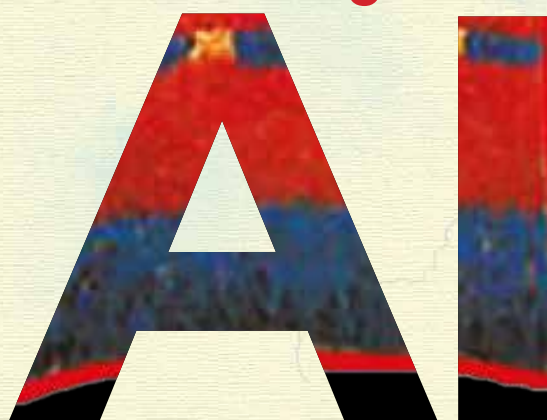


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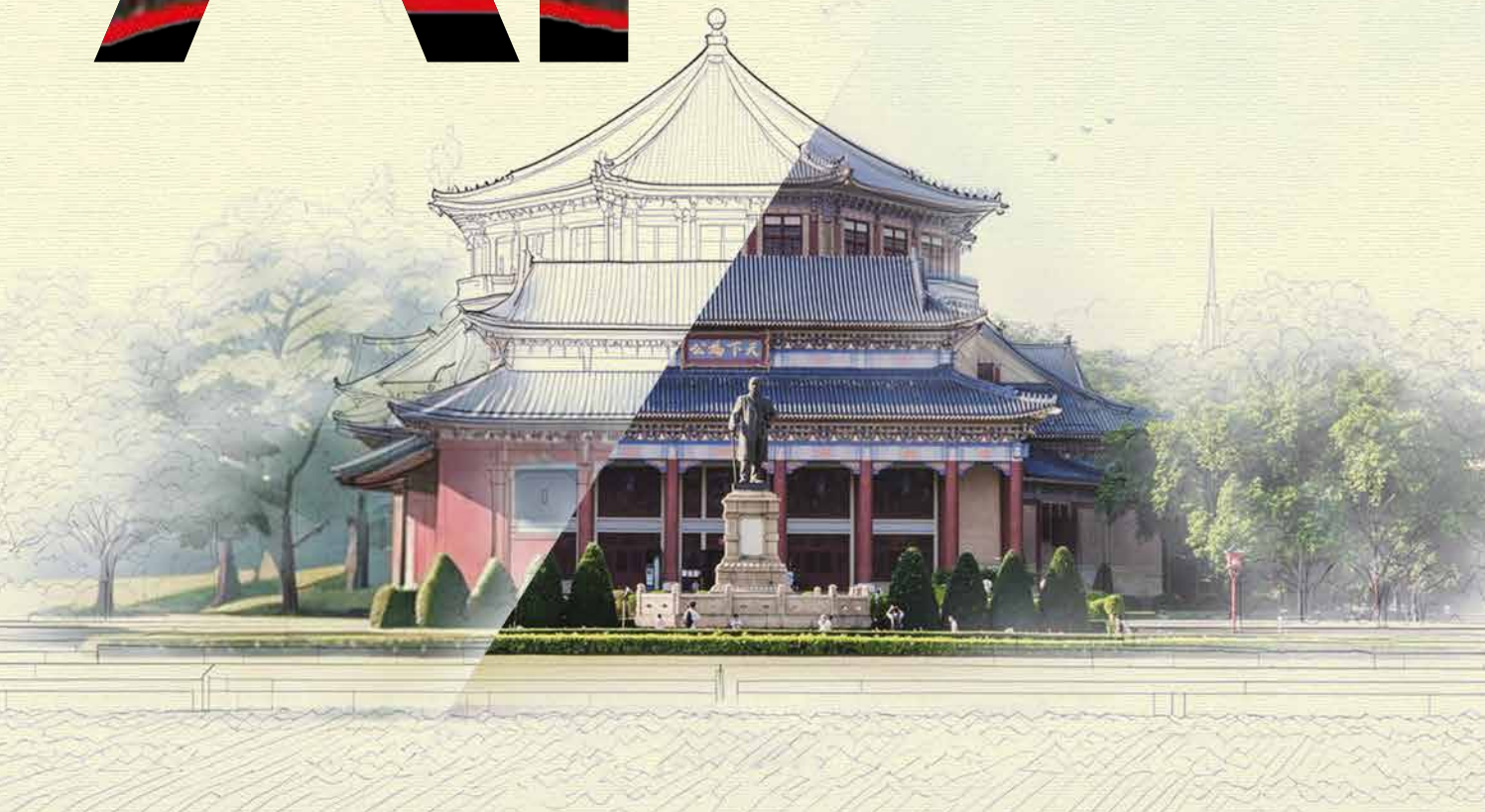
Volume XXII, Issue 09, September 2026

