, Mars and beyond,

Not only feasible but also routine.

However, it also reinforces the need for sustainable practices in aerospace.

As humanity expands its footprints in space,

It should not be at the expense our planet – our home.

Bal Krishna, Editor
bal@mycoordinates.org

The status quo of architecture and its impact on urban management: Christopher Alexander's insights

Alexander's critique of modern architecture is not only a call for reform within the architectural discipline but also a blueprint for rethinking urban management.

Bin Jiang
LivableCityLAB, Thrust of Urban Governance and Design, The Hong Kong University of Science and Technology (Guangzhou), China

Christopher Alexander argued that modernist approach to architecture prioritizes innovation, abstraction, and mechanistic efficiency at the expense of human-centered and organic values. According to Christopher Alexander, this shift has led to a proliferation of buildings that are visually striking, but often feel cold, impersonal, and disconnected from the deeper needs of the people who inhabit and/or see them. Alexander called for a return to timeless architectural principles such as harmony, balance, and a deep connection to the natural and cultural context. He introduced the concept of living structure, which emphasizes creating spaces that resonate with the intrinsic order found in nature and human life, fostering environments that are not only functional and beautiful but also profoundly life-affirming. Alexander challenged the dominance of "iconic" but alienating designs, calling for a holistic, human-centered approach to architecture that prioritizes the well-being of individuals and communities, creating spaces that nurture a sense of place, belonging, and harmony with the world around them.

1. Introduction

The architectural landscape of the 20th and 21st centuries has been marked by a profound and pervasive crisis that was vocally critiqued by Christopher Alexander, a seminal figure in architectural theory (Mehaffy, 2007a; 2007b; Salingaros, 2020). This crisis strikes at the core of architectural practice and education. Following the rise of modernism, architecture has increasingly been driven by principles that prioritize novelty, abstraction, and mechanistic efficiency (Jencks, 2002) over humanistic and organic values. The shift toward sleek and often sterile forms has led to buildings that are visually innovative, but fail to engage with the deeper aspects of human experience and environmental harmony. This architectural crisis mirrors broader challenges in urban management, where cities are increasingly prioritizing innovation and efficiency at the expense of human-centered values. This paper situates Alexander's insights within the urban context, proposing that the principles he advocated for—such as harmony, balance, and living structure—are crucial for shaping cities that are both functional and socially sustainable.

Christopher Alexander's critique of contemporary architecture (Alexander, 2002-2005) is both scathing and insightful. He contended that the modernist movement, which emphasizes on breaking from tradition and embracing industrialization and technology as ends in themselves, has led to a disconnection between architecture

and its fundamental purpose, which is to create spaces that nurture, sustain, and enhance human life. The modernist agenda, with its focus on form over substance and on the aestheticization of the machine, has produced an architectural landscape dominated by buildings that may be visually striking but are often devoid of the qualities that make spaces feel alive and meaningful.

Alexander's insights challenge the foundations of modernist practices. He questioned the validity of an architectural approach that views buildings as mere objects to be admired for their visual "impact", rather than as structurally living entities that must interact harmoniously with their environment and the people who inhabit and/or see them. According to Alexander, the crisis in architecture (see Section 2 for more details) is rooted in a fundamental misunderstanding of what it means to create spaces that are truly beautiful and meaningful. According to Alexander, beauty, is not a superficial attribute but a manifestation of deeper, more complex relationships between a space and its users, between form and function, and between the built environment and the natural world.

Alexander's diagnosis of the ailments afflicting contemporary architecture is both a critique and a call to action. Alexander advocated for a profound rethinking of the discipline that moves away from the mechanistic, dehumanized approaches that have dominated the field for the past century (Le Corbusier 1923; Millais, 2017; Curl 2018) towards a return to the principles that have historically governed the creation of architecture. These principles, which emphasize harmony, balance, and a deep connection to the natural and cultural context (Alexander, 1979), are rooted in a timeless understanding of what makes spaces meaningful and alive.

Alexander did not merely call for a revival of past styles or forms (Alexander, 2002); he sought a reinvigoration of the underlying values that have always made architecture a vital and life-affirming discipline. His vision for architecture is deeply rooted in the recognition of the intrinsic order and beauty that is inherent in the natural world, emphasizing that the built environment must resonate with these qualities to truly serve humanity. This paper reviews the current architectural crisis and the rise of the grassroots movement toward new traditional architecture (NTA). We introduce the concept of living structure and critically examine modernist architecture, with a focus on starchitects. Finally, we present a new vision of architecture rooted in living structure, framed within an organic view of space and the world.

The remainder of this paper is organized as follows. Section 2 addresses the architectural crisis, examining how modernist architecture has strayed from holistic design principles. Section 3 explores the grassroots movement that calls for NTA, advocating for a return to enduring design values. Section 4 introduces Alexander's concept of living structure, proposing a more integrated and life-affirming approach to architecture. Section 5 critiques the role of "starchitects" and the focus on novelty over substance, while Section 6 presents a holistic vision for the future of architecture. Finally, Section 7 draws on Alexander's insights and concludes with the implications of our research.

2. The architectural crisis

The crisis in contemporary architecture, as observed by Alexander (2002-2005), originates from a profound departure from the holistic and integrative principles that historically guided the discipline and architectural practices. In earlier architectural traditions, design was an organic process in which every element of a building was conceived in relation to the whole, ensuring that the final structure was not only functional but also imbued with a sense of harmony and life (Venturi, 1966; Curl 2018; Alexander 1979; Alexander 2002-2005). This approach recognized the importance of creating spaces that were in tune with both their physical environment and the psychological needs of their inhabitants or the people in general.

The advent of modernist architecture in the 20th century marked a significant shift in this paradigm. Modernism, driven by rapid technological advancements and the desire to break away from historical precedents, embraced a mechanistic worldview (Curl, 2018; Descartes 1644, 1983). This perspective viewed buildings as machines, reducing architecture to a series of functional components that can be assembled and manipulated with little regard for their relationship to the broader environment or to human experience (see Fig. 1 for two types of architecture). The focus shifted towards efficiency, standardization, and a minimalist aesthetic that favored stark forms and abstract geometries over the warmth and richness of traditional designs.

This mechanistic approach led to form being prioritized over function. Architects became more concerned with creating "iconic" structures that

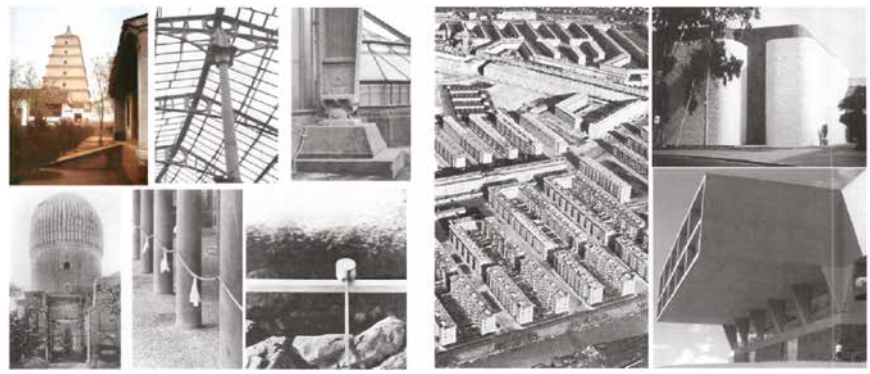


Fig. 1. Two types of architecture imply two kinds of order: Organic and mechanical (Alexander, 2002–2005).

could stand out in a crowded urban landscape, often at the expense of the human experience. The result was a proliferation of buildings that, while visually striking, often lacked the deeper qualities that contribute to a sense of place and belonging (Lewicka, 2011). These structures were characterized by sleek lines and bold forms, but frequently appeared cold, impersonal, and disconnected from the needs of the people who used and/saw them.

Alexander described this phenomenon as a form of "ugliness" that has came to dominate cities and towns in the 20th and 21st centuries. This ugliness is not merely a matter of aesthetic preference; it reflects a deeper malaise in the way we conceive and create our built environment. Instead of creating spaces that nurture and support human life (Alexander, 1979), we have constructed environments that often feel alienating and lack the qualities that make places feel alive and welcoming. The root of this ugliness lies in the detachment of architectural practice from the principles of harmony, order, and beauty that once guided the creation of human-centered spaces.

This architectural crisis is exacerbated by the growing influence of commercial interests in the design process. In a world where economic considerations often dictate design choices, the creation of spaces has become increasingly driven by market forces and superficial trends. In a quest for profitability and recognition, developers and architects may opt for designs that are flashy and attention-grabbing but ultimately fail to meet the deeper needs of the people who inhabit and/see them. The result is a built environment that prioritizes short-term visual appeal and commercial success over long-term sustainability and human well-being.

This crisis is evident in the way many modern buildings and urban evelopments appear disconnected from their surroundings and the people who use and/see them. The homogenization of design, with its reliance on standardized materials and construction techniques, has led to the creation of spaces that lack character and fail to resonate with the unique identities of the communities they serve. In contrast to the richly textured and contextually sensitive architecture of the past (Fig. 2), a lot of modern architecture seems sterile and out of place, contributing to a sense of disorientation and fragmentation in cities.

Alexander's critique of modernist architecture represents a call to return to a more human-centered approach to design that recognizes the importance of creating spaces that are not only functional but also deeply connected to the lives and experiences of the people. Alexander proposed reengagement with the principles of harmony, order, and beauty, suggesting that it is only by restoring these values to their rightful place at the heart of architectural practice that we can begin to address the crisis that has engulfed the discipline.

This crisis is reflected in the design of modern cities. Prioritizing sleek, mechanistic structures over organic and human-centered design has contributed to urban environments that lack vitality and fail to foster a sense of place. As cities grow, the need for a more holistic, human-centered approach to urban design and management becomes increasingly urgent.

3. The movement towards a new traditional architecture

In response to the perceived shortcomings of modernism, a burgeoning movement known as "new traditional architecture" has emerged, championed by figures like Michael Diamant (2008). This movement consciously rejects the dominant architectural trends of the 20th and 21st centuries, which often prioritized innovation, abstraction, and stylistic experimentation at the expense of timeless design principles (Alexander, 1979). Proponents of NTA argue that the aesthetic and functional dissonance found in a lot of modernist architecture has contributed to the "uglification" of urban environments through buildings that, despite being celebrated for their novelty, fail to resonate with the deeper human need for beauty, order, and harmony.

Essentially NTA is a call to return to the classical principles that have guided architectural practice for millennia. These principles, rooted in the traditions of ancient Greece and Rome and refined through the Renaissance and other periods of architectural flourishing, emphasize the importance of proportion, scale, and harmony in design. Similarly, traditional architectures from diverse cultural heritages, such as Chinese, Japanese, Korean, African, Spanish, and other indigenous and regional styles developed over centuries, embody their own expressions of these principles, often incorporating elements

Fig. 2. Examples of brickwork and organic architectural structures from the past.

of symmetry, spatial balance, and natural harmony that reflect the values, beliefs, and environmental contexts of their respective societies. While modernist architecture often seeks to break from the past and create entirely new forms, NTA embraces historical precedents as a source of enduring wisdom. The movement asserts that the classical approach holds intrinsic value, fostering a universally recognizable sense of balance and coherence that is deeply comforting. This is exemplified by the 15 geometrical and transformational properties (Fig. 3) that are believed to be universal (Alexander, 2002-2005) across all architectural traditions and cultural contexts.

Proponents of NTA have criticized it's the tendency of modernism to create spaces that feel alienating and disjointed. The stark, minimalist forms and monolithic structures often appear cold, impersonal, and disconnected from both the human scale and the natural environment. In contrast, NTA aims to design buildings that are not only functional but also deeply connected to human emotions and experiences. Because they incorporate living structures, which evoke a strong sense of place attachment (Lewicka, 2011). By employing architectural principles such as levels of scale, local symmetries, thick boundaries, and alternating repetition, NTA fosters environments that feel harmonious and emotionally resonant.

NTA also emphasizes the importance of creating spaces that are "alive" which means they resonate with the human spirit and contribute to the well-being of their occupants. This concept of "aliveness" is closely related to the concept of living structure (Alexander, 2002-2005), where the built environment is designed in a way that supports human life in its fullest sense, encouraging interaction, reflection, and a sense of belonging. Therefore NTA is not merely about replicating the past but about drawing on timeless principles (Alexander, 1979; Alexander, 2002-2005) to create environments that are vibrant and responsive to the needs of contemporary society.

The resurgence of traditional architectural practices can also be seen as a form of resistance against the homogenization of global architecture. International styles have becoming increasingly dominating, leading to cities around the world looking increasingly alike. As a response to this, NTA advocates for a more localized, culturally informed approach. By re-engaging with regional architectural traditions, this movement seeks to restore a sense of place and identity to the built environment (Lewicka, 2011), ensuring that architecture reflects the values, history, and character of the communities it serves.

In essence, the movement towards NTA is both a critique of the modernist paradigm and a proactive effort to reclaim the lost art of building. It invites architects to look beyond the transient allure of novelty and to rediscover the enduring qualities of beauty, proportion, and harmony that have defined great architecture throughout history. Through this approach, NTA aims to create spaces that are not only aesthetically pleasing but also deeply resonant with the human condition, fostering environments that nurture both the body and the soul.

4. Living structure: A new perspective on architecture

The concept of living structure introduces a transformative way of thinking about architecture and urban management that moves beyond the mechanistic and reductionist views that have long dominated the discipline. This concept suggests that all matter, whether organic or inorganic, possesses a degree of life, not merely in a biological sense but as an intrinsic quality of its structure and arrangement (Alexander, 2002-2005, Gabriel & Quillien, 2019; Jiang, 2019). This idea challenges the conventional understanding of architecture as simply being the assembly of materials to meet functional requirements (Jiang & Huang, 2021). Instead, it invites us to consider the deeper, often intangible qualities that make a space feel alive, resonant, and meaningful. In urban environments, living structure encourages the creation of cities that grow organically and remain adaptable over time emphasizing the importance of interconnectedness, both within the built environment and between the city and its natural surroundings. By applying living structure principles, urban

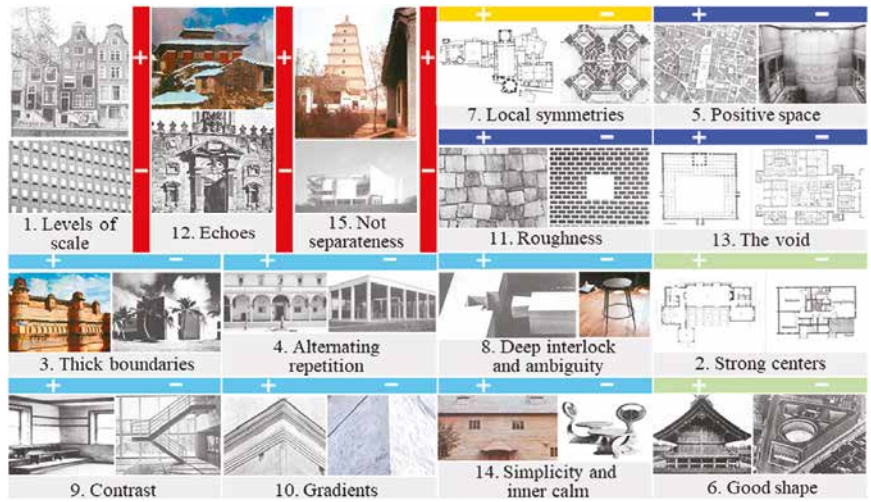


Fig. 3. (Color online) Visualization of the fifteen geometrical and transformation properties
(Note: Each property of living structure is shown with positive (+) and negative (−) examples, mainly from Alexander (2002-2005). The properties are divided into five groups, each of which is color-coded. The red group represents global properties spanning multiple scales, while the two blue groups highlight local properties. 'Local symmetries' is uniquely emphasized, and 'strong centers' and 'good shape' are included as optional, practical properties, though not part of the core fifteen.). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

managers and planners can create spaces that support social interaction, foster a sense of community, and enhance the overall well-being of their residents.

The notion of living structure is a direct response to the mechanistic worldview that has heavily influenced modern architecture. This view often conceives buildings as machines that are composed of discrete parts that operate independently to serve specific functions. While this approach has led to innovations in efficiency and the optimization of space, it has also resulted in designs that can feel cold, alienating, and disconnected from their environment. Alexander argued that while such structures may meet functional and aesthetic criteria on the surface, they often lack the deeper sense of life that makes a space truly engaging and supportive of human well-being.

The living structure concept posits that spaces and buildings can be designed to resonate with their surroundings, creating a sense of harmony, coherence, and vitality. This resonance is not just a matter of visual appeal; it is a quality that can be measured objectively and felt subjectively. For instance, a living structure might incorporate patterns, proportions, and relationships that echo those found in nature, fostering a deep connection between the built environment and the natural world (see Fig. 4 for two examples: one with a more dynamic, living structure, and the other with a less vibrant, more static design). This approach requires us to consider every element of a building, from the smallest detail to the overall form, as part of an interconnected whole that contributes to the life of the structure.