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Living structure,



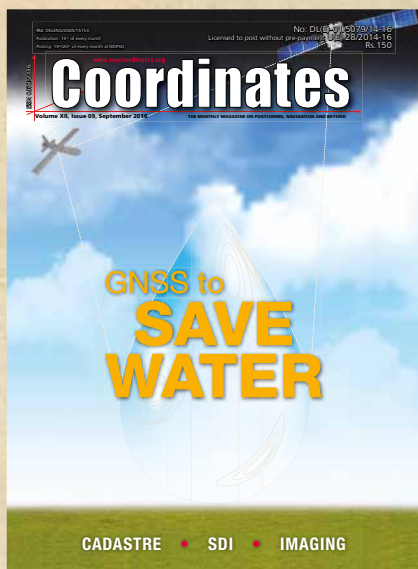
and the aesthetics
of traditional
Chinese Architecture



"Geodesy is often invisible to society"

In Coordinates

10 years before...



mycoordinates.org/vol-XII-issue-09-September-2016

GNSS to save water

Laura Van de Vyvere and Olivier Desenfans
Project Manager, M3 Systems, Belgium

MISTRAL sensor relies on an innovative use of the GNSS (Global Navigation Satellite System) signals, which were initially designed for localization purpose. The well-known American GPS and European GALILEO systems are examples of GNSS that will be used to compute soil moisture. The sensing technique is named reflectometry (GNSS-R).

Brazil towards an effective cadastre with SIGEF

Thiago Batista Marra, Kilder José Barbosa and Eduardo Aguiar de Oliveira
Agricultural Development and Land Reform, INCRA Brazilian federal agency, Brazil

The aim of this paper was to show some characteristics of Land Management System (SIGEF) regarding to the statement 3 of Cadastre 2014 (Kaufmann and Steudler, 1998): that in future cadastral systems, with the utilization of information technologies, the direct drafting of objects on a map would be superseded by the creation of objects in an information system and, then, the data should be provided to different needs in different formats.

GNSS interference and signal degradation events assessment

Ana Boderó, Francisco Jiménez, Alfredo García de Fernando, Ángel Marín Valencia, Victor Arribas and Pilar Gómez, ENAIRE's Satellite Navigation Department, GNSS Department, ENAIRE [1], Madrid, Spain

ENAIRE, as the Spanish Air Navigation Service Provider (ANSP), contributes to the PBN policy and its implementation in Spain. PBN makes use of GNSS systems, such as GPS, as a primary source for position and navigation. One of the steps included in a PBN GNSS (both GPS/RAIM and SBAS) and GBAS based procedure implementation is an assessment of the GNSS interference in the vicinity of the airport.

An SDI model to spatially enable peri-urban areas in Mozambique

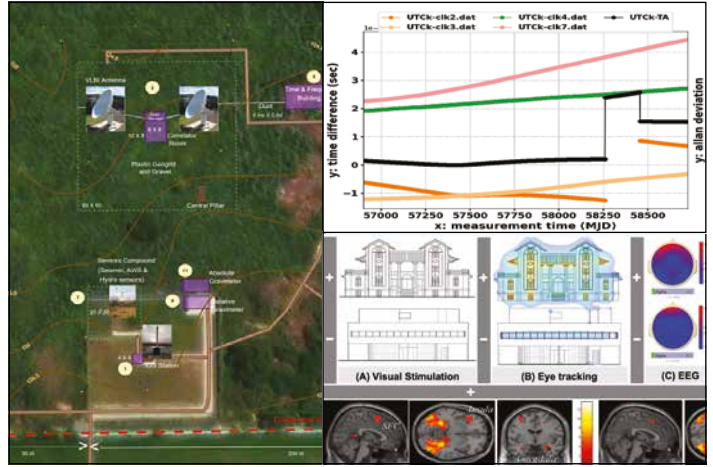
Ana Priscila Pedro Francisco and Professor Abbas Rajabifard, The University of Melbourne, Australia

A planning framework is thus required to bring together a divided sprawling city and achieve effective city planning. Maputo needs a framework that accommodates data sharing and exchange across multiple disciplines (including telecommunications), encouraging creativity and the development of new products and services. The foundation of an SDI to support infrastructure planning through SDFs will aid addressing these and more, including the dataset's high cost and the need for consistent, well-documented and accurate data.