One of the key principles that Alexander emphasized is the importance of 'centers' or substructures as referred to by this author (see Fig. 4 for substructures) within a design. These centers are focal points that naturally attract attention and organize the space around them. In a living structure, centers are not isolated elements but are part of a network of relationships that give the building its sense of coherence and vitality. The degree of life in a structure can be assessed by how well these centers are integrated and how they contribute to the overall harmony of space.

The implications of living structure extend far beyond individual buildings. Alexander's ideas challenge us to think about the broader context in which the buildings' designs and plans exist. A building that embodies living structure does not just stand alone; it contributes to the life of its surrounding environment, whether that is a neighborhood, a city, or a landscape. This holistic perspective encourages us to consider how our designs and plans will interact with and enhance the natural and social fabric around them. It also requires a sensitivity to the cultural and historical context, ensuring that new structures respect and contribute to the continuity of the built environment.

Alexander's philosophy also critiques the mechanistic approach that often dominates architectural and urban education and practice, where a design or plan is segmented into functional, aesthetic, and technical aspects. Alexander argued that this fragmented approach fails to capture the essence of what makes a space feel alive. Instead, he advocated for an organic approach that views buildings as living entities, deeply intertwined with the lives of the people who use them and the environments they inhabit. This perspective encourages us to design with a sense of stewardship, recognizing that our design work is not just about creating isolated structures but about contributing to the ongoing story of human life and the natural world.

Alexander's living structure concept invites us to fundamentally rethink architecture as a discipline. It challenges the notion that buildings should be designed solely for efficiency or visual impact and instead emphasizes the creation of spaces that resonate with the deeper needs of human beings and the natural world. This holistic, human-centered approach calls for a return to timeless principles of design, such as levels of scale, local symmetries, thick boundaries, and echoes, which have always underpinned great architecture. By embracing these principles, we can create spaces that are not only functional and beautiful but also profoundly life-affirming—spaces that engage the senses, foster well-being, and contribute to a greater sense of harmony in the world.

As we look towards the future of architecture, Alexander's insights remind us that the most enduring and beloved spaces are those that embody the principles of living structure. These are the spaces that people return to time and again, that become woven into the fabric of their lives, and that stand the test of time not because of their boldness or innovation, but because of their deep-rooted connection to human nature and the natural world. In a world increasingly dominated by rapid technological change and fleeting trends, the concept of living structure offers a return to the timeless values that make architecture a true art form.

Adopting this perspective allows us to move beyond the current fragmented,

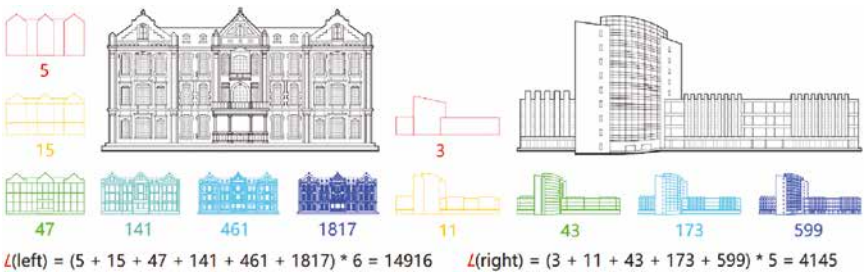


Fig. 4. (Color online) Shanghai Jiao Tong University library buildings and their substructures|z
(Note: The degree of living structure is calculated using formula L = S × H (Jiang & de Rijke, 2023). The older library on the left exhibits a higher degree of living structure than the newer one on the right.). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

utilitarian practices towards a more integrated, meaningful approach to design. This approach not only addresses the shortcomings of modernist ideologies but also lays the foundation for a future in which the built environment is seen as a living, breathing entity that affirms and enriches our daily lives. Through the lens of living structure, architecture can again become a discipline that serves the deeper needs of humanity, creating spaces that are not only practical and beautiful but also profoundly resonant with the essence of life itself.

5. Critique of modernist architecture and the role of starchitects

Christopher Alexander's critique of modernist architecture targets not just the aesthetic and functional flaws but also the cultural and philosophical forces behind its adoption. A key focus is on "starchitects", that is, architects celebrated for their bold and visually striking designs. While these starchitects are indeed influential, they often exacerbate the issues they aim to solve, contributing to disjointed urban environments. And although their iconic buildings are attention-grabbing, they can also disrupt the urban fabric, creating uninviting spaces disconnected from everyday life. Alexander's critique underscores the need for urban design that prioritizes human experience over architectural spectacle.

5.1. The rise of starchitects and the pursuit of novelty

The 20th century witnessed the emergence of starchitects who were driven by the desire to leave a personal mark on the architectural landscape, and therefore prioritized novelty and individual expression over the more enduring values of beauty, functionality, and harmony. This pursuit of the new and the unique became a hallmark of modernist architecture, leading to the creation of buildings that, while visually striking, often failed to meet the needs of the people who lived and worked in them.

Alexander characterized this phenomenon as a "mass psychosis" (Alexander, 2002-2005), a term that reflects the widespread and almost uncritical acceptance of these avant-garde approaches to design. Architects became more concerned with making bold statements and pushing the boundaries of form, often at the expense of creating spaces that were livable, comfortable, and in tune with human scale and needs. This obsession with novelty led to the proliferation of what Alexander called "insane, image-ridden, hollow" architecture – buildings that may appear "impressive", but are ultimately disconnected from the realities of everyday life.

5.2. The disconnect between architecture and human experience

One of Alexander's key critiques is that modernist architecture, as epitomized by the work of many starchitects, often results in a built environment that is at odds with the needs and desires of its users or the people. The emphasis on abstract forms, stark materials, and unconventional designs can lead to the creation of spaces that feel alienating, cold, and unwelcoming. Instead of enhancing human life, these buildings can create environments that are uncomfortable, disorienting, and even oppressive.

The fundamental purpose of architecture is to create spaces that support and enrich human, not only by meeting functional requirements but also by addressing the psychological and emotional needs of the people who inhabit and/see these spaces. In its quest for innovation and self-expression, modernist architecture often neglects these aspects, leading to a widespread dissatisfaction with the built environment.

5.3. The role of starchitects in perpetuating architectural ugliness

Through their significant influence and visibility, starchitects have played a crucial role in shaping the architectural trends of the 20th and 21st centuries. However, Alexander argued that their work often contributes to the uglification of cities. The pursuit of iconic status can lead architects to prioritize form over substance, resulting in buildings that, may be visually striking, but lack the deeper qualities that make a space truly beautiful and meaningful.

Moreover, the influence of starchitects extends beyond individual buildings to the broader cultural and professional context of architecture. Their work instigates trends and norms that other architects feel pressured to follow, even when these trends may not serve the best interests of the people who use the buildings. This has led to a homogenization of architectural styles, where the same kinds of stark, abstract forms are replicated across different cities and contexts, contributing to a sense of disconnection and placelessness in the built environment.

5.4. A call for a return to human-centered design

Alexander's critique is a condemnation of modernist architecture and starchitects, but also a call to action. He advocated for a return to an architecture that is grounded in human experience, prioritizing the creation of spaces that are not only functional but also deeply resonant with the people who use and/or see them. This involves moving away from the pursuit of novelty for its own sake and instead focusing on the timeless principles of beauty, harmony, and wholeness.

In Alexander's view, architects should see themselves as creators of environments that support and enhance human life, not as artists striving for personal expression. Doing this requires a profound shift in how architecture is conceived and practiced, moving away from the abstract, mechanistic approaches of modernism towards a more organic, human-centered way of thinking about space and design.

6. Towards a new vision of architecture

Christopher Alexander's vision for the transformation of architecture represents a

paradigm shift away from the fragmented, mechanistic views (Descartes, 1644) that have dominated the field since the advent of modernism. Alexander critiqued the reductionist approach that characterized a lot of 20th-century architecture, where buildings ware often treated as mere objects composed of isolated parts. This approach strips architecture of its deeper meaning and fails to create spaces that truly resonate with the human spirit.

Instead, Alexander called for an architectural practice rooted in holistic thinking (Bohm, 1980; Whitehead, 1929). In his view, a building should not be seen as a collection of separate components—walls, windows, roofs, etc.—but as an integrated whole where every element is interrelated and contributes to a larger whole. This holistic approach recognizes that the function of a building cannot be divorced from its form, and that ornamentation is not merely decorative but instead integral to the structure's overall harmony and coherence. This emphasis on the inseparability of function and ornament challenges the minimalist tendencies of modernism, where the pursuit of "form follows function" often leads to stark, lifeless spaces.

The concept of living structure describe spaces that possess a certain quality of life. This idea is not limited to organic forms and applies to all matter, whether natural or manmade. A living structure is one that embodies a sense of order, harmony, and wholeness, making it resonate deeply with those who experience it. The degree to which a building or space is "alive" is determined by its structure—specifically, how its various parts relate to each other and to the whole. A space that is rich in connections, patterns, and coherence will naturally evoke a sense of well-being and comfort in its occupants.

To achieve this vision, Alexander called for architects to develop a deep understanding of the principles that govern living structures. This involves studying the patterns and relationships (Alexander et al., 1977) found in nature, which have evolved over millennia to create environments that support life. Applying these principles to architectural design documented in his magnum opus The Nature of Order (Alexander, 2002-2005) enables us to create spaces that are not only functional but also deeply attuned to physical and emotional human needs. This approach requires a shift in focus from designing buildings as isolated objects to viewing them as part of a larger, interconnected whole.

Moreover, Alexander's vision emphasizes the importance of creating spaces that resonate with human feelings and experiences. He argued that architecture should move beyond mere utility and aesthetics to engage with the deeper aspects of human existence. In his view, a well-designed building should evoke feelings of peace, joy, and a sense of belonging and should be a place where people feel connected to themselves, to others, and to the world around them (Alexander, 1979). This requires us to consider the physical dimensions of space as well as its psychological and emotional impact.

In practice, this means designing spaces that are adaptable, human-centric, and responsive to the changing needs of their users. It involves incorporating elements that foster a sense of continuity with the past while accommodating the realities of the present and future. Thus Alexander's vision thus calls for a new kind of architecture that is deeply rooted in the realities of life, sensitive to the subtleties of human experience, and committed to creating environments that support and enhance the well-being of all who inhabit and/see them.

7. Conclusion

Alexander's critique of modern architecture is not only a call for reform within the architectural discipline but also a blueprint for rethinking urban management. His concept of living structure, when applied to urban design, offers a path toward cities that are not only functional but also deeply resonant with the human experience. Urban managers and planners can draw on these principles to create sustainable, adaptable cities that nurture both their inhabitants and the environment. Modernist architecture's emphasis on cold, machine-like efficiency, standardized forms, and a top-down approach, often neglects the fundamental human need for connection, warmth, and harmony. It is driven by a pursuit of innovation for its own sake, resulting in spaces that are abstract, minimalist, and detached from the lives of those who inhabit them. While such an approach is often technically advanced, it frequently sacrifices the organic richness and contextual sensitivity that are essential for creating environments in which people truly feel at home.

In stark contrast, Alexander's vision of architecture is one that is deeply human-centered, rooted in the creation of living structures that resonate with the natural and social rhythms of life. Alexandrian architecture does not prioritize form over function, nor does it treat aesthetics as a mere afterthought. Instead, it seeks a harmonious balance where form and function are inseparable, and where beauty emerges naturally from the context and purpose of the design. This approach emphasizes the maintenance of harmony across scales, from the smallest detail to the overall form, ensuring that every aspect of the built environment contributes to a sense of belonging and vitality.

Alexandrian architecture reclaims the role of architecture as a means of enhancing the human experience. It challenges us to move beyond the sterile, mythological narratives of modernism and to embrace a more organic, knowledge-based approach that is integrated with nature and sensitive to the complexities of human life. Alexander's insights offer a transformative vision for the future of architecture that is more attuned to the needs of people and also more in harmony with the world around us. By embracing these principles, we can create spaces that are functional and aesthetically pleasing,

but also deeply enriching and life-affirming, setting the stage for a built environment that truly reflects the essence of what it means to be human.

CRediT authorship contribution statement

Bin Jiang: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This paper is a reprint of the original paper (Jiang 2024). The paper was prepared with the support of ChatGPT-4; however, the author takes full responsibility for any errors or oversights.

The author gratefully acknowledges the Christopher Alexander & Center for Environmental Structure Archive for providing the images in Figs. 1 and 2, with special thanks to Maggie Alexander. Appreciation is also extended to Qianxiang Yao and Huan Qian for their help in creating Figs. 3 and 4. Special thanks to Professors Shih-Kung Lai and Chaosu Li for their insightful comments, which greatly contributed to improving the paper. The paper was supported by the Startup Fund of The Hong Kong University of Science and Technology (Guangzhou) (G0101000142), the City-University Joint Fund of the Science and Technology Project of Guangzhou (P00285), and Guangdong Provincial Key Lab of Integrated Communication, Sensing and Internet of Things (2023B1212010007).

References

Alexander, C. (1979). *The timeless way of building*. New York: Oxford University Press.

Alexander, C. (2002). Our new architecture and the many world cultures: An open letter to classicist and traditional architects. https://www.livingneighborhoods.org/library/many-world-cultures.pdf.

Alexander, C. (2002-2005). *The Nature of order: An Essay on the Art of Building and the Nature of the universe, center for environmental structure*. Berkeley: CA, 2005.

Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977). *A pattern language: Towns, buildings, construction*. New York: Oxford University Press.

Bohm, D. (1980). *Wholeness and the implicate order*. London and New York: Routledge.

Curl, J. S. (2018). Making dystopia: *The strange rise and survival of architectural barbarism*. London: Oxford University Press.

Descartes, R. (1644, 1983). *Principles of philosophy*. Dordrecht: Reidel. Diamant, M. (2008). New traditional architecture & urbanism. https://newtrad.org/.

Gabriel, R. P., & Quillien, J. (2019). A search for beauty/A struggle with complexity: Christopher Alexander. *Urban Science*, 3(2), 64.

Jencks, C. (2002). *The new paradigm in architecture: The language of post-modernism*. London: Yale University Press.

Jiang, B. (2019). Living structure down to earth and up to heaven: Christopher Alexander. *Urban Science*, 3(3), 96.

Jiang B. (2024), The status quo of architecture and its impact on urban management: Christopher Alexander's insights, *Journal of Urban Management*, xx(x), xx-xx.

Jiang, B., & de Rijke, C. (2023). Living images: A recursive approach to computing the structural beauty of images or the livingness of space. *Annals of the Association of American Geographers*, 113(6), 1329–1347.

Jiang, B., & Huang, J. (2021). A new approach to detecting and designing living structure of urban environments. *Computers, Environment and Urban Systems*, 88,1–10.

Le, Corbusier. (1923). *Towards a new architecture*. London: Butterworth Architecture.

Lewicka, M. (2011). Place attachment: How far have we come in the last 40 years? *Journal of Environmental Psychology*, 31, 207–230.

Mehaffy, M. W. (2007a). Notes on the genesis of wholes: Christopher Alexander and his continuing influence. *Urban Design International*, 12,41–49.

Mehaffy, M. W. (2007b). On the nature of order: An interview with christopher alexander. *Urban Design International*, 12,51–57.

Millais, M. (2017). Le corbusier, the dishonest architect. Newcastle upon Tyne, England: Cambridge Scholars Publishing.Salingaros, N. A. (2020). Connecting to the world: Christopher Alexander's tool for human-centered design. She Ji: *The Journal of Design, Economics, and Innovation*, 6(4), 455–481.

Venturi, R. (1966). *Complexity and contradiction in architecture*. New York: The Museum of Modern Art.

Whitehead, A. N. (1929). Process and reality: *An essay in cosmology*. New York: Free Press.

GNSS Constellation Specific Monthly Analysis Summary: September 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. Please refer to previous issues for past analysis. The two new Galileo satellites (GSAT0225-PRN E29) and GSAT0227-PRN E06) which are declared operational and usable from 05 September, 2024 are included in the analysis. Furthermore, the time transfer method using GNSS pseudorange measurements is introduced in this month's analysis. The impact of each constellation in time synchronization and dissimination applications will be further analyzed in next issues.

Analyzed Parameters for September, 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.

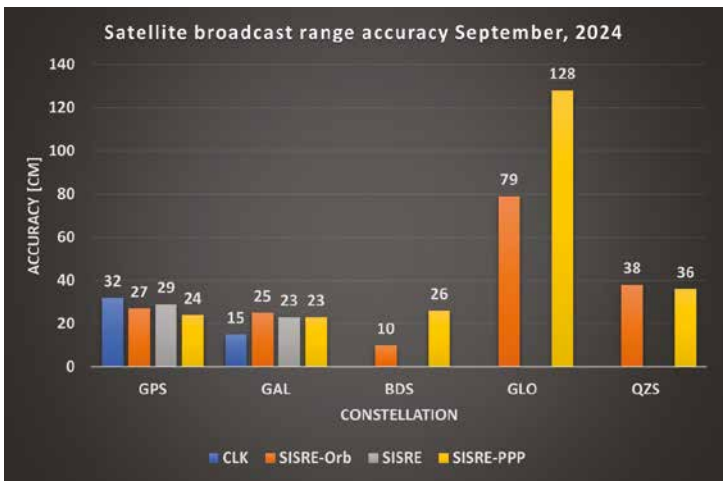
d. **URA**: User Range Accuracy as an indicator of the confidence on the accuracy of satellite ephemeris. It is mostly used in the integrity computation of RAIM.