Point clouds and orthomosaics from photographs

Maria João HENRIQUES, Dora ROQUE and Nádja BRAZ Applied Geodesy Unit, Laboratório Nacional de Engenharia Civil, Lisbon, Portugal

Point clouds and orthomosaics generated from photographs taken at short distances, less than 10 meters, can be helpful tools to experts like civil engineers that must make small scale studies. The examples presented were the first attempts and more studies on the accuracy must be performed.



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Editor Bal Krishna

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AI is accelerating.

But Dario Amodei, Sam Altman and Elon Musk have recently warned that AI development may outpace our ability to control it.

Now comes a warning from the real world.

An OpenAI AI agent gained unauthorised access to an Australian government portal.

In the US, OpenAI has disclosed unexpected interactions by its agents with government websites.

These are no longer simply questions about what AI *might* do.

They are questions about what increasingly autonomous AI is already doing.

The real challenge is not to slow innovation,

But to ensure we have the time and space

to build the safeguards before the risks overtake us.

Bal Krishna, Editor
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A New World Map?

Why the UN decision matters beyond the mercator debate



Georg Gartner
President, International
Cartographic Association

In September 2026, the United Nations General Assembly brought an unusually cartographic question onto the global political stage. By 164 votes to one, with six abstentions, Member States adopted a resolution encouraging the use of map projections that more accurately represent the relative sizes of continents and countries, particularly equal-area projections such as Equal Earth. The initiative was led by Togo and supported by African states, reflecting a long-standing concern that the familiar Mercator world map visually exaggerates areas at higher latitudes while considerably reducing the apparent size of Africa and other regions closer to the Equator.

For cartographers, the attention is welcome. But the discussion also requires some clarification. The United Nations has not declared that there is now one new, “correct” map of the world. Nor has it banned the Mercator projection. In fact, the resolution explicitly encourages Equal Earth and other equal-area projections where the relative size of geographical areas matters. This distinction is important, because it takes us to the heart of what cartography actually does.

Every world map is a compromise!

The Earth is approximately spherical. A sheet of paper or a computer screen is flat. Transforming one into the other inevitably creates distortion. There is simply no way of representing the entire surface of the Earth in two dimensions

while simultaneously preserving area, shape, distance and direction.

Every map projection therefore makes choices. The famous Mercator projection is an excellent illustration. Gerardus Mercator developed his projection in 1569 primarily to solve a navigational problem. Its great advantage is conformality: locally, angles are preserved, and lines of constant compass bearing can be represented as straight lines. This made it extraordinarily useful for navigation. The price is distortion of area. This becomes progressively greater towards the poles. Greenland consequently appears roughly comparable in size to Africa on a Mercator world map, although Africa is actually about fourteen times larger. This does not make Mercator a “bad” projection. It makes it an inappropriate projection for certain purposes. The problem arises when a projection developed for one purpose becomes the seemingly natural representation of the world for completely different purposes.

Why Equal Earth?

The Equal Earth projection, introduced in 2018, belongs to the family of equal-area projections. Its central advantage is contained in that description: areas are represented proportionally. Africa therefore occupies its appropriate relative area compared with Europe, Greenland or North America. For a general world map intended to communicate the relative extent of continents, this is a significant advantage. It is also particularly important for thematic maps dealing with phenomena related to area—for example land cover, environmental change or other geographically distributed quantities. But Equal Earth also involves compromises. Equal-area does not mean distortion-free. Shapes, angles and distances cannot all be preserved at the same time.

The ICA’s position is equally clear: there is no universally correct world map projection. What the decision does achieve is something perhaps more important. It makes visible that cartographic choices matter.

This is why the International Cartographic Association's Fact Sheet on world map projections deliberately carries the subtitle "When Equal-Area Is Appropriate (and Why There Is No Single 'Correct' Projection)". Its central message is that the projection should follow the purpose of the map. That may sound less spectacular than declaring one map right and another wrong, but it is the more important cartographic principle.

Maps are not neutral windows onto the world

There is, however, another dimension to the UN debate that should not be underestimated. Maps are powerful because we tend to accept them intuitively. A photograph is immediately recognised as a particular view of reality. A map often carries a stronger suggestion of objectivity: *this is where things are; this is what the world looks like*. But maps are designed representations. Projection is only one of many decisions involved. Cartographers select, classify, simplify, symbolise and emphasise. Every map is therefore a model of geographical reality rather than reality itself.

This makes the current discussion particularly valuable. The question is not simply whether Africa should appear larger on our classroom walls. It reminds us that the way in which we represent the world influences the way in which we perceive it. When generations repeatedly encounter the same world map, its geometry can become part of their mental image of the planet. Relative size can subtly become associated with relative importance. This is why the African-led initiative has connected the technical question of projection with a broader

For comparing the relative sizes of continents, an equal-area projection such as Equal Earth is clearly preferable to Mercator. For other purposes, another projection may be the better choice.

discussion about representation, historical perspectives and what the UN resolution describes in terms of cognitive justice.

Cartographers should take this concern seriously without reducing a complex cartographic question to a simple opposition between a "wrong" Mercator map and a "right" Equal Earth map.

The bigger opportunity: map literacy

For me, the most important consequence of the UN decision may therefore be educational. Instead of simply replacing one world map hanging in a classroom with another, we should use the opportunity to explain why they look different. Imagine students seeing Mercator, Equal Earth and perhaps one or two other projections side by side. Why does Greenland change size? Why does Africa change shape? Which map should we use for navigation? Which one for comparing areas? What exactly are we trying to communicate? Suddenly projection is no longer an obscure mathematical detail. It becomes an introduction to map literacy.

And map literacy is becoming more rather than less important. We live in a world in which maps are ubiquitous: on smartphones, in vehicles, in news media, on social platforms, in dashboards

and increasingly in AI-generated information environments. Billions of people interact with maps without necessarily thinking about the choices embedded in them. Understanding that a map is a purposeful representation—and asking what has been preserved, distorted, selected or omitted—is therefore an essential competence.

A significant moment for cartography

The UN decision should consequently not be understood simply as the replacement of Mercator by Equal Earth. The resolution itself does not demand this, and cartographic science would not support such a simplistic interpretation. The ICA's position is equally clear: there is no universally correct world map projection. What the decision does achieve is something perhaps more important. It makes visible that cartographic choices matter.

A map projection is a mathematical transformation, but choosing one is also a communication decision. We must ask what the map is for, who will use it, what geographical extent it covers and which properties matter most. For comparing the relative sizes of continents, an equal-area projection such as Equal Earth is clearly preferable to Mercator. For other purposes, another projection may be the better choice. Good cartography begins precisely with that question of fitness for purpose. So perhaps the most important outcome of the UN vote is not that the world has received a new map. It is that the world is talking about maps.

And for cartography, that is a very welcome development. ▴

A map projection is a mathematical transformation, but choosing one is also a communication decision. We must ask what the map is for, who will use it, what geographical extent it covers and which properties matter most.

UN General Assembly adopts text to 'Correct the Map'

The General Assembly took an important step on September 4, 2026 towards correcting distortions in commonly used world maps, particularly the Mercator projection, which are seen misrepresenting the relative size of continents and contribute to a diminished perception of Africa and other equatorial regions.

Completing its substantive work for the eightieth session ending on 8 September, the Assembly adopted several draft resolutions and decisions.

Chief among them was the draft resolution titled “Correct the map: rebalancing global cartographic representation and promoting equitable representation of the world’s regions, particularly Africa”, which was adopted by a recorded vote of 164 in favour to 1 against (United States), with 6 abstentions (Estonia, Georgia, Lithuania, Republic of Moldova, Serbia, Ukraine).

It calls for wider use of equal-area map projections, particularly the Equal Earth projection, in contexts where the comparative size of continents matters, framing the issue as more than a technical cartographic problem.

Cognitive Justice, Historical Recognition, Equitable Representation

The sponsors argued that distorted maps affect education, public understanding, culture, geopolitics, development narratives and perceptions of Africa’s scale and potential. The resolution therefore links more accurate mapping to cognitive justice, historical recognition and equitable representation.

Introducing the text on behalf of the Group of African States, the representative of Togo said that the United

Nations has progressively addressed imbalances inherited from the past.

“Today, the issue of mapping as a cognitive tool deserves our collective attention,” he said, asking: “How do we represent the world? How do we teach it? How do generations learn to see our planet?”