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

f. **Time Transfer Performance**: The analysis shows the performance of different GNSS system and time link methods for timing and synchronization applications including the realization of the UTC.

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

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

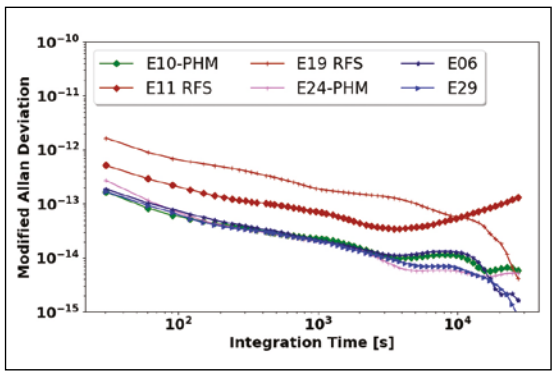


(c)-1 Satellite Clock Jump per Mission Segment Upload

Const	Mean [ns]	Max [ns]	95_Percentile [ns]	99_Percentile [ns]	Remark (Best and Worst 95 %)
IRNSS	6.32	8334.1	8.94	39.8	Best I02 (4.49 ns) Worst I06 (16.89 ns) Big jumps for each satellite, in particular for I06
GPS	0.38	11.54	0.87	1.95	Best G23 (0.43 ns) Worst G03 (2.56 ns) Relatively large jump for G 27 on day 270
GAL	11.04	840232.8	0.18	0.45	Best E27 (0.14 ns) Worst E19 (0.35 ns). E26 had a big jump on day 247. Note: E14 and E18 are excluded

(c)-2 New Galileo Satellites Clock Performance

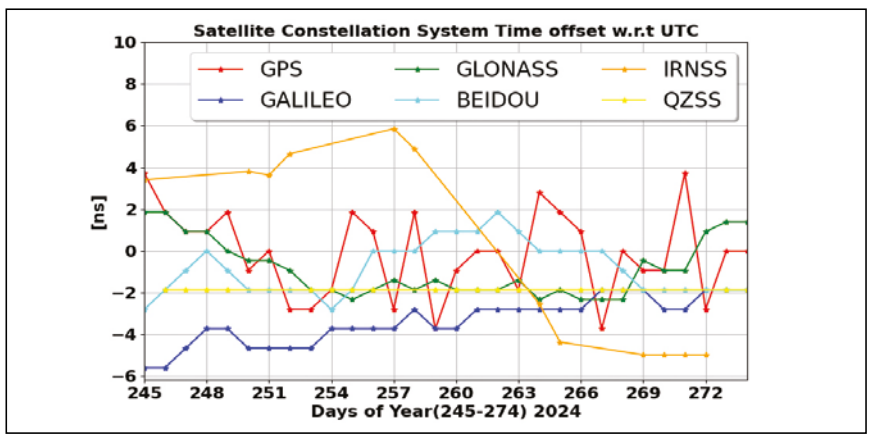
The stability and noise characteristics of the Passive Hydrogen Maser (PHM) on-board the newly operational Galileo satellites E06 and E29 (blue colors) are analysed using the CODE final clock products (day of year 270, 2024 was picked randomly). The performance is similar to other satellites with PHM (pink and green) and it is also evident that both atomic clocks from E06 and E29 behave almost identical. In the figure, the modified allan deviation was computed based on the python library (Allan Tools). Galileo satellites with RFS atomic clocks (brown) are also shown for comparison.



(d) User Range Accuracy (Number of Occurrences in Broadcast Data 01-30 September)

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	2914	3	5	-	1	-	-	-
I03	-	-	-	-	-	-	-	-
I06	784	12	10	2	9	1	102	16 (2),11.3 (5)
I09	625	2	-	-	-	-	-	-
I10	1076	5	3	1	1	1	-	-

(e) GNSS-UTC Offset



(f) Time Transfer

GNSS has been used for the realization of International Atomic Time (TAI) and UTC for some decades now. The technology is heavily used, due to high precision with low cost, in time synchronization and dissemination in almost all digital technologies in the modern world. The realization of the UTC standard requires the continuous monitoring of the accuracy and stability of the time transfer among the contributing precise time laboratories from around the world. Similarly, such monitoring is also required for the use of GNSS for time synchronization and dissemination (**Wang et.al, 2014**). The BIPM is the organization responsible for the realization of UTC standard using different methods, the GNSS time transfer with common view being one of them. The CGGTTS analysis tool (**BIPM et.al, 2024 c**) from BIPM is used in common view mode to understand how different GNSS constellations behave in terms of their application for time transfer. Using the dual frequency ionospheric free code measurements, the time link between NPLI (responsible for time dissemination in India) and NIMT (responsible for time dissemination in Thailand) is checked with GPS, Galileo and Beidou constellations. The data is provided as part of the capacity building program by BIPM and the source is referenced here (**BIPM et.al, 2024 b**). In the figure (f), it can be observed that all constellations provide accuracy in the level of several nanoseconds which is excellent and good enough for the vast majority of timing and synchronization applications. There indeed appears to be systematic biases among the constellations as they are using different signals and have varying behavior in terms of signal noise and delays (**BIPM et.al, 2024 a**). Overall, the biases in common view time transfer can be explained by the time transfer noise, multipath noise and the hardware system delays at the two sites. The ephemeris errors are common and canceled out while the ionospheric error is almost removed with the iono-free combination. Acknowledging these, it can be concluded that the time transfer accuracy and precision in terms of stability & noise look

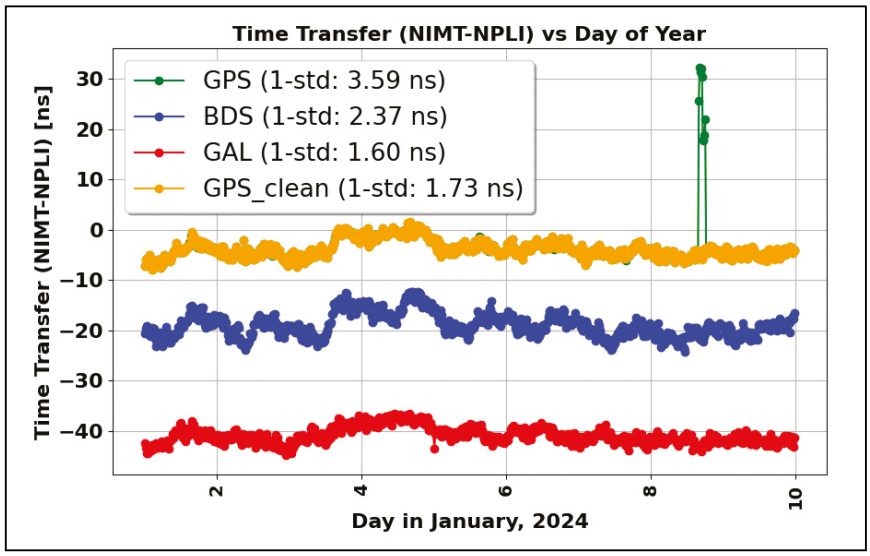


Figure f: The performance of time link between two remote sites represented by timing laboratories equipped atomic clock drivenlocal oscillators. GPS, BDS and GAL signals are used for first 10 days in January 2024 and the accuracy and precision performance look reasonable.

reasonable for each constellation. This monitoring has multiple applications, one being the direct calibration of the time link, such that potential systematic offset can be identified and removed and then the link can be reliably used for the time synchronization between remote clocks. At the same time any anomalies within the time laboratories or the reference timing source can be detected. For example, in the Figure (f), the GPS based time transfer (green color) is impacted by an outlier and this is due to the misbehaving satellite G12 (only the average of all satellites is shown in the figure) and when this satellite is excluded the noise level gets better. Other time transfer methods including all in view with precise clock & orbit products, PPP with carrier phase, ambiguity fixed solutions, multi-frequencies combination and multi-constellation multi frequencies have the potential to provide highly enhanced performance in terms of accuracy and stability and will be assessed in the upcoming issues of the article.

Monthly Performance Remarks:

1. Satellite Clock and Orbit Accuracy:
   - For Galileo, the performance looked similar to the past months. There is, however, a slight degradation in GPS. Galileo E27 had an outage due to maintenance in the atomic clock.
   - For GLONASS, the overall performance seems to have improved in terms of orbits and clocks in comparison to earlier months in 2024 and looked similar to last month
   - For BDS and QZSS, the performance looks very much the same as in the past.
   - For IRNSS, I06 has the poorest performance in terms of URA and satellite clock jumps.

2. UTC Prediction (GNSS-UTC):
   - All constellations show better stability in comparison to previous months. Galileo started to converge to the nominal range after it diverged slightly last month.

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.

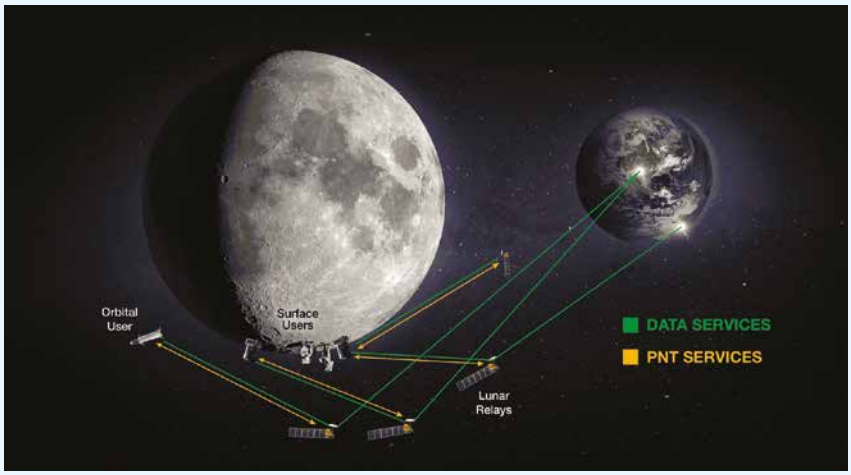
Data sources and Tools:

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))

Time Transfer Through GNSS Pseudorange Measurements: https://e-learning.bipm.org/login/index.php Allan Tools, https://pypi.org/project/AllanTools/gLAB GNSS, https://gage.upc.edu/en/learning-materials/software-tools/glab-tool-suite

NASA selects lunar relay contractor for lunar communication and navigation services



Lunar relay supporting Artemis Moon missions. Credit: NASA/David Ryan

NASA has awarded a contract to Intuitive Machines, LLC of Houston, to support the agency's lunar relay systems as part of the Near Space Network, operated by the agency's Goddard Space Flight Center in Greenbelt, Maryland.

This Subcategory 2.2 GEO to Cislunar Relay Services is a new firm-fixed-price, multiple award, indefinite-delivery/indefinite-quantity task order contract. The contract has a base period of five years with an additional 5-year option period, with a maximum potential value of $4.82 billion.

Lunar relays will play an essential role in NASA's Artemis campaign to establish a long-term presence on the Moon. These relays will provide vital communication and navigation services for the exploration and scientific study of the Moon's South Pole region. Without the extended coverage offered by lunar relays, landing opportunities at the Moon's South Pole will be significantly limited due to the lack of direct communication between potential landing sites and ground stations on Earth.

The lunar relay award also includes services to support position, navigation, and timing capabilities, which are crucial for ensuring the safety of navigation on and around the lunar surface. Under the contract, Intuitive Machines also will enable NASA to provide communication and navigation services to customer missions in the near space region.

The initial task award will support the progressive validation of lunar relay capabilities/services for Artemis. NASA anticipates these lunar relay services will be used with human landing systems, the LTV (lunar terrain vehicle), and CLPS (Commercial Lunar Payload Services) flights.

As lunar relay services become fully operational, they will be integrated into the Near Space Network's expanding portfolio, enhancing communications and navigation support for future lunar missions. By implementing these new capabilities reliance on NASA's Deep Space Network will be reduced.

NASA's goal is to provide users with communication and navigation services that are secure, reliable, and affordable, so that all NASA users receive the services required by their mission within their latency, accuracy, and availability requirements.

This is another step in NASA partnering with U.S. industry to build commercial space partners to support NASA missions, including NASA's long-term Moon to Mars objectives for interoperable communications and navigation capabilities. This award is part of the Space Communications and Navigation (SCaN) Program and will be executed by the Near Space Network team at NASA Goddard. *www.nasa.gov*

Intelligent airborne monitoring of irregularly shaped man-made marine objects using statistical Machine Learning techniques

The objective of this study is to create a new platform for the automated detection of irregularly shaped man-made marine objects (ISMMMOs) in large datasets derived from marine aerial survey imagery. We present here the first part of the paper. The concluding part of the paper will be published in the next issue

Kaya Kuru
School of Engineering and Computing, University of Central Lancashire, Fylde Rd, Preston, Lancashire, PR12HE, UK

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

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

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

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

Abstract

The marine economy has historically been highly diversified and prolific due to the fact that the Earth's oceans comprise two-thirds of its total surface area. As technology advances, leading enterprises and ecological organisations are building and mobilising new devices supported by cutting-edge marine mechatronics solutions to explore and harness this challenging environment. Automated tracking of these types of industries and the marine life around them can help us figure out what's causing the current changes in species numbers, predict what could happen in the future, and create the right policies to help reduce the environmental impact and make the planet more sustainable. The objective of this study is to create a new platform for the automated detection of irregularly shaped man-made marine objects (ISMMMOs) in large datasets derived from marine aerial survey imagery. In this context, a novel nonparametric methodology, which harbours several hybrid statistical Machine Learning (ML) methods, was developed to automatically segment ISMMMOs on the sea surface in large surveys. This methodology was validated on a wide range of marine domains, providing robust empirical proof of concept. This approach enables the detection of ISMMMOs automatically, without any prior training, with accuracy (*ACC*), Matthews correlation coefficient (*MCC*), negative predictive value (*NPV*), positive predictive value (*PPV*), specificity (*Sp*) and sensitivity (*Se*) over 0.95. The outlined methodology can be utilised for a variety of purposes, but it's especially useful for researchers and policymakers who want to keep an eye on how the maritime industry is deploying and make sure the right policies are in place to meet regulatory and legal requirements to promote maritime tech innovation and shape what the future looks like for the marine ecosystem. For the first time in the literature, a method, the so-called ISMMMOD, has been developed to automate the detection of all types of ISMMMOs by statistical ML techniques that require no prior training, which will pioneer the monitoring of human footprint in the marine ecosystem.

1. Introduction

The process of marine spatial planning is highly contentious due to the presence of multiple stakeholders, often with conflicting objectives and values (Elrick-Barr et al., 2022). The maritime economy has historically been highly diversified

and prolific due to the fact that the Earth's oceans comprise two-thirds of its total surface area. As technology advances, leading enterprises and ecological organisations are building and mobilising new devices supported by cutting-edge marine mechatronics solutions (Shi et al., 2017) within the framework of Automation of Everything (AoE) (Kuru and Yetgin, 2019) to explore and harness this challenging environment. More specifically, robotic vehicles, autonomous vehicles, and surface vessels have been deployed for the offshore industries and deep sea archaeology, ocean engineering projects, rescue operations and environmental measurements for the last several decades. For instance, the Argo program, an international collaboration, has deployed approximately 3900 instruments in the world's oceans to facilitate the collection of data for climatological and oceanographic studies. (Riser et al., 2016). Besides, artificial structures such as gas, oil and deep seabed mining platforms, offshore renewable energy harvesting technologies such as oil and gas installations, wind farms and wave energy converters, fish farms, ships, boats and yachts for transportation, autonomous marine vehicles from unmanned ships to smaller vessels are becoming inevitable components of the offshore environment. For instance, in recent years, the offshore wind industry has seen a remarkable expansion, with an annual rate of growth of 25%, for constructing offshore energy islands to meet the reduction of gas emission targets (Zhang et al., 2021). These may conflict with nature conservation objectives, such as habitat loss or species endangerment. In other words, this rapidly expanding industry, which allows for extensive, ongoing human influence in the marine domain, has the potential to have a significant impact on the marine environment, particularly on the marine floor, on turtles, fish, and birds. For instance, the population of monitored seabirds, which account for about 19% of the all seabird populations, declined by almost 70% from 1950 to 2010 (Paleczny et al., 2015), resulting in a net loss of almost 3 billion (%29) birds since 1970 (Rosenberg et al., 2019). The decline of bird populations serves as a stark reminder of the need for immediate action to mitigate threats to the eventual decline of avifauna and the resulting degradation of ecosystem health, functionality, and services (Rosenberg et al., 2019). Intervention into nature is a natural consequence of human activities, however, when managed effectively, these interventions can be beneficial not only to the environment, but also to the ongoing development of civilisation (S`anchez-Marr`e et al., 2004). To better understand the planet and to ensure effective conservation planning, it is essential to have a comprehensive understanding of the species, habitats, and sites that require protection. Unfortunately, for the majority of species and regions, comprehensive quantitative knowledge is not yet available (Bibby et al., 1998). One of the key objectives of the development and utilisation of ecological models and applications is to influence the ecological policy practices, outputs and results in a beneficial manner (McIntosh et al., 2011). There is an urgent need to monitor the environmental upheavals, impacts and possible trends with environmental time series analysis, models and tools as the footprint of human activities increases with the rapid development of the industry. In this manner, modelling, automated detection, location and real-time monitoring of industrial sites and ecosystems around them can help uncover the current and potential future effects on nature. Furthermore, the insights observed and models developed based on these insights may help researchers and policymakers to monitor this diverse ecosystem along with the associated maritime industries and thereby help to determine the legal and regulatory requirements for reducing the ecological foot-print concerning immediate foreseeable environmental problems.

There are numerous studies in the literature to detect underwater man-made objects (MMOs) within a limited region of interest (RoI) using underwater imagery, robots or sonography. For instance, Abu et al. (Abu and Diamant, 2022) proposes a contour-based features analysis method to discern underwater MMOs from natural environment considering that contours of MMOs' are supposed to be smoother than natural objects. There are a limited number of studies in the literature to detect specific types of surface marine MMOs using supervised Machine Learning (ML) and Deep Learning (DL) approaches that require prior training in the marine ecosystem. For instance, Han et al. (Han et al., 2022) proposed a DL technique titled LCSE-ResNet to detect, classify and locate vessels and oil platforms based on remote optical imagery, by which all other MMOs are excluded. There are no studies in the literature that investigates the detection of all types of surface marine MMOs, which makes this research the first study of its kind. Most irregularly shaped man-made marine objects (ISMMMOs) are made of materials such as metal, treated wood, fibreglass, PVC plastic, glass, or concrete and they have different types of irregular shapes and colours. Hence, it is infeasible to apply: i) a template matching technique based on a specific object to input as a template, and ii) a supervised ML approach based on a prior knowledge/similar datasets to train similar objects and then detect these objects automatically. Moreover,

To better understand the planet and to ensure effective conservation planning, it is essential to have a comprehensive understanding of the species, habitats, and sites that require protection. Unfortunately, for the majority of species and regions, comprehensive quantitative knowledge is not yet available

the current clustering algorithms used to group visual datasets are not capable of accomplishing this task with a high degree of precision (Kuru et al., 2013; Kuru and Khan, 2018), particularly for objects with indefinite shapes. Therefore, a new method is needed to realise this objective. On one hand, automatic detection of ISMMMOs is not easy based on two main reasons which pose a considerable challenge: i) the rapidly changing background depending on the camera, water turbidity, weather, wind, wave speed and period, sun glint and density of clouds, and ii) various non-definitive morphologies of MMOs. On the other hand, the characteristics of ISMMMOs differ from the natural environment and other natural objects within this ecosystem regarding the composition, features of the surface, saturation of light and colourfulness relative to the brightness to which an area radiate a varying amount of light.

Many studies aim to detect marine natural objects in sea areas using stationary land-based fixed cameras, in particular, sea animals: detection of animals in deep-sea video (Mehrnejad et al., 2013), detection of sharks using multispectral imaging (Lopez et al., 2014), and detection of killer whales using infrared spectrum (Graber, 2011). Furthermore, aerial surveys from a helicopter or small aircraft have been conducted for many years to detect, locate and monitor specific marine animals using human-based visual observations. Although there are several studies for the detection of MMOs such as ship (Saur et al., 2011), specific objects (e.g., boats, humans) on the ocean surface using infrared cameras (Leira et al., 2015). To the best of our understanding, there is no study that aims to detect all kinds of ISMMMOs automatically with unsupervised approaches using standard advanced cameras and aerial surveys, in particular, from the perspective of ecology. Aerial surveys provide a cost-effective way to collect environmental information over large areas in a short amount of time; however, they may not provide reliable data if not conducted correctly (Davis et al., 2022). Long-term data using standardised and well-structured approaches are the best way to measure change in ecology; unfortunately, this data is not available for most biogeographical regions (Clements and Robinson, 2022) due to the cost of data processing with intensive human intervention. In this sense, this study mainly aims to fill this gap in the scientific literature either by processing the collected data in an automated way, with no human intervention, to separate several hundreds of ISMMMOs from large surveys, or by processing images as they are streamed from the airborne camera systems to monitor ISMMMOs with their geospatial locations immediately with a novel approach using statistical ML techniques and HSV colour mode.

In a conventional marine survey program, there may be a large number of images, e.g., around a million, collected over a period of one year to be analysed for a particular site, and it is labour-intensive to categorise the data into two groups: positive images containing man- made material and negative images without man-made material. In fact, many of the surveys that APEM Ltd.[3] has acquired indicate that 95% of the aerial survey images do not accommodate any targeted object (Kuru et al., 2023). According to some research on visual perception, humans perceive only a small portion of an environment or scene in detail under typical viewing conditions (Noe et al., 2000), which may result in discarding other details that should be taken into account. Although the elements that influence how a scene is perceived are not yet known, it appears that focus is a significant factor (Noe et al., 2000). Within this context, detection of ISMMMOs in large-scale images within very large surveys is a non-trivial task and labour-intensive. Therefore, the utilisation of automated intelligent computer systems to automate this work would be highly advantageous in order to facilitate the development of efficient environmental models with real-world inputs.

To the best of our knowledge, this study, for the first time, explicitly

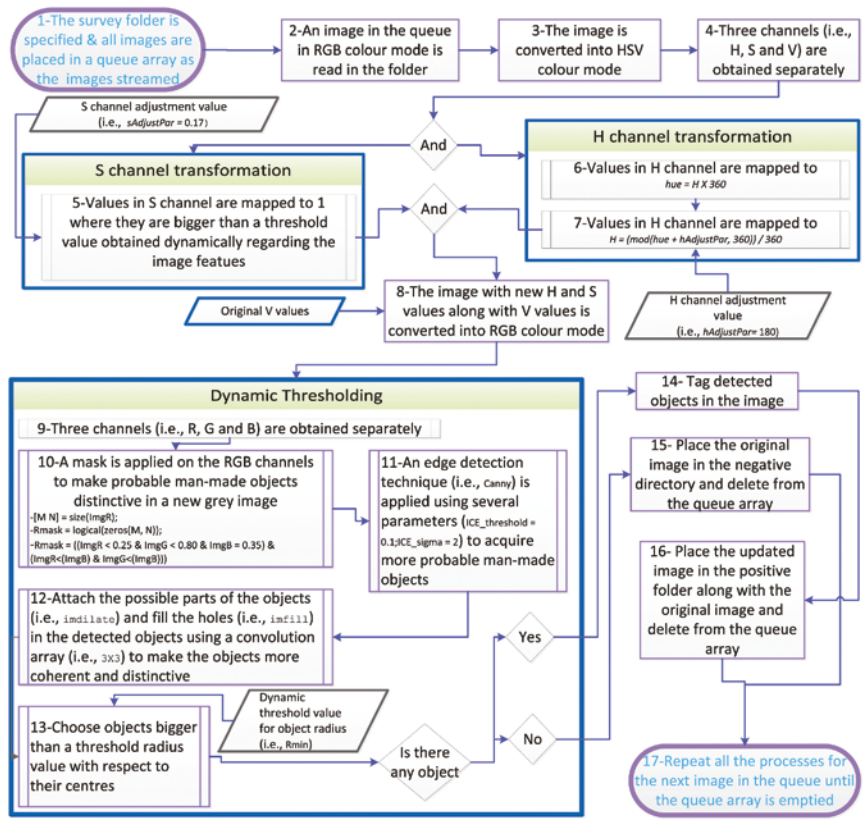


Fig. 1. Overall methodology. The images as they stream are automatically placed in the queue array to be processed in an automated way.

investigates the automatic detection of offshore ISMMMOs to assist researchers, environmentalists, and policymakers in monitoring and managing the various applications of the maritime industry and to provide guidance on the necessary regulations and legal requirements.

In order to illustrate the novelty of this research, specific contributions are listed below.

1. A novel methodology, the so-called ISMMMOD, that detects and splits ISMMMOs automatically in large-scale images in typical very large marine surveys is built.
2. The ISMMMOD is developed using the HSV colour space and statistical analysis of histograms of the channels in this space based on the ROC (receiver operating characteristic) curve analysis. The techniques in the methodology differ man-made-built structures from natural maritime habitats (i.e., waves, sea animals, birds, seawater) in various aspects, in particular, composition, features of the surface and saturation of light.

The rest of this document is structured as follows: The methodology is revealed in Section 2. The datasets on which the methodology is built and tested are explored in Section 3. A summary of the findings is provided in Section 4. Discussions are outlined in Section 5. Section 6 draws a conclusion as well as future potential works. Finally, the limitations of the study are disclosed in Section 7.

2. Methodology

All types of mobile and stationary human activities – human foot-print – are required to be monitored on a regular basis and most of these activities involve the use of non-uniform, human built structures in multiple shapes during the exploration and exploitation of these tough marine ecosystem. Detecting these non-uniform structures on their highly dynamic background entails the development of a new technique that is not based on pretrained uniform object classifiers, but based on the features independent from their shapes. In this respect, we would like to reveal the features that are different from the maritime ecosystem by which a new detection method is aimed to be developed. Built structures differ from the natural maritime habitats and their creatures in various aspects, in particular, composition, features of the surface and saturation of light. The saturation level of ISMMMOs significantly varies from their surroundings (i.e., waves, sea animals, birds, seawater). More explicitly, the saturation level of these ISMMMOs is more intense than that of the natural marine life, and in this study, more saturated sections in images considering this distinguishing feature are made distinct to detect these artificial objects. More specifically, the methodology is based on the HSV colour space (elaborated in Section 2.1) and statistical analysis of histograms of the channels in this space (elaborated in Section 2.2). The essential phases of the technique and its automated execution are depicted in *Fig. 1*. The dynamic thresholding in the implementation of the methodology is presented in Algorithm 1 and the automated implementation of the overall methodology is presented in Algorithms 2 and 3 which are placed in *Appendix A*. The execution of the methodology is exemplified for the images in Figs. 11a, 12a, 13a, 14a, 15a. The techniques in this research was built with Matlab R2020a. The interface is shown in *Fig. 2*. Generally speaking, in the proposed approach, the aerial image in RGB colour space is converted into HSV colour space and then the converted image is split into three components (i.e., channels), namely *H, S* and *V* that are designed to approximate the human vision. The result is a 3D matrix with elements of Hue, Saturation and Value. In the next step, the histograms of these components are computed as illustrated in the first rows of Figs. 11b, 12b, 13b, 14b, 15b. Then, the dynamically calculated threshold value is applied to *S* component along with shifting the *H* channel. At the end, the morphological operations, namely, masking, filter, and smoothing are carried out to extract the required area by suppressing the irrelevant parts mentioned in Section 2.3 such as glinting regions. The statistical terms used throughout the paper are explained regarding the scope of this paper in Table 3 for the readers who are not familiar with these

In a conventional marine survey program, there may be a large number of images, e.g., around a million, collected over a period of one year to be analysed for a particular site, and it is labour-intensive to categorise the data into two groups: positive images containing man- made material and negative images without man-made material

Fig. 2. User interfaces. Left: the main platform developed for multi purpose environmental applications. Right: man-made object detection and splitting interface that can be opened from the main platform.

commonly used terms for the statistical analysis related to the confusion matrix.

Before revealing the methodology on data samples in detail, we would like to explore the basic concepts of the HSV colour space in Section 2.1 to shed light on the developed techniques. Then, the phases of the methodology (Fig. 1) are disclosed on the sample images acquired from various image surveys. The dynamic thresholding phase for *S* channel is explained in Section 2.2. The phases of the masking and dilation are presented in Section 2.3.

2.1. HSV and its applications in the methodology

The main colour models are RGB, HSV, CIELAB, CMYK, and XYZ. The colour models different from the RGB are employed to realise different objectives because several fundamental issues can not be addressed using the additive RGB colour mode for image segmentation such that it is not viable to get the luminance of the image regarding human perception. For instance, the CIELAB colour space that is close to the human visual perception is applied to H&E stained microscopical images to correct the Kohler illumination problem in microscopical images (Kuru, 2014). Likewise, HSV provides a close representation of human visual perception of colour in cylindrical-coordinate representations as illustrated in *Fig. 4* whereas the RGB colour mode represents the colours processing in the human biological visual system (Loesdau et al., 2014). HSV stands for i) the hue that corresponds to the angle (from the red at 0°, to the green at 120° and the blue at 240°, and then back to red again at 360◦), more explicitly, moving from red to yellow to green to cyan to blue to magenta and back to red, ii) the saturation that corresponds to the distance from the axis (i.e., radius), the brightness of the colour, and iii) the value indicating the luminance or intensity.

In HSV, the component, hue, has the most control over the colour information compared to the other components in terms of determining the colour information whereas the saturation designates the colourfulness relative to the brightness based on the amount of light it appears to absorb and how much light it seems to be emitting. The saturation characteristics of ISMMMOs are significantly different from those of the sea background and maritime animals, as explained earlier. Therefore, we process the chromatic hue and saturation components to reveal the artificial objects not belonging to the natural marine environment. First, the hue component is shifted by 180° to suppress the blueish background into reddish (Fig. 4) as shown in the examples in Figs. 11c, 12c, 13c, 14c, 15c and in the technical reports in the supplements. Second, more saturated sections of the image are made more distinctive as explained in Section 2.2.

2.2. Dynamic thresholding in *S* channel

It is observed that the closer the values

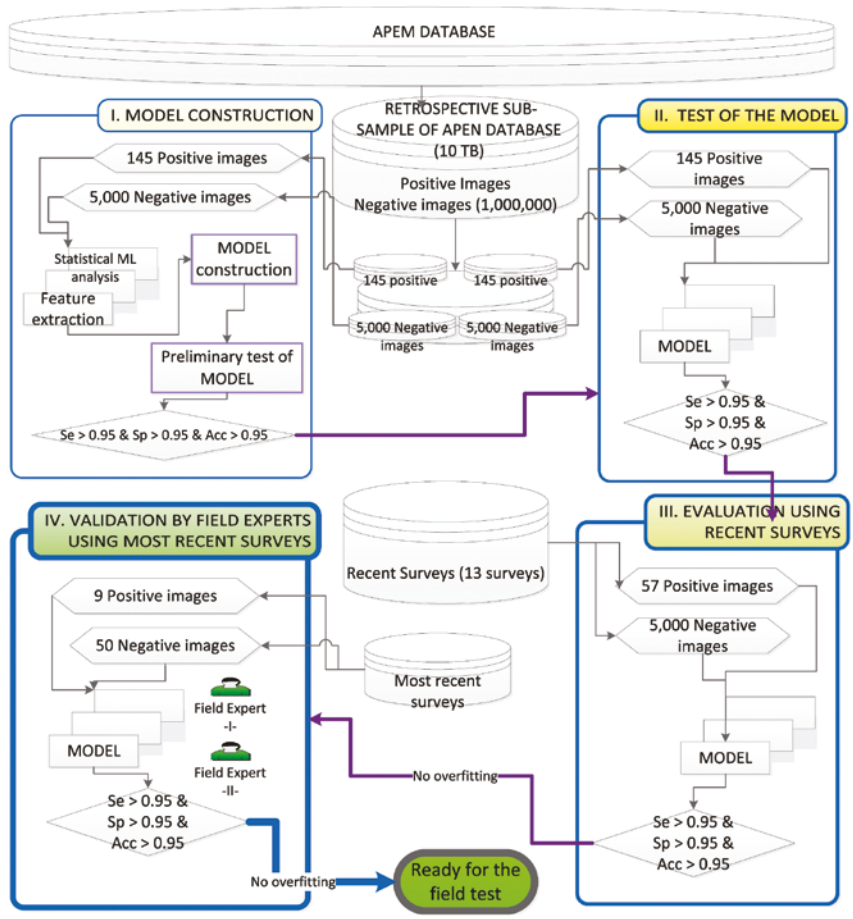


Fig. 3. Use of datasets during model construction, testing, evaluation, and validation of the model.