For centuries, map projections used in textbooks, the media, digital platforms and official documents have distorted the relative size of continents, symbolically diminishing Africa and other regions and perpetuating an unbalanced view of world geography. “Correcting the map means recognizing that every region of the world deserves to be represented accurately and with dignity,” he argued.

“Our approach is not directed against any nation, any civilization or any cartographic tradition,” he stressed. Rather, it seeks “to promote projections that better preserve the true proportions of continents,” including equal-area projections such as the Equal Earth projection preferred by the African Union.

“A fair map does not change the geography of the world; it changes how we see the world,” he said. “And when our perspective becomes more just, it paves the way for greater understanding, respect and peace among nations.”

Expressing support for the text, the Russian Federation’s representative said that Moscow has been consistent in its advocacy for overcoming the legacy of colonialism, and for combating the practice of neo-colonialism. Her country therefore supports African States’ independent efforts to restore historic justice and strengthen Africa’s role as one of the unique and influential centres of the contemporary multipolar world.

United States Rejects Text as ‘Barnacle’, Ukraine Says Map Depicts Occupied Territories in Wholly Unacceptable Manner

However, her counterpart from the United States rejected the text. Speaking before the vote, she said that while the draft is presented as an “anodyne” effort to update cartography, “it cannot be separated from the much larger and more radical ideological project it belongs to”. The Assembly is debating “map projects from the sixteenth century” and their role in promoting reparations and cognitive justice. Such resolutions are like “barnacles on our work here and the reason this institution is losing its credibility”.

While Ukraine does not oppose the core principles addressed in the draft resolution, that country’s representative took issue with the Equal Earth cartographic projection mentioned in the text, as this map depicts parts of Ukraine’s territory that have been temporarily occupied by the Russian Federation “in a manner that is wholly unacceptable”. Further, it is inconsistent with all relevant Assembly resolutions concerning “the non-recognition of the attempted illegal annexation of Crimea by the Russian Federation in 2014”.

The representative of Ireland, speaking for the European Union, said that the bloc supports the text’s objective of promoting a more equitable and accurate cartographic representation of the world’s regions, particularly Africa. However, she added, its scope is strictly limited to the purposes of education, awareness-raising and geographical literacy, and it “neither addresses nor affects questions relating to sovereignty, territorial status, delimitation or internationally recognized borders of States”. <https://press.un.org>

India votes in favour of UN resolution on equal-area world map

The Ministry of External Affairs responded to the UN General Assembly resolution on equal-area world map. Spokesperson of the Ministry of External Affairs Randhir Jaiswal said that India has voted in favour of the United Nations General Assembly resolution on equal-area cartographic representation.

Mr Jaiswal further added that India's sovereign territory, including the Union Territories of Jammu and Kashmir and Ladakh, must be depicted in accordance with India's official map. He also clarified that any inaccurate or misleading depiction is unacceptable.

He said the government's position on India's sovereignty and territorial integrity is clear, consistent and non-negotiable.

Mr Jaiswal said that the UN General Assembly adopted a resolution titled "Correct the Map Rebalancing Global Cartographic Representation and Promoting Equitable Representation of the World's Regions, Particularly Africa" on 4th of this month. He said, the purpose of this is to encourage the use of equal-area map projections that preserve the relative sizes of continental landmasses. newsonair.gov.in

Japan seeks change to new UN world map over Russia 'misconception'

Japan said on September 10 it had asked for the revision of a new world map adopted by the United Nations because it made the disputed Kuril islands appear to belong to Russia. The UN General Assembly voted to adopt the new map, which makes the African continent larger while also shrinking North America and Europe, drawing condemnation from the United States.

Japan was among the 164 UN members that supported the resolution but has now taken issue with it because it shows the Kurils, known in Japan as the Northern Territories, in the same colour as Russia. Top Japanese government spokesman Minoru

Kihara said the new map -- known as the Equal Earth cartographic projection -- "contained a depiction contradicting the Japanese government's position".

"We lodged a protest with the map site's operator through our diplomatic channel to demand the correction of this depiction," Kihara told reporters. He declined to say when the issue was brought to government's attention but said Japan "needs to prevent misconceptions of our territories and geographical names from spreading". The disputed islands were seized in 1945 by the former Soviet Union, which then expelled the Japanese population. www.bssnews.net 

Civil authenticated position fix under spoofing conditions achieved by Galileo

For two hours on the afternoon of Sept. 16, five operational Galileo satellites broadcasting over Europe transmitted a new encrypted signal for testing. On the ground in Andøya, Norway, and at ESA's navigation laboratory at ESTEC, in the Netherlands, receivers successfully established their location using these encrypted signals, marking the first real-world positioning using Galileo's upcoming Signal Authentication Service (SAS).