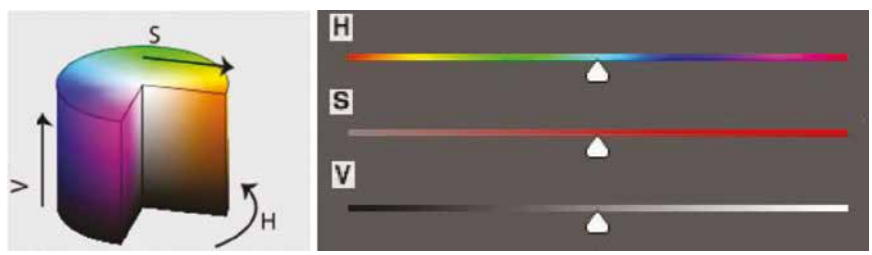


Fig. 4. Model of the HSV colour space. The left image is the courtesy of the author in (Rosebrock, 2017).

of histogram *S* are to the centre, with respect to the distribution of histograms, the likelier the pixels are of representing the background and natural marine life, and vice versa the more likelier they represent ISMMMOs wherever these values get away from the axis meaning that saturation is greater. However, there is no specific value that makes this separation distinct based on the different features of the images acquired in different circumstances, mainly different lighting times of the day, month, season, and type of camera. Furthermore, the distribution of the histogram values plays a major role in representing the characteristics of the image regarding the colourfulness relative to the brightness to which to which an area radiate a varying amount of light as explained in Section 1. The objective is to separate more saturated regions from less saturated ones to determine if there is an unnatural object. All threshold values and necessary parameters need to be determined based on the distribution and features of datasets in many surveys without any user intervention due to the maritime dynamics and image capturing techniques. It is noteworthy to emphasise that the saturation values are almost normally distributed with a Gaussian function as displayed in Eq. 1. The exact distribution of data points using this Gaussian function is presented in Fig. 5 with respect to the σ.

$$P(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2} \qquad (1)$$

In the first instance, a viable threshold value that separates more saturated regions from less saturated ones is found using 145 images with ISMMMOs and

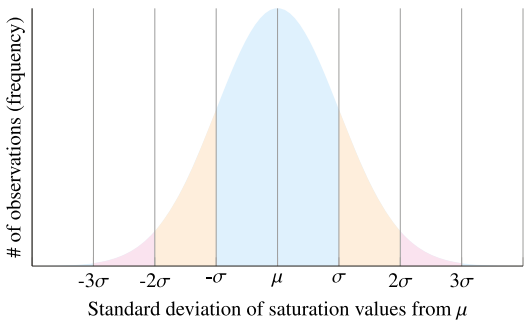


Fig. 5. Generation of the probability distribution using the Gaussian function in Eq. 1 and representation of the standard deviation (σ) of saturation values from μ. Areas: blue (one σ of μ): 0.6826; orange: 0.2718; magenta: 0.0428; sides (right of 3σ and left of -3σ): 0.0027. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Algorithm 1: HSV colour space adjustment function where hAdjust = 0.17 and sAdjustPar = 180.

```
FUNCTION newImage = HSVadjustManMade(img, hAdjust,sAdjustMask):
− >convert the image from RGB colour space into HSV space;
hsvVAL = rgb2hsv(img);
hue = 360*hsvVAL(:,:,1);
h = hsvVAL(:,:,1); s = hsvVAL(:,:,2); v = hsvVAL(:,:,3);
meanS = mean2(s);
stdS = std2(s);
− >perform the dynamic thresholding for S channel;
if meanS > 0.50 then
    sAdjust = meanS - 2*stdS;
else if meanS > 0.25 then
    sAdjust = meanS - stdS/2;
else if meanS > sAdjustMask then
    sAdjust = meanS;
else
    sAdjust = meanS + 4*stdS;
s (s > sAdjust) = 1;
− >perform the shifting of H channel;
h = (mod(hue + hAdjust, 360)) / 360;
− >acquire the updated RGB image from HSV space;
hsvVAL(:, :, 1) = h; hsvVAL(:, :, 2) = s; hsvVAL(:, :, 3) = v;
newImage = hsv2rgb(hsvVAL);
```

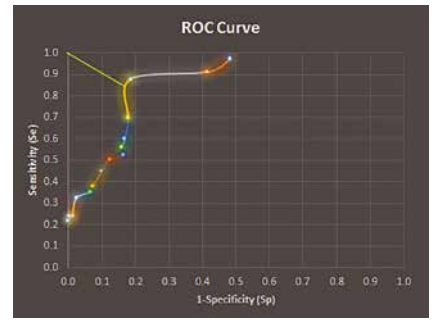


Fig. 6. ROC Curve for Table 4 based on TPR (y-axis) and FPR (x-axis) at 17 classification thresholds: The best cut-off point is 0.17 that is closest to the upper left corner of the curve between the cut-off points 0.15 and 0.20.

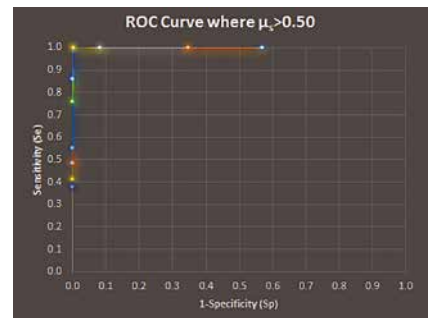


Fig. 7. ROC Curve for Table 5: The best cut-off point is μ - 2σ.

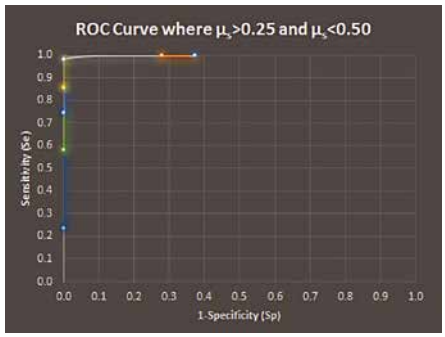


Fig. 8. ROC Curve for Table 6: The best cut-off point is μ - σ/2.

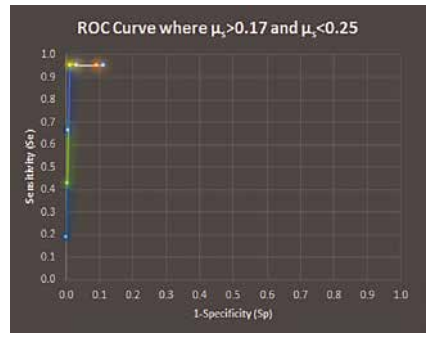


Fig. 9. ROC Curve for Table 7: The best cut-off point is μ.

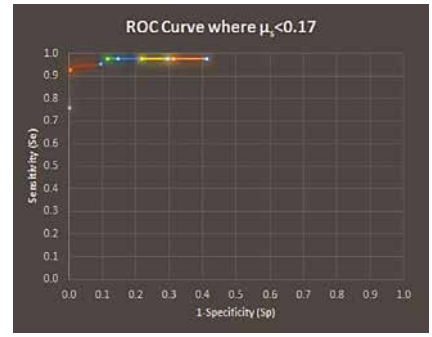


Fig. 10. ROC Curve for μs where <0.17 (Table 8): The best cut-off point is μ + 4σ.

5000 images with no ISMMMOs which were acquired from 22 aerial surveys as shown Fig. 3 I. A ROC curve is an ideal figure to observe how the classification model performs at various classification cut-off points using TPR (True Positive Rate) and FPR (False Positive Rate) (1-TNR) (Table 3). Hence, a ROC curve is established using a large set of threshold values, i.e., cut-off points (i.e., 17) for the purpose of determining the optimal cut-off point, which is the point of the curve nearest to the upper left-hand corner. The results are shown in Table 4. The optimum cut-off point, 0.17, is found, which is between the cut-off points of 0.15 and 0.20 as displayed in *Fig. 6*, and this results in 0.856 (i.e., TP = 124) and 0.817 (i.e., TN = 817) and 0.80 for sensitivity (*Se*), specificity (*Sp*) and accuracy (i.e., *ACC*) respectively. However, these outcomes are far away from our objectives in terms of separating images with ISMMMOs from others within large-scale surveys with higher accuracy rates. In other words, in order to achieve the desired separation (i.e., (*Se*) > 0.95, *Sp* > 0.95, and *ACC* > 0.95), a curve that is much closer to the top left-hand side of the ROC figure is required where the area under the ROC curve (i.e., AUC) increases, which is a desirable outcome for a test.

The saturation varies significantly, in particular, from one survey to another based on the changing conditions as mentioned above and demonstrated in the technical reports in the supplements with many examples.[4] Therefore, the designs of various ROC curves are based on the several most important sections of the histogram concerning the distribution of the saturation, and *Se* and *Sp* values by determining the required number of dynamic cut-off points for increasing the Se and *Sp* values significantly. Technically speaking, i) the mean values (μ) and standard deviations (σ) are acquired following the histogram of the *S* components are obtained from those 145 images mentioned earlier, ii) they are classified based on their μ values and iii) those classes are analysed separately to find out the best cut-off points for each class. The sections on which the ROC curves are analysed are depicted in Figs. 7, 8, 9, 10 and in Tables 5, 6, 7 and *8* based on the distribution of the histogram using the statistical analysis of the μ and σ values where the cut-off points on the ROC curves are specified based on the times of σ in the both directions of μ (Fig. 5).

The number of the cut-off points for each class is specified based on the distribution of the histogram values. This analysis is mainly carried out to find out i) if there is an evident saturated region in the

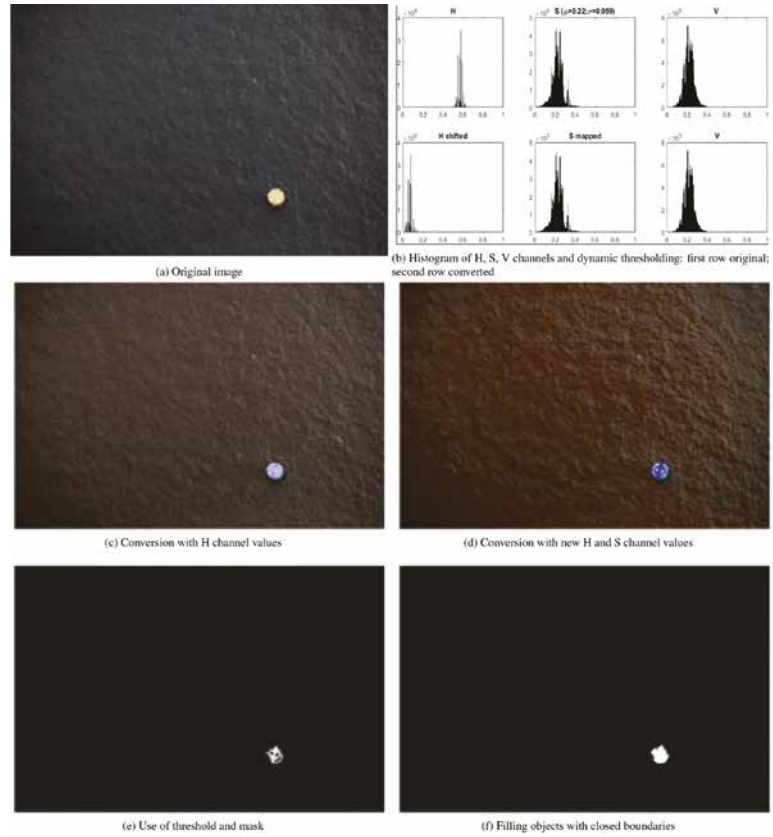


Fig. 11. Stationary example 1: man-made object detection.

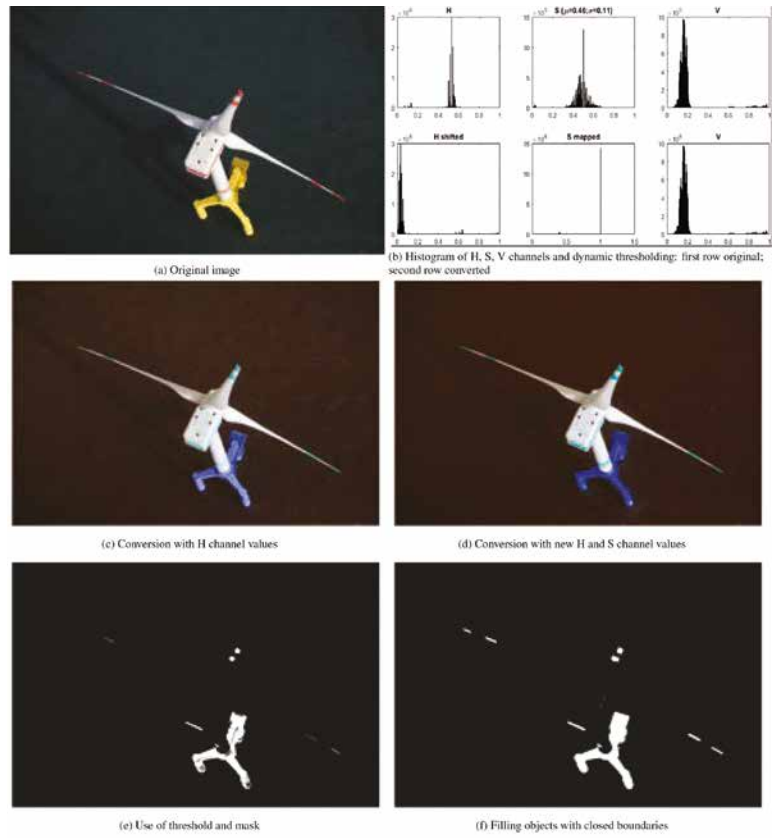


Fig. 12. Stationary example 2: man-made object detection.

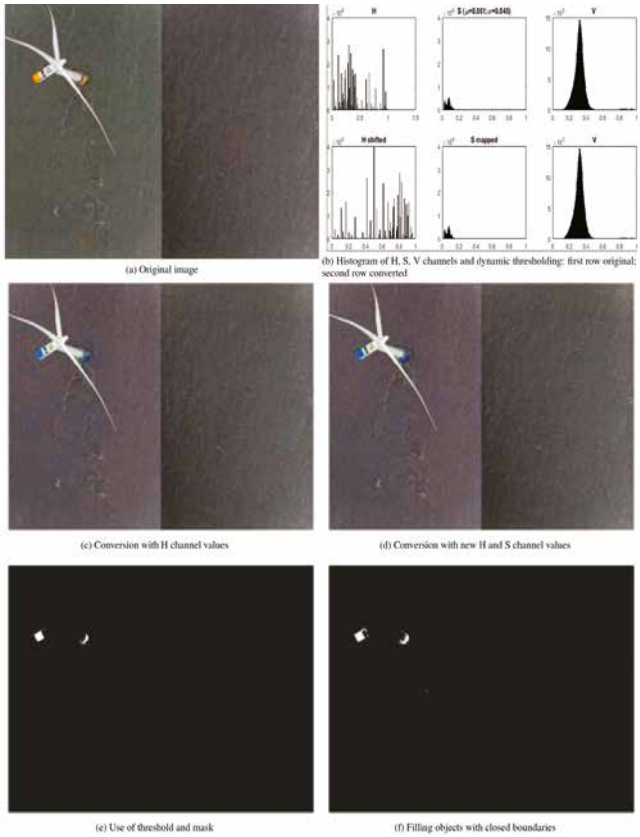


Fig. 13. Stationary example 3: man-made object detection.

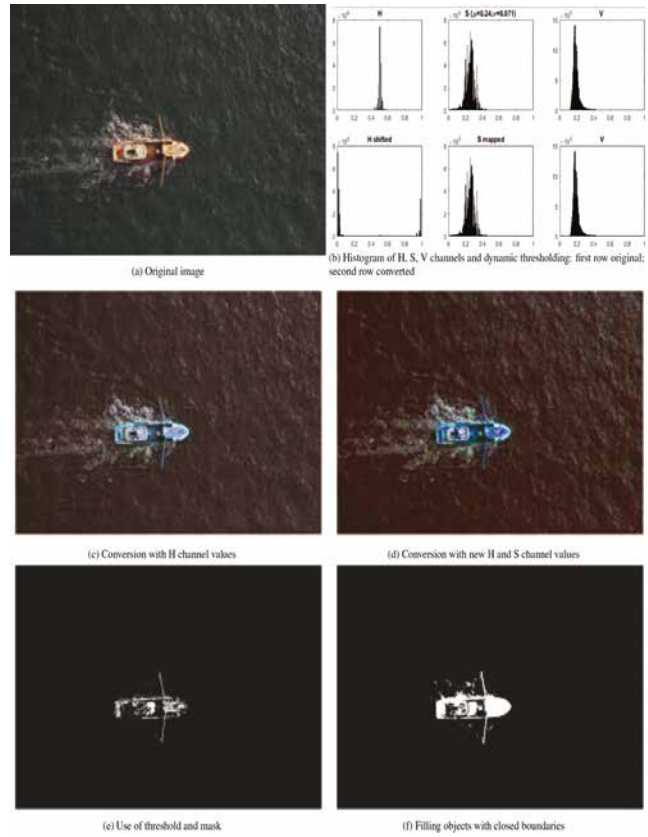


Fig. 14. Moving example 1: man-made object detection.

image that distinctively differs from the other majority regions regarding the features of saturation and most importantly ii) what the best cut-off points making this distinction resulting in higher *Se* and *Sp* values are. The histogram values based on the obtained best cut-off points are transformed to the most outer side of the radius in S channel and set to 1 to make the most saturated sections more distinct, in other words, the probable ISMMMOs visible using the masking and dilation techniques mentioned in Section 2.3. Several examples are presented in Figs. 11, 12, 13, 14 and 15. The observed best cut-off points regarding the analysed sections along with their *Se* and *Sp* values in those ROC curves are summarised in *Table 9*. The implementation of dynamic thresholding is presented in Algorithm 1 and exemplified in Figs. 11d, 12d, 13d, 14d, 15d with several examples along with *H* shifting whose new histograms are presented in the second rows of Figs. 11b, 12b, 13b, 14b, 15b.

The methodology was developed using the characteristics and distribution of 22 surveys with around 3 million large-scale images that have been acquired in the various geographical regions, and in the various time zones and seasons. The images with no ISMMMOs were exploited to obtain the general characteristic of the background whereas the images with ISMMMOs were used to determine the general characteristics of ISMMMOs. Both features are merged in the methodology

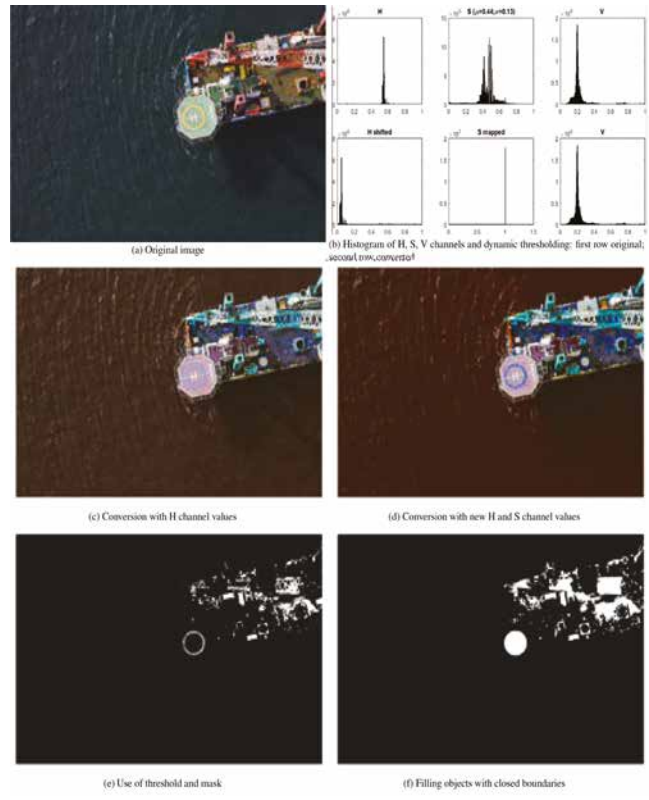


Fig. 15. Moving example 2: man-made object detection.

Table 1: Formulas for converting from RGB to HSV colour space.

Channel	Formula	Condition / Output	
Rnew	= Red / 255	Output: 0 < Rnew < 1	Red value mapped between 0 and 1
Gnew	= Green / 255	Output: 0 < Gnew < 1	Green value mapped between 0 and 1
Bnew	= Blue / 255	Output: 0 < Bnew < 1	Blue value mapped between 0 and 1
MaxRGB	= Max (Rnew, Gnew, Bnew)	Output: maximum assigned	Maximum of three components found
MinRGB	= Min (Rnew, Gnew, Bnew)	Output: minimum assigned	Minimum of three components found
Hue (H)	= 0	If Rnew = Gnew = Bnew	Zero assigned
	= 60 * ((Gnew - Bnew) / (MaxRGB - MinRGB)) + 0	If max is Rnew	
	= 60 * ((Bnew - Rnew) / (MaxRGB - MinRGB)) + 2	If max is Gnew	Add 360 to Hue if H < 0
	= 60 * ((Rnew - Gnew) / (MaxRGB - MinRGB)) + 4	If max is Bnew	
Saturation (S)	= 0	If Rnew = Gnew = Bnew	Zero assigned
	= (MaxRGB - MinRGB) / MaxRGB	Else	If all components different
Value (V)	= MaxRGB	Output: maximum assigned	Maximum of three components assigned

Table 2: Formulas for converting from HSV to RGB colour space.

Channel	Formula	Condition / Output	
Chroma (Chr)	= S * V	Output: Colourfulness	Intermediate colour purity calculated
MidX value	= $Chr(1-\|(H/60) mod 2-1\|)$	Output: Mid value	Intermediate conversion value calculated
MidM value	= V - Chr	Output: Mid parameter	Intermediate parameter calculated
(MidR, MidG, MidB)	= (Chr, MidX, 0)	If $0 \leq H < 60$	Intermediate red, green and blue calculated based on Hue
	= (MidX, Chr, 0)	If $60 \leq H < 120$	Intermediate red, green and blue calculated based on Hue
	= (0, Chr, MidX)	If $120 \leq H < 180$	Intermediate red, green and blue calculated based on Hue
	= (0, MidX, Chr)	If $180 \leq H < 240$	Intermediate red, green and blue calculated based on Hue
	= (MidX, 0, Chr)	If $240 \leq H < 300$	Intermediate red, green and blue calculated based on Hue
	= (Chr, 0, MidX)	If $300 \leq H < 360$	Intermediate red, green and blue calculated based on Hue
Rback	= (MidR + MidM) × 255	Output: Targeted red value	Red value calculated using intermediate parameter
Gback	= (MidG + MidM) × 255	Output: Targeted green value	Green value calculated using intermediate parameter
Bback	= (MidX + MidM) * 255	Output: Targeted blue value	Blue value calculated using intermediate parameter

Table 3: Main statistical terms and calculations used throughout the paper.

#	Abbreviation	Description	Detail
1	P	Positive	An image with ISMMMO
2	N	Negative	An image with no ISMMMO
3	TP	True Positive	An image with ISMMMO is tagged as "image with ISMMMO"
4	TN	True Negative	An image without ISMMMO is tagged as "image without ISMMMO"
5	FP	False Positive (False Alarm)	An image without ISMMMO is tagged as "image with ISMMMO"
6	FN	False Negative	An image with ISMMMO is tagged as "image without ISMMMO"
			True Positive Rate (TPR) = Se = TP / (TP + FN)
7	Se	Sensitivity	How strong is the test in detecting images with ISMMMO correctly.
			True Negative Rate (TNR) = Sp = TN / (TN + FP)
8	Sp	Specificity	How strong is the test in detecting images without ISMMMO correctly.
			Precision (Pr) = PPV = TP / (TP + FP)
9	PPV	Positive Predictive Value	How strong is the test in assigning images with ISMMMO to Positive class.
			NPV = TN / (TN / FN)
10	NPV	Negative Predictive Value	How strong is the test in assigning images without ISMMMO to Negative class.
11	ACC	Accuracy	ACC = (TN + TP) / (FP + FN + TP + TN) Overall correct assignment rate of the test.
			MCC = $(TN * TP - FN * FP)/\sqrt{(TP+FN)(TP+FP)(TN+FN)(TN+FP)}$
12	MCC	Matthews Correlation Coefficient	Quality of a test concerning the unbalance in classes
13	μ	Mean	Arithmetic average of a set of observed values.
14	σ	Standard deviation	Measurement of variation, dispersion from the average, within a set of observed values.

Table 4: Finding the optimum point using 17 cut-off points. 145 images with ISMMMOs

Cut-off	*TP*	*FN*	*TN*	*FP*	*Se*	*Sp*	*1-Sp*
0.05	141	4	517	483	0.972	0.517	0.483
0.10	132	13	585	415	0.910	0.585	0.415
0.15	127	18	814	186	0.876	0.814	0.186
0.20	101	44	821	179	0.697	0.821	0.179
0.25	87	58	832	168	0.600	0.832	0.168
0.30	81	64	841	159	0.559	0.841	0.159
0.35	76	69	835	165	0.524	0.835	0.165
0.40	73	72	877	123	0.503	0.877	0.123
0.45	65	80	901	99	0.448	0.901	0.099
0.50	55	90	927	73	0.379	0.927	0.073
0.55	51	94	932	68	0.352	0.932	0.068
0.60	51	94	936	64	0.352	0.936	0.064
0.65	47	98	977	23	0.324	0.977	0.023
0.70	35	110	988	12	0.241	0.988	0.012
0.75	35	110	997	3	0.241	0.997	0.003
0.80	32	113	1000	0	0.221	1.000	0.000
0.85	32	113	1000	0	0.221	1.000	0.000

Table 5: Statistical analysis using 11 cut-off points: 29 images with ISMMMOs where μs > 0.50.

Cut-off	*TP*	*FN*	*TN*	*FP*	*Se*	*Sp*	*1-Sp*
μ **- 5**σ	29	0	432	568	1.000	0.398	0.602
μ **- 4**σ	29	0	653	347	1.000	0.653	0.347
μ **- 3**σ	29	0	917	83	1.000	0.917	0.083
μ - 2σ	29	0	997	3	1.000	0.997	0.003
μ - σ	25	4	999	1	0.862	0.999	0.001
μ	22	7	1000	0	0.759	1.000	0.000
$\mu + \sigma$	16	13	1000	0	0.552	1.000	0.000
$\mu +$ **2**σ	14	15	1000	0	0.483	1.000	0.000
$\mu +$ **3**σ	14	15	1000	0	0.483	1.000	0.000
$\mu +$ **4**σ	12	17	1000	0	0.414	1.000	0.000
μ **- 5**σ	11	18	1000	0	0.379	1.000	0.000

Table 6: Statistical analysis using 7 cut-off points. 55 images with ISMMMOs where μs >0.25 and < 0.50.

Cut-off	*TP*	*FN*	*TN*	*FP*	*Se*	*Sp*	*1-Sp*
μ **- 2**σ	20	1	887	113	0.952	0.887	0.113
μ - σ	20	1	908	92	0.952	0.908	0.092
μ - $\sigma/2$	20	1	967	33	0.952	0.967	0.033
μ	20	1	987	13	0.952	0.987	0.013
$\mu + \sigma/2$	14	7	993	7	0.667	0.993	0.007
$\mu + \sigma$	9	12	995	5	0.429	0.995	0.005
$\mu +$ **2**σ	4	17	998	2	0.190	0.998	0.002

Table 7: Statistical analysis using 7 cut-off points. 21 images with ISMMMOs where μs > 0.17 and < 0.25.

Cut-off	*TP*	*FN*	*TN*	*FP*	*Se*	*Sp*	*1-Sp*
μ - $\mathbf{2}\sigma$	55	0	627	373	1.000	0.627	0.373
μ - σ	55	0	721	279	1.000	0.721	0.279
μ - $\sigma/2$	54	1	998	2	0.982	0.998	0.002
μ	47	8	1000	0	0.855	1.000	0.000
$\mu + \sigma/2$	41	14	1000	0	0.745	1.000	0.000
$\mu + \sigma$	32	23	1000	0	0.582	1.000	0.000
$\mu + \mathbf{2}\sigma$	13	42	1000	0	0.236	1.000	0.000

Table 8: Statistical analysis using 10 cut-off points. 40 images with ISMMMOs where μs < 0.17.

Cut-off	*TP*	*FN*	*TN*	*FP*	*Se*	*Sp*	*1-Sp*
μ - σ	40	1	587	413	0.976	0.587	0.413
μ - $\sigma/2$	40	1	685	315	0.976	0.685	0.315
μ	40	1	704	296	0.976	0.704	0.296
$\mu + \sigma/2$	40	1	781	219	0.976	0.781	0.219
$\mu + \sigma$	40	1	851	149	0.976	0.851	0.149
$\mu + \mathbf{2}\sigma$	40	1	883	117	0.976	0.883	0.117
$\mu + \mathbf{3}\sigma$	39	2	903	97	0.951	0.903	0.097
$\mu + \mathbf{4}\sigma$	38	3	994	6	0.927	0.994	0.006
$\mu + \mathbf{5}\sigma$	31	10	997	3	0.756	0.997	0.003
$\mu + \mathbf{6}\sigma$	27	14	997	3	0.659	0.997	0.003

to distinguish the ISMMMOs from its background and consequently discern the positive images from the negative images for further analysis.

2.3. Masking and dilation

Two masks are applied on the image acquired from the dynamic thresholding technique on *H* and *S* channels mentioned above, one of which is for detecting the blueish part and the other one is for removing the unwanted background parts from the image. First mask (i.e.,((*ImgR < 0.25&ImgG < 0.80&ImgB = 1)&(ImgR < (ImgB)&ImgG < (ImgB)*))) makes the blueish sections visible by suppressing all other sections, in particular, reddish parts that dominantly indicate the background of sea as depicted in Figs. 11e, 12e, 13e, 14e, 15e and in our technical reports. After applying this mask, the obtained image is dilated and holes are filled to make ISMMMOs coherent as shown in Figs. 11f, 12f, 13f, 14f, 15f. This process is

Appendix A. Pseudo codes of the methodology based on the Matlab syntax

Algorithm 2: Main methodology titled startSplittingObjectsUnsupervised: Phases of the operations to detect man-made objects in images.

Data: The target directory of a survey with images.
Result: Two directories, one of which is for images with man-made objects, and the other is for other images.

```
-->Variables;
infoDetail=''; steps = 1; k=1; posImageCount = 0; name = 'Human object detection';
set(handles.edtGeneral, 'String', ''); set(handles.edtDetail, 'String', ''); set(h,'Name','WilDetection: Splitting images using unsupervised technique'); set(h,
    'Position', [1090 50 355 50]) set(handles.edtGeneral, 'String', strcat(name,' is on process...')); set(handles.edtDetail, 'String', 'The information will be
    displayed here after the process above is completed.');
-->Create NEG and POS folder;
[parentFolder deepestFolder] = fileparts(imageDir); negSubFolder = sprintf('%s/NEG-%s', imageDir, deepestFolder); posSubFolder =
    sprintf('%s/POS-%s', imageDir, deepestFolder);
--> Create the folders if they do not exist.;
if exist(negSubFolder, 'dir') then
    mkdir(negSubFolder);
if exist(posSubFolder, 'dir') then
    mkdir(posSubFolder);
--> Progress bar to show the progress of the process;
h = waitbar(0.1,'Please wait...','CreateCancelBtn',... 'setappdata(gcbf,"canceling",1); delete(gcbf);')
--> Start splitting;
[Result,posImageCount] = startSplittingManMadeObjects(imageDir,posSubFolder,handles,h);
infoDetail = strcat(name,' has been completed; Total count of POS images is', ' ', num2str(posImageCount));
c_str1=[infoDetail];
set(handles.edtDetail, 'String', c_str); set(h,'Name','WilDetection: Splitting process of man-made object detection is COMPLETED');
waitbar(k / steps,h,sprintf('COMPLETED'));
ImDir = dir([imageDir, '.jpg']);
totNegImageCount = length(ImDir(not([ImDir.isdir])));
set(handles.edtNegCount, 'String', num2str(totNegImageCount));
set(handles.edtGeneral, 'String', ' All tasks have been completed');
result = 'Splitting images has been completed.';
```

Table 9: Dynamic threshold points for S channel based on μ and σ acquired from the statistical analysis of the images using several cut-off points as depicted in Tables 5, 6, 7, 8. The most closest pointi to the upper left corner of the ROC curve indicate the ideal cut-off points as shown in Figs. 7, 8, 9, 10.

Mean of the S channel (μ)	threshold	objective	Se	Sp	example
> 0.50	$\mu - 2x\sigma$	Almost all values are mapped to 1	1.00	0.997	Fig. 16b
> 0.25	$\mu - \sigma/2$	Most of the values are mapped to 1	0.982	0.987	Fig. 12b
> sAdjustMask (i.e, 0.17)	μ	Almost half of the values are mapped to 1	0.927	0.994	Fig. 14b
otherwise (i.e., < 0.17)	$\mu + 4x\sigma$	Most of the values are not mapped to 1, left as is	0.96	0.95	Fig. 13b

mainly performed to gain the complete white areas of objects that are not obtained with the proposed technique as elaborated in Sections 5 and 7.

There might be several small unwanted dots that are not a part of the ISMMMOs after applying the first mask, usually a process of glinting sections after the HSV processing phase. Around 20% of the blank images come up with similar small dots usually after dilation and filling holes in the image as depicted in Fig. 16h). Several examples for these types of processed images can be reached from our technical report (e.g., examples 4, 6, 7, 15, 17, 19, 20 in MarineObjects_ Man- made_Technical_Blank_1.pdf) in the supplements. These small sections are much smaller than the ISMMMOs and are discarded by applying a size mask technique. In the last phase of the implementation, the images with detected ISMMMOs are labelled as positive images and placed in a separate directory by the application for further analysis.

End notes

[1] https://apem-inc.com

[2] https://www.apemltd.co.uk

[3] APEM Ltd. is an environmental company and proposes novel solutions for environmental problems (https://www.apemltd.co.uk).

[4] The reports from 1 to 7 titled as MarineObjects_Man-made_ Supplement are for ISMMMOs and the reports from 1 to 5 titled as MarineObjects_Man-made_ Supplement_Blank are for blank images.

The paper is republished with authors' permission.To be concluded in next issue.

USGS experts responding to two major natural hazards

As U.S. Geological Survey staff prepare for Hurricane Milton to hit Florida's west coast, agency experts are still dealing with the after-effects of Hurricane Helene that made landfall in Florida late last month and continued a path of destruction north through Georgia, North Carolina, South Carolina and Tennessee.

While USGS experts are deploying wave sensors and forecasting coastal change in anticipation of Milton's arrival, many of their agency colleagues have been hard at work mapping landslides, repairing and replacing damaged streamgages, and analyzing sensor data to provide the science information needed to help emergency responders and local officials with ongoing Helene recovery efforts.