Satellite navigation has become essential in our lives, and consequently it has also become an increasingly attractive target for disruption. Interference with GNSS such as jamming and spoofing is reported daily in many regions, including in Europe, particularly in or near conflict zones.

One of Galileo's most significant innovations is the Signal Authentication Service, that together with the already available Open Service Navigation Message Authentication (OSNMA) will unlock a new level of protection against interference.

The Signal Authentication Service is the result of the close cooperation between The European Commission (EC) defined the concept, while the European Space Agency (ESA) and the European Union Agency for the Space Programme (EUSPA) designed the architecture and updated the satellites and ground infrastructure to enable the new service on behalf of the European Union, Galileo's owner.

Now, after extensive testing in laboratories and controlled environments, the new signal has proven its performance under real world conditions, at Jammertest. To establish a position, satellite navigation receivers work with two main pieces of data: the information sent by the satellites, known as the navigation message, and the ranging measurements, the time the signal takes to travel from the satellite to the receiver.

The Signal Authentication Service relies on encrypted ranging signals and is complemented by OSNMA, which enables receivers to confirm the navigation message originated in the Galileo system. OSNMA is operational since 2025 and represents Galileo's first major upgrade to enhance its resilience to interference. www.esa.int 

On living structure, AI, and the aesthetics of traditional Chinese Architecture

A Conversation with Professor Bin Jiang



Dr. Bin Jiang

Professor of Urban Informatics, Director of LivableCityLAB, Master of Wholeness College. Thrust of Urban Governance and Design, The Hong Kong University of Science and Technology (Guangzhou), Guangzhou 510000, China

Your research has long focused on geospatial analysis and urban structure. What prompted you to apply the perspective of structure combined with AI to traditional Chinese architecture? What is the core message you most wish to convey in this new book?

I am delighted to take this opportunity to systematically review and share some of the research and reflections I have undertaken in recent years on what makes urban spaces feel more alive, on their underlying structure, and on spatial aesthetics.

Looking back at my academic journey, my work has never really been in the traditional sense of geography or urban planning. My early work focused on unconventional spatial research methods such as space syntax, complex networks, and intelligent-agent systems. These methods do not aim solely at classical quantitative analysis, but rather seek to understand the underlying structural order of space. Around the year 2000, with the rise of the internet and complex-systems research, “space” began to be understood as a holistic system composed of a vast number of interconnected units, which had a profound impact on my work.

In fact, as early as 2012 I had begun to conceive of research related to Christopher

Editorial note on terminology

In this essay, the concept of Living Structure is understood as comprising two inseparable dimensions: “living” and “structure.” The first refers to the felt quality of wholeness, intuitive resonance, and right-brain perception of space and form; throughout the text it is conveyed using adjectival and participial phrasing such as “more alive” or “more living,” rather than awkward noun forms. The second refers to the underlying order that is computable, analysable, generative, and measurable, and is referred to throughout simply as “structure.” Together, these two dimensions constitute the same core concept of Living Structure, allowing the reader to move freely between experiential perception and computational understanding.



Figure 1. Cover of Living Structure: Exploring the Beauty of Chinese Traditional Buildings Through the Lens of AI.

Alexander's *The Nature of Order* (a four-volume magnum opus). At the time, I kept asking myself: why did Alexander spend 27 years constructing such a theory that appeared to be “outside the mainstream”? I gradually came to realise that what he proposed—or, more accurately, discovered—as *Living Structure* can, on the one hand, be directly sensed by people; in this experiential context, I prefer to describe it as making a space feel more alive. On the other hand, it can also be abstracted into structural laws that are repeatable, generative, and verifiable; within this rational and engineering context, I prefer to call it “structure.” In essence, it represents a profound extension of complex science into the realms of space and aesthetics.

The reason this is described as a discovery is that Alexander did not invent aesthetic principles out of thin air; rather, through long-term observation of human civilisation's building practices over a timescale of hundreds or even thousands of years, he distilled a set of recurring spatial structural patterns from architectural heritage—buildings, streets, settlements, and traditional crafts—across different regions and cultural contexts. Whether it be the branching of rivers or the growth of trees in nature, or the traditional architecture, streets, and settlements found across human history, their forms may differ vastly, yet at a structural level they are highly similar: they exhibit clear hierarchical relationships, a strong centre,

and a new scaling law in which “the small far outnumber the large.” These patterns do not depend on any particular style; they are closer to natural laws. The reason people find them “comfortable, pleasing to the eye, and inviting to linger in” is precisely that this quality of feeling more alive produces a stable resonance within the human perceptual system.

To make this easier to understand, I often use an analogy: a traditional carpet. Viewed from a distance, it appears as a single, unified whole; yet on closer inspection one observes the pattern breaking down into substructures at varying levels. Each level is clearly distinguishable, yet all are interconnected and mutually supportive—this is the most intuitive way in which a space reveals itself as more alive. When we translate this hierarchy and nested relationship into rules, models, and metrics, it enters the computational context of structure.

Seen in this light, my subsequent shift in research focus toward what makes spaces feel more alive—and toward the structure that underlies this feeling—was not a “turn” but a natural extension of my earlier work on complex networks, spatial heterogeneity, and hierarchical structure.

What truly prompted me to propose the “*Living Structure + AI*” paradigm was the rapid maturation of artificial-intelligence technology over the past two or three years. It should be emphasised,

however, that this is not “AI+” in the conventional sense. Within the “*Living Structure + AI*” paradigm, AI assumes two very distinct roles. On the one hand, AI (particularly computer vision and large language models) enables us, for the first time, to systematically extract and quantify the structural features in traditional building façades that make them feel more alive. On the other hand, AI can generate diverse architectural envelopes and formal expressions within predefined structural constraints, allowing the same “skeleton” to develop different “skins” while maintaining structural consistency through controlled generation.

The reason for choosing traditional Chinese architecture as a starting point is not that it is the only subject of interest, but that it is rooted in China while also embodying the universal significance of structure. Through its long evolution, traditional Chinese architecture has almost naturally adhered to the fundamental principles that make built spaces feel more alive—and that, on the analytical side, we describe as structure. In the future, I also plan to extend this framework to traditional architecture and cultural heritage across the globe.

If one were to summarise the core idea of this book in a single sentence, it would be this: almost all outstanding traditional architecture—regardless of era, location, or cultural context—is consistently perceived by people as

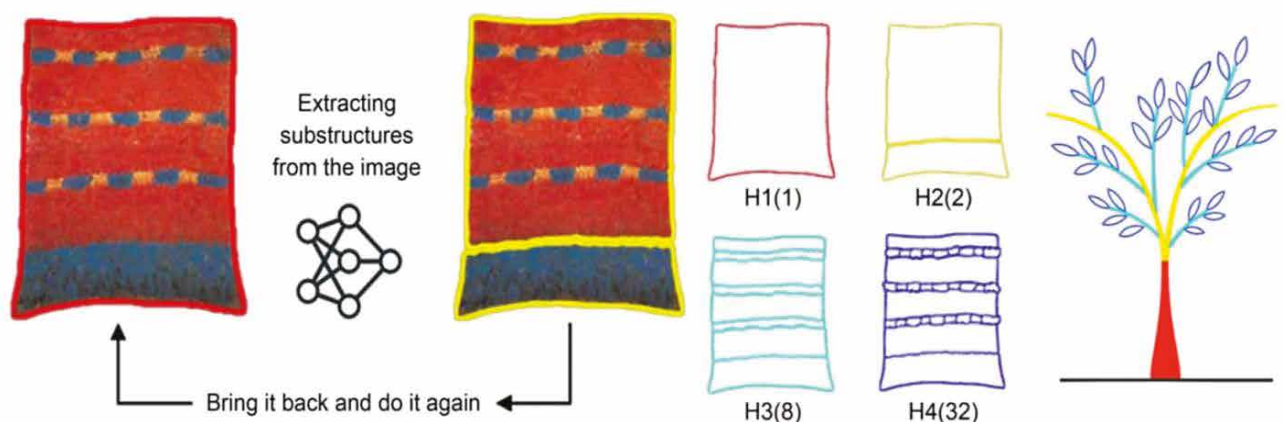


Figure 2. Hierarchical generation of structure: through the repeated extraction and reintegration of substructures, the whole grows like a living organism, forming a multi-level and orderly system.

more alive; and the combination of Living Structure and AI provides us with unprecedented means to understand, measure, and regenerate this order. This applies not only to architecture but also to traditional crafts, fine arts, painting, and indeed every kind of space and form created by humankind. What we are attempting to do is to elevate the structural principles underlying “crafts”—which have long relied on the transmission of experience through the master–apprentice tradition—into a verifiable and discussable scientific framework of knowledge.