To meet requests for local technical assistance, USGS activated its landslide event team to collect remotely sensed imagery and map landslides to gain a better picture of the extent and severity of landslide impacts. It continues to support requests from the North Carolina and Tennessee geological survey offices to identify landslide locations and landslide impacts to state transportation networks and the infrastructure environments. Hurricanes are known to lead to landslide and debris flow hazards in the southern Appalachian Mountains so experts at the USGS Geologic Hazards Science Center helped create a multi-agency Landslides Observations Dashboard to map landslides associated with Helene and aid state officials in determining the extent and severity of landslide occurrence and impacts.

Two USGS landslide experts conducted aerial reconnaissance flights between October 3 and October 5 in partnership with U.S. Fish & Wildlife Services to obtain a better understanding of the extent and severity of landslide impacts in the southern Appalachian region. USGS experts continue to review the data and imagery from these flights to confirm locations of some landslides and assist local authorities as they work to protect lives and vital infrastructure. *www.usgs.gov*

NCDOT and partners capturing Helene impacts from the sky

The N.C. Department of Transportation's Division of Aviation is using aircraft to capture imagery, assess infrastructure, and assist with disaster relief efforts in the wake of Hurricane Helene. A range of aviation resources have been deployed in Western North Carolina, including N.C. National Guard aircraft, NCDOT's aerial imagery planes and drones, and private organizations making air drops of food, water and other emergency supplies.

NCDOT's drone teams and Photogrammetry unit, the Civil Air Patrol and the National Oceanic and Atmospheric Administration have flown over 240 missions to capture images that are being used to inform the massive disaster response effort. This real-time data enables NCDOT teams to gather information about difficult to reach areas and prioritize safe response and recovery operations.

NCDOT employs three primary types of imagery: rapid situational awareness images, site-specific drone images, and photogrammetry images. *bladenonline.com*

Iran to launch three indigenous remote-sensing satellites

The head of the Iranian Space Agency (ISA) says the country plans to launch three homegrown remote-sensing satellites into orbit by the end of the current Iranian calendar year, which ends on March 20, 2025.

The agency aims to send Kowsar, Tolo-3 (Sunrise-3) and Zafar-2 (Victory-2) Earth observation satellites into orbit soon so that they would form a satellite constellation and work together as a system. *www.presstv.ir*

Role of Geospatial Data in infrastructure projects

The General Authority for Survey and Geospatial Information (GEOSA) has signed a memorandum of understanding (MoU) with the Riyadh Infrastructure Projects Center (RIPC) to bolster the role of geospatial data in planning and executing infrastructure projects. The signing took place during the recently concluded Saudi Infrastructure Summit,

The agreement outlines a commitment to enhance the use of reliable geospatial information in infrastructure planning and execution across the Riyadh Region. It includes adopting official maps, geospatial data, and baseline maps issued by GEOSA as certified sources. The MoU aims to support RIPC with geospatial data, services, technologies, and consulting while promoting integration among government entities and advancing the maturity of the geospatial sector. Additionally, it aims to utilize the Saudi Arabia National Spatial Reference System (SANSRS) for all surveying activities and leverage national geodetic infrastructure products and services. *www.zawya.com*

UAE Cabinet Approves Supreme Space Council Establishment

The UAE Cabinet has approved the formation of the Supreme Space Council, which will include the following:

- The Minister of Industry and Advanced Technology;
- The Minister of Economy, the Chairperson of the Board of Directors of the UAE Space Agency, as member and Secretary-General of the Council;
- The Minister of State for Artificial Intelligence, Digital Economy and Remote Work Applications;
- The Vice President of the Mohammed bin Rashid Space Centre, Faisal bin Abdulaziz Al Bannai, Advisor to the President for Strategic Research and Advanced Technology; and
- Major General Dr. Mubarak bin Ghafan Al Jabri, Assistant Undersecretary for Support and Defence Industries within the Ministry of Defence; Assistant Undersecretary for Support and Defence Industries at the Ministry of Defence.

Furthermore, the Council's key responsibilities include approving the public policies for regulating the space sector and related activities, defining national space sector priorities and identifying the technologies necessary to ensure the country's technological independence. Likewise, the Council will set investment and acquisition priorities for both public and private entities involved in space activities. *https://spacewatch.global*

NGA selects NV5 for geospatial contract

NV5 Global, Inc. has been awarded a prime contract with the National Geospatial-Intelligence Agency (NGA) to provide unclassified commercial geospatial intelligence (GEOINT)-derived computer vision and analytic services under the Luno A program.

The $290 million contract is a five-year, multiple-award indefinite delivery, indefinite quantity contract to monitor global economic and environmental activity, as well as military capabilities. www.NV5.com

TCarta provides high-tech solution to ship groundings

TCarta Marine of Denver offers a cost-effective, environmentally safe solution using Earth observation satellites to derive accurate water depth measurements in near-shore areas.

It has mapped nearly one third of the world's coastlines with SDB and offers products in custom and off-the-shelf versions. Custom SDB data sets are typically generated using high-resolution satellite imagery capable of resolving seafloor objects, such as shoals and reefs, with one-meter resolution. *www.tcarta.com*The first two news may be together given one page to give prominence

ESA launches Moonlight to establish lunar communications and navigation infrastructure

ESA has officially launched its Moonlight programme, a landmark initiative to create a satellite constellation orbiting the Moon for communications and navigation services. With over 400 planned lunar missions by space agencies and private companies in the next two decades, this programme marks a significant step towards sustainable lunar exploration and the development of a lunar economy.

The Moonlight Lunar Communications and Navigation Services (LCNS) programme will enable precise, autonomous landings and surface mobility, while facilitating high-speed, low-latency communication and data transfer between Earth and the Moon. This infrastructure is essential for humanity's return to and long-term presence on the Moon, while enhancing efficiency and significantly reducing operational and user costs.

The Moonlight programme addresses critical needs in human and robotic space exploration while creating commercial opportunities for European industry in the emerging lunar economy. It will play a crucial role in supporting future deep space exploration efforts.

Moonlight will consist of five satellites – four for navigation and one for communications – connected to Earth via three dedicated ground stations, creating a data network spanning up to 400 000 km. The satellites will be strategically positioned to prioritise coverage of the lunar south pole, an area of particular interest for future missions due to its "peaks of eternal light" suitable for solar power and "craters of eternal darkness" containing polar ice which can be a source of water, oxygen and rocket fuel.

Moonlight's implementation will occur in phases, beginning with the Lunar Pathfinder, a communications relay satellite manufactured by Surrey Satellite Technology Ltd (SSTL), set to begin operations in 2026.

Following Lunar Pathfinder, Moonlight services will be gradually deployed, with initial operations by the end of 2028 and full operations by 2030.

ESA is collaborating with NASA and JAXA on LunaNet, a framework for lunar communication and navigation standards. This cooperation ensures compatibility with future lunar infrastructures and technologies, allowing a global customer base to benefit from Moonlight's services. Moonlight will comply with LunaNet's standards and undergo the first-ever lunar navigation interoperability tests, planned for 2029. *www.esa.int*

Galileo constellation expands with two new satellites

SpaceX has launched the latest pair of Galileo satellites from the Kennedy Space Center in Florida. The SpaceX Falcon 9 rocket carried satellites 31 and 32 (FM26 and FM32) to their designated orbits.

This launch, number 13 in the Galileo program, marks a crucial milestone in the constellation's development. The addition of these satellites completes the designed constellation, with the required operational satellites plus one spare per orbital plane. The new pair will undergo testing at their final altitude of 23,222 km before becoming operational. *www.esa.int*

China completes national eLoran network

The Dunhuang long-wave timing station, a critical component of China's high-precision ground-based timing system, has been completed and tested. This marks a significant advancement in China's development of a three-dimensional cross-timing system that spans air, space and land. The high-precision ground-based timing system leverages eLoran radio long-wave and fiber-optic timing technology. This system is designed to operate independently of satellite navigation timing, providing backup, complementary functions and mutual enhancement with existing timing systems.

China has constructed three additional long-wave timing stations in Dunhuang, Korla and Nagqu. When combined with existing stations, the new stations are designed to achieve nationwide coverage of long-wave timing signals.

During the construction of the Dunhuang station, researchers reported significant breakthroughs in high-precision transmission control and pulse time reference feedback modulation technology. They achieved a megawatt-level Loran timing transmission accuracy of 20 ns, surpassing the current international standard of 50 ns.

Final pair of backup Beidou satellites launched

China launched the last pair of backup satellites for its Beidou navigation system recently. A Long March 3B rocket equipped with a Yuanzheng-1 upper stage lifted off from the Xichang Satellite Launch Center at 9:14 p.m. Eastern Sept. 18 (0114 UTC Sept. 19). Two backup Beidou positioning, navigation and timing (PNT) satellites were successfully inserted into medium Earth orbits (MEO). These satellites are the 59th and 60th launched for China's Beidou GNSS.

The new pair will join existing Beidou MEO orbital planes as backups. This will allow maintenance and management of satellites while maintaining full operation of the system. Additionally, the pair will conduct experiments for the future Beidou-4 next-generation navigation satellite technology. They feature improvements over earlier Beidou satellites in areas including autonomous integrity monitoring and atomic clock technology.

Development of the future combat air system (FCAS)

UAV Navigation-Grupo Oesía has announced that SATNUS (a company formed by GMV, Sener Aeroespacial and Tecnobit-Grupo Oesía) has counted on its collaboration in the ambitious European program Future Combat Air System (FCAS). This program aims to develop a future-generation weapon system (NGWS), which will integrate a new generation of manned fighters (NGF) and multiple remotely piloted air systems (Remote Carriers or RC), all interconnected through a Combat Cloud (CC). With its participation, UAV Navigation-Grupo Oesía will provide innovative technological solutions and offer comprehensive support in the autopilot technical development, integration and operation phase. This support will be fundamental for the evolution and maturation of the technological capabilities of the program, contributing to the remotely piloted manned systems meeting the demanding requirements of this future combat air system. *www.uavnavigation.com*

Wingtra introduces MAP61

Wingtra has launched the MAP61 mapping sensor, designed to assist professionals in generating larger mapping outputs more efficiently. This ultra-high-resolution sensor offers detailed 3D data in a single pass, providing valuable analytics for vertical assets. It can cover up to 460 hectares (1,140 acres) in a single flight, reducing fieldwork time and enhancing productivity. *wingtra.com*

Drone technology for livestock management

The University of Kentucky Martin-Gatton College of Agriculture, Food and Environment has secured a $910,000 grant from the USDA to develop and refine drone technology in cattle management.

This five-year project, titled "Precision Livestock Management: Cattle Monitoring and Herding Using

Cooperative Drones," explores how drones can assist in herding, monitoring and collecting physiological data from beef cattle. The project aims to reduce labor demands and enhance operational efficiency for livestock producers.

The research will focus on several key objectives. First, the team will develop a multi-agent drone control system that enables drones to work semi-autonomously near cattle. This system will be designed to adjust its operations based on the behavior and movement of the animals, ensuring safe and effective interaction.

The project will also examine the physiological responses of cattle, particularly how different breeds react to the drones' presence and movement. *uknow.uky.edu*

Productivity tools for mid-level smart drone surveying software plan

Virtual Surveyor has significantly reorganized its smart drone surveying software plans with the addition of the Productivity Tools suite to the Ridge plan. Previously available only in the highest-level subscription package, the Productivity Tools enhance the speed of creating survey products from UAV-derived images and LiDAR data. *www.virtual-surveyor.com*

NTH to now certify drones at lower than market prices

The 105-year-old state-run industrial testing agency, the National Test House (NTH), will certify drones for commercial operations at lower-than-market prices, according to the government, in a boost for smaller firms in the fast-growing sector with applications spanning logistics to agriculture.

NTH is a wing of the consumer affairs ministry and is the only government agency that certifies drones and its services are set at a highly competitive fee of ₹1.5 lakh for the certification process, which is the lowest in the industry. The heritage technical agency is a British-era institution that served the railways with its expertise.

Compared to lower rates of the NTH, which has a range of latest equipment, market rates for certification can go up to ₹10-12 lakh. NTH has been able to offer cheaper rates because it is an integrated drone certification facility, said Alok Srivastava, the director-general of the Ghaziabad-based NTH. This means that manufacturers don't need to go to different centres to test different components.

Anna University gets patent for path-breaking drone technology

Researchers at the Madras Institute of Technology, Anna University, Chennai, have developed a path-breaking technology that is claimed to open up a new era of drone operations.

The Indian Patent Office, Intellectual Property India, has granted patent for the airborne-based intelligent autonomous landing system for mini-Unmanned Aerial Vehicles that come with accurate identification of geographical location of landing sites from the plurality of images captured.

According to K. Senthil Kumar, Professor and Director, Dr. Kalam Advanced UAV Research Centre, Department of Aerospace Engineering, MIT, the technology would immensely help in the delivery/pick up of load such as weapons, ammunition, medicines, food etc. to armed forces deployed along hilly terrains or inaccessible locations along the border.

While existing UAVs were designed to land at a pre-determined well prepared plain surface locations, the system developed by his team of researchers is capable of not only finding the precise location of a marker like a particular coloured dress or object on the site and land there safely even if it were to be a hilly terrain with uneven surface and slope.

"Once the landing site is identified, the position coordinates are obtained and UAV lands at the target including moving platforms. Further, QR code can also be used to enhance reliability. The efficiency of the UAV landing system is increased, landing time is reduced, and the complete process is on-board and autonomous using AI and deep learning algorithms. The system is particularly useful for Beyond Visual Line of Sight (BVLOS) applications," Dr. Senthil Kumar explained.

According to him, the UAV landing system could be utilised in high-altitude logistics drones to assist armed and border security forces in day-to-day essential supplies delivery to border posts, emergency relief and rescue operations or delivery of certain goods to strengthen combat missions. "We now have UAVs with the capability to fly up to 50 kg load to 20 km. Efforts are on to enhance the load to 100 kg and flying distance to 50 km."

Besides defence, firefighting and surveillance operations, Dr. Senthil Kumar said, the intelligent autonomous landing system for mini-Unmanned Aerial Vehicles could also be used for civilian missions such as organ/medicine delivery in healthcare, product delivery in e-commerce etc.

Trimble's direct georeferencing solution

Trimble has launched premium direct georeferencing solutions for mapping sensors on uncrewed aerial vehicles (UAVs) – the Trimble® APX RTX portfolio. When used by original equipment manufacturers (OEMs) and drone payload integrators, their customers can fly around-the-clock in widely variable environments to efficiently and quickly deliver high accuracy, reliable map products. This is made possible by the integration of Trimble CenterPoint® RTX, which enables real-time and post-mission direct georeferencing of camera, LiDAR and hyperspectral mapping sensors on UAVs with centimeter-level accuracy. It achieves this without needing base stations, making mapping more efficient. *www.trimble.com*

SPH Engineering, Radar Systems, Inc., launch GPR

SPH Engineering, in partnership with Radar Systems, Inc., have launched of a Ground Penetrating Radar (GPR) model, Zond Aero 500 NG, the first of its kind model to be designed for both terrestrial and drone-mounted surveys. GPR Zond Aero 500 NG stands out as the only fully universal system available on the market. They are specifically engineered from the ground up for both terrestrial and airborne applications. While pairing a drone with a GPR system offers significant productivity and safety benefits. *www.sphengineering.com*

Unicore, ArduSimple unveil GNSS RTK receivers

Unicore has partnered with ArduSimple to integrate Unicore's tripleband GNSS real time kinematic (RTK) receivers into ArduSimple's evaluation boards.

The UM980, UM981 and UM982 RTK modules are integrated into the ArduSimple simpleRTK3B series to accelerate high-precision GNSS integration. Supporting Galileo High Accuracy Service (HAS) and fast update rate (50Hz), these devices are suitable for applications that require reliable and precise navigation. *www.ardusimple.com*

Honeywell launches its next-generation resilient EGI

Honeywell has unveiled its resilient embedded GPS/inertial navigation system (EGI), designed to address the evolving challenges of modern warfare and meet U.S. government mandates for greater power competition. This navigation system integrates GPS and inertial navigation technologies to deliver precise position, velocity and timing information for various applications. The system includes M-code capability, an atomic clock and open architecture compliance, allowing crucial mission flexibility with alternative positioning, navigation and timing (PNT) forms. aerospace. *honeywell.com*

Harxon launches new smart antenna Harxon has introduced a new line of smart antennas that seamlessly integrate advanced antenna technology with a comprehensive real-time kinematic (RTK) positioning module.

The series includes both housed and embedded versions tailored for specific use cases. The HX-MR401A and HX-MR402A are housed versions, while the HX-ME403A and HX-ME404A are embedded versions designed for UAVs. *https://en.harxon.com*

Advanced Navigation unveils the Certus mini series

Advanced Navigation has expanded its Certus product line by introducing the Certus Mini-series. It comes in three variants:

- Certus Mini D: A dual-antenna inertial navigation system (INS)
- Certus Mini N: A GNSS-aided INS
- Certus Mini A: An attitude and heading reference system (AHRS)

www.advancednavigation.com

Tronics developing north-seeking MEMS gyro

Tronics Microsystems, a TDK company, has upgraded its GYPRO4000 product line, which consists of tactical-grade digital MEMS gyroscopes. The GYPRO4300 is a high-dynamics MEMS gyro designed for precision navigation applications. It features a ±300 °/s input range, 200 Hz bandwidth and 1 ms latency, making it ideal for dynamic environments. With a bias instability of 0.4 °/h and an Angular Random Walk of 0.07 °/√h, the GYPRO4300 offers high-performance sensing in a compact, digital and low size, weight and power (SWaP) package. *www.tronics.tdk.com*

Topcon, u-blox to offer comprehensive GNSS positioning services

u-blox and Topcon Positioning Systems have formed a strategic partnership to develop a high-precision GNSS positioning service for the mass market.

The partnership was formed in response to the increasing demand for GNSS precise positioning across various applications. According to a recent EUSPA report, services enabled by GNSS devices are projected to generate approximately 80% of total GNSS revenues by 2033. The comprehensive GNSS correction services will serve a wide range of applications requiring precise positioning, including automotive, industrial, robotics etc. *www.u-blox.com*

RX Networks introduces TruePoint

Rx Networks has announced the launch of TruePoint | REACH, an advanced, hardware-agnostic, cloud-based correction service designed to deliver centimeter-level location accuracy across the globe for various professional applications.

It enhances GNSS receivers' performance with precise centimeter-level positioning, revolutionizing sectors like smart agriculture, machine control, mining etc. The service is compatible with leading commercial off-the-shelf receivers using the RTCM 3.3 SSR and the 3GPP LPP SSR format. Key hardware partnerships are currently in the planning stages and will be announced soon. *rxnetworks.com*

ComNav Technology introduces Jupiter Laser RTK

ComNav Technology has introduced its Jupiter Laser RTK, designed for surveying applications. It integrates GNSS, auto-IMU (inertial measurement unit), laser, and dual-camera systems into a single unit.

The system builds upon the laser technology featured in ComNav's Universe series, incorporating a precise green laser that remains visible even in bright daylight conditions. This feature enables precise measurements of points in hard-to-reach, signal-blocked or potentially hazardous locations. *www.comnavtech.com*

Trimble opens technology lab at Florida A&M University

Florida A&M University (FAMU) and Trimble celebrated the grand opening of the new Trimble Technology Lab at the Tallahassee campus on October 2.

The lab at FAMU is set to revolutionize the learning experience for students in architecture and construction engineering by providing access to state-of-the-art technology and software solutions.

In addition to the donation of software and hardware technologies from Trimble, the Trimble Foundation Fund — Trimble's philanthropic donor-advised fund — provided a grant to support the renovation and refurbishment of classroom spaces to house the new labs. FAMU is the first institution to be a recipient of a grant from Trimble Foundation Fund in connection with the establishment of a Trimble Technology Lab. *www.trimble.com*

CHCNAV unveils GNSS receiver with IMU tilt compensation

CHC Navigation (CHCNAV) has unveiled the i83 Pro, an inertial measurement unit (IMU)-real-time kinematic (RTK) GNSS receiver. It combines GNSS capabilities with extensive compatibility options to address the diverse needs of surveying, construction and mapping professionals.

The i83 Pro incorporates CHCNAV's third-generation GNSS antenna and the latest iStar algorithm, designed to boost GNSS signal tracking efficiency by 30. With 336 channels supporting GPS, GLONASS, BeiDou, Galileo and QZSS constellations, it can achieve centimeter-level precision rapidly, even in challenging environments. *www.chcnav.com*

Trimble and Worldsensing Collaboration

Trimble and Worldsensing have announced the introduction of a solution for long term 3D ground and structural movement monitoring that will combine Trimble 4D Control™ (T4D) monitoring software with the new Trimble GNSS Meter, powered by Worldsensing. This solution helps minimize the risks associated with land and structure instability by enabling faster and more cost-effective deployment for a greater range of project types. *www.trimble.com*

Teledyne Marine launches Intrepid

Teledyne Marine introduces the Intrepid, a GNSS/Inertial Navigation System.

The system is integrated with the SeaBat T20-ASV processor and comprises a compact inertial measurement unit (IMU) and two GNSS antennas, delivering reliable and precise positioning.

With the Intrepid on board, no manual interfacing between sensors is required, as the system automatically streams data to third-party software. This eliminates the need for manual sensor interfacing and reduces downtime.

Safran unveils GNSS/PNT simulator

Safran Navigation and Timing has unveiled its latest GNSS simulator, the Skydel GSG-8 Gen2, an evolution of its GSG-8 simulator. This new PNT test solution is part of Safran's family of Skydel-based simulators.

The GPU-based GSG-8 Gen2 simulator delivers high-end GNSS signal testing capabilities in a user-friendly, turnkey package. It features six front-facing RF outputs and a combined output. It covers the entire GNSS bandwidth and offers a 1,000 Hz simulation iteration rate, high dynamics, real-time synchronization and simulation of all-in-view satellite signals. *www.safran-group.com*

Quectel launches QLM29H series GNSS receiver

Quectel Wireless Solutions has announced the launch of the Quectel QLM29H range of dual-band, multi-constellation receivers. It combines the LC29H GNSS module and an integrated GNSS patch antenna to simplify RF design. It supports dual-band L1 and L5 signals, providing excellent multipath mitigation, especially in challenging environments such as urban canyons, where high-precision positioning is critical. It supports concurrent reception of global and regional GNSS constellations, such as GPS, GLONASS, Galileo, BDS and NavIC, as well as QZSS and SBAS. *www.quectel.com*

Leica BLK ARC now the first certified reality capture device

Leica Geosystems has announced a strengthening of its partnership with Boston Dynamics making the Leica BLK ARC the first certified reality capture device for Boston Dynamics' Spot. This announcement includes software integrations to deliver a new seamless laser scanning workflow for the agile mobile robot.

By integrating this workflow into Boston Dynamics' Orbit™ robot fleet management software and Spot app, Spot customers can stack and control BLK ARC reality capture missions as part of a full suite of autonomous robotic capabilities alongside other payloads. This workflow enables customers to document and capture site conditions in plants, warehouses and enclosed structures, as well as provide infrastructure for asset management, BIM modelling, fire investigation and much more. *leica-geosystems.com*

GeoCue launches LP360 land software

GeoCue released LP360 Land, a new addition to the LP360 software ecosystem designed to elevate handheld LiDAR scanning with the TrueView GO. It empowers users to easily transform their raw handheld data into valuable insights and deliverables. It offers an intuitive workflow that simplifies the processing of LiDAR, GNSS, and SLAM handheld sensor data. *www.geocue.com*

Esri releases new edition of GIS Map Design Guide

Esri has announced the publication of Designing Better Maps: A Guide for GIS Users, Third Edition. Award-winning author and cartography expert Cynthia A. Brewer draws on her sophisticated mix of experiences—performing academic research; teaching, mentoring, and collaborating with students and analysts;

SUBSCRIPTION FORM

YES! I want my Coordinates

I would like to subscribe for (tick one)

☐ 1 year	☐ 2 years	☐ 3 years
12 issues	24 issues	36 issues
Rs.1800/US$140	Rs.3400/US$200	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

November 2024

K-GEO Festa 2024
06 - 08 November 2024
Seoul, South Korea
https://kgeofesta.kr/fairDash.do?hl=ENG

IAG Workshop on Asia Pacific Gravity, Geoid, and Vertical Datums
06 - 08 November 2024
Philippines - Manila
https://iagworkshop2024.dge

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

45th Asian Conference on Remote Sensing
17-21 November 2024
Colombo, Sri Lanka
www.survey.gov.lk

UN/Spain Workshop on GNSS and Related Space Technologies
18 - 22 November 2024
MÃ LAGA, SPAIN
www.unoosa.org

2024 Pacific Islands GIS & Remote Sensing User Conference
25 - 29 November
Suva, Fiji
https://pgrsc.org

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

December 2024

OHOW 2024 (One Health One World Symposium)
10 - 12 December 2024
Universiti Putra Malayasia (UPM), Malaysia
https://ikp.upm.edu

Workshop on GNSS
10 -13 December 2024
Hanoi, Vietnam
https://soict.hust.edu.vn/navis

February 2025

DGI (Defence Geospatial Intelligence)
10 - 12 February, 2025
London, UK
https://dgi.wbresearch.com

MENA Geospatial Forum
24 - 25 February 2025
Dubai, UAE
https://menageospatialforum.com

March 2025

Munich Satellite Navigation Summit
26 - 28 March 2025
Munich, Germany
www.munich-satellite-navigation-summit.org

April 2025

Geo Connect Asia
09 - 10 April 2025
Singapore
www.geoconnectasia.com

and working with mapmakers at federal agencies—to present this invaluable guide. With more than 400 full-color illustrations, the book applies design best practices to both reference and statistical mapping. *www.esri.com*

GMV is to develop the European GNSS Service Centre

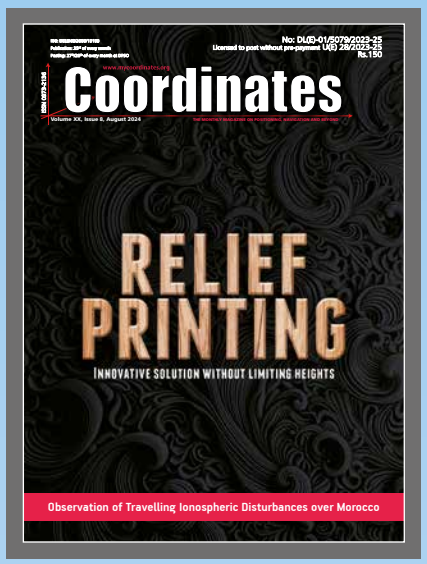
The European Commission has awarded to GMV and Indra a €15-million, 4-year framework contract for supplying the infrastructure of the European GNSS Service Centre (GSC). The GSC is an integral part of the infrastructure of Europe's Galileo navigation program. Its main mission is to provide support services and consultancy for user communities of the system's open service and commercial service. The center will also be the system access point for operators of commercial services provided through Galileo satellites.

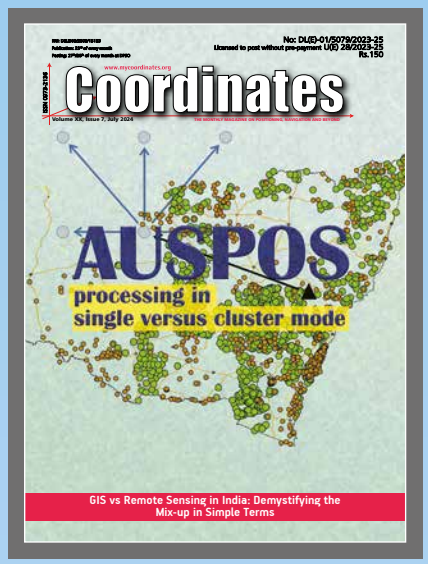
The consortium will be responsible for developing the center and ensuring it meets all European Union requirements. It will be housed in the National Institute of Aerospace Technologies (Instituto Nacional de Técnica Aeroespacial: INTA) at Torrejón de Ardoz, Madrid. *www.gmv.com*

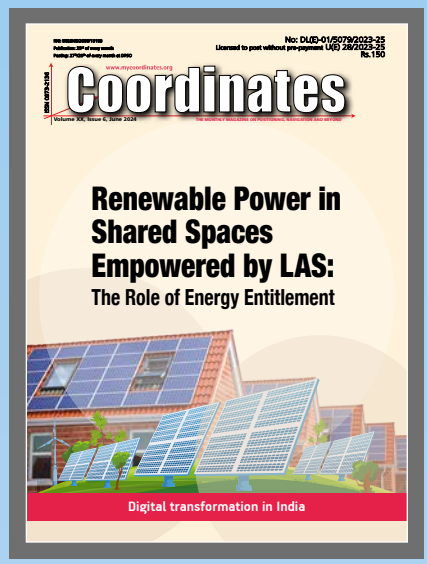
Calian releases full band smart choke antenna

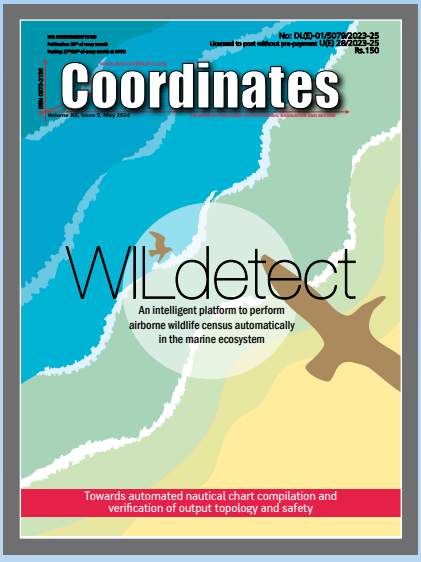
Calian GNSS, formerly Tallysman Wireless, has introduced the VCS6000XF full band smart choke antenna, a new product designed for Continuously Operating Reference Station (CORS) applications. This antenna combines Tallysman Verachoke antenna elements with Septentrio's Mosaic X5 full-band receiver to offer an integrated solution for OEM CORS systems.

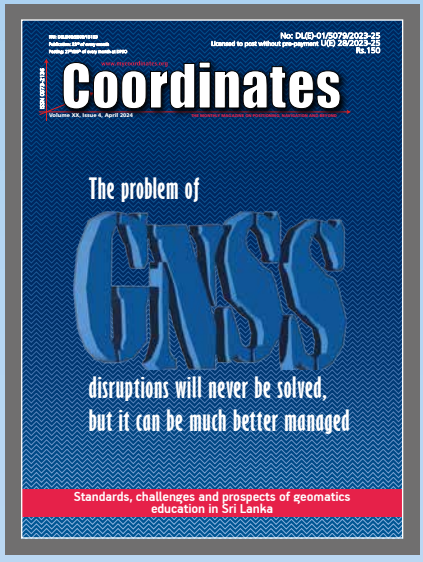
The VCS6000XF offers comprehensive GNSS signal reception, including GPS/QZSS L1/L2/L5, GLONASS G1/G2/G3, Galileo E1/E5a/E5b/E6/E5 AltBoc, BeiDou B1/B2/B2a/B3, NavIC L5, SBAS and L-Band correction services. *www.calian.com*

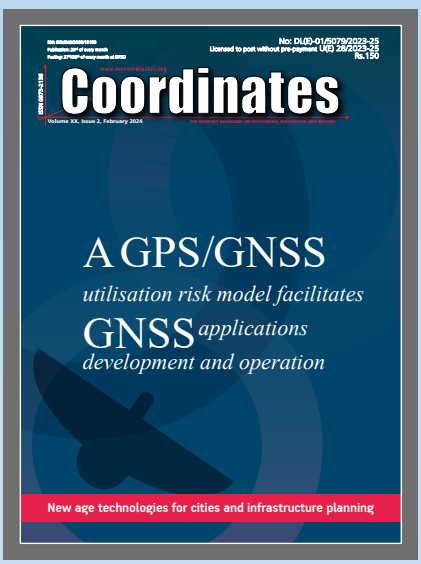


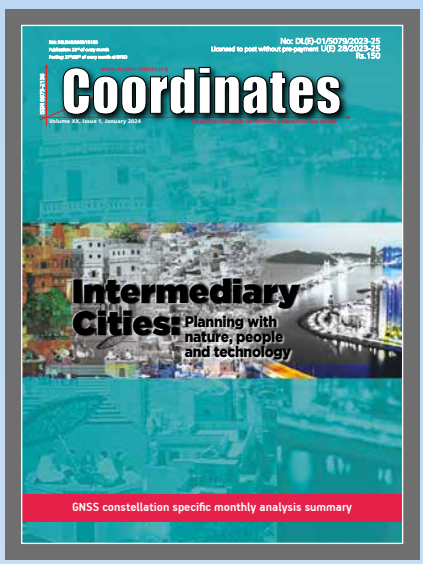


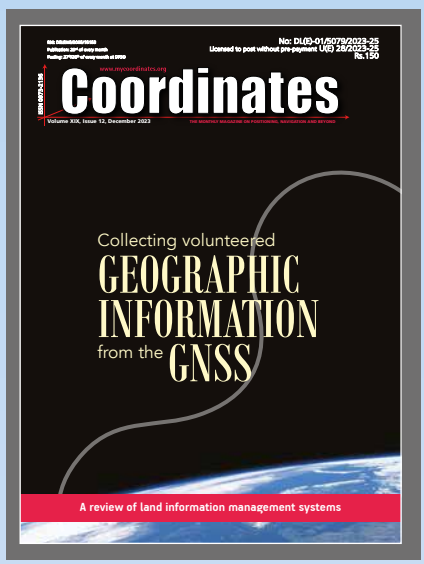












"The monthly magazine on Positioning, Navigation and Beyond"

Download your copy of Coordinates at www.mycoordinates.org

SBG SYSTEMS

Motion & Navigation you can trust

HIGH PERFORMANCE INS/GNSS

- High-end Technology in the Smallest Package
- Reliable Navigation and Positioning Everywhere
- Post-Processing with Qinertia PPK Software

Ekinox Micro

Compact INS for Mission Critical Applications

Ellipse-D

Smallest Dual-antenna Multi-band GNSS INS

Ellipse OEM

OEM INS when Size and Performance Matter

qrco.de/coordinatesmag

MADE IN FRANCE