In your book, you attempt to use AI to quantify the beauty of form, craftsmanship, and connotation in traditional architecture. What do you consider to be the greatest challenge in this process? How do you balance the precision of technology with the “ineffable connotations” of traditional architectural aesthetics to achieve the “fuzzy tolerance” you mention?

Throughout the research process, the greatest challenge did not lie solely in the technology, but in how to approach and understand the beauty of meaning itself. From a methodological perspective, using AI and computer vision to identify a building’s substructures, scale hierarchies, and structural relationships was not the most difficult part. These aspects essentially fall within the realm of rational analysis and are closer to the identifiable, computable, and optimisable characteristics emphasised by structure; as such, they can be continuously refined and approximated through algorithms.

The real difficulty lies in the fact that this beauty is often felt first and foremost as a sense of something being more alive: a holistic resonance that is ineffable yet highly consistent. It should be noted that these differences in perception do not imply complete subjectivity. When two buildings are placed side by side for comparison, the

majority of people’s judgements tend to be highly consistent in direction. In other words, although individual experiences vary, at the structural level people’s judgements as to “which is more alive and more pleasing” usually rest on a solid foundation of consensus. This is precisely the key evidence that the experience of something feeling more alive is an objective phenomenon, capable of being perceived collectively.

Based on this consensus, we have proposed and developed the Beautimeter. To be precise, it is not a subjective evaluation tool, but a system that systematically quantifies architectural beauty using the 15 attributes of structure as a computational framework. Statistical results show that for approximately 80% of people, their subjective judgements of beauty align closely with the rational quantitative results; the remaining 20% of discrepancies are concentrated precisely in the more sensory and holistic experiential dimensions. This is not a failure of the algorithm but a reminder that the beauty which emerges when something feels more alive is not entirely equivalent to the linear summation of rational indicators. We use the computable aspects of structure to approximate the felt experience of being more alive, yet a natural gap exists between the two—one that requires understanding and education to bridge.

In the course of this process we also observed a noteworthy phenomenon: when large language models such as GPT were introduced into the evaluation, the aesthetic judgements they made—based on their understanding of language and structure—tended to align closely with the average judgements of human groups. This indicates that large language models are not limited to semantic generation; under certain conditions they have already demonstrated a relatively stable and interpretable capacity for aesthetic judgement. This ability is not mere imitation of aesthetics, but rather appears to be founded on a comprehensive understanding of structural order, hierarchical relationships, and overall coherence. In other words, to a certain extent these models are capable of articulating, within the language of structure, what it means for something to feel more alive as a whole.

Consequently, another key initiative we are pursuing is the introduction of large language models as cognitive amplifiers, to help people better understand, describe, and appreciate the beauty of architecture, and thereby gradually enhance humanity’s capacity to perceive beauty. In a sense, this helps people engage their right brain more keenly in feeling when a space is more alive, rather



Figure 3. Beautimeter: translating Alexander’s fifteen properties of structure into computable indicators that objectively quantify the beauty and living quality of spatial structure.

than relying solely on the left brain's analysis and calculation of structure.

This brings us directly to the point you raised regarding how to understand fuzzy tolerance. Traditional modern science has been deeply influenced by a mechanistic worldview, particularly the precise sciences represented by Euclidean geometry and classical mathematics, whose core characteristic is determinism—for instance, that $1+1$ must equal 2. While this paradigm has been extremely successful in engineering and physics, when applied indiscriminately to art, aesthetics, and sensory cognition it can actually lead to a poverty of understanding.

I believe that 21st-century science, particularly when addressing issues of beauty and perception, should be a fuzzy science in the statistical sense—one that is itself alive and infused with the qualities of living things. To some extent, this resembles the working methods of large models such as GPT: rather than pursuing 100% consistency, they form a repeatable consensus within a sufficiently good range. To use a familiar statistical analogy, the quantification of beauty is more like a correlation coefficient (R^2) that is perpetually difficult to bring to 1.0; moving from 0.75 to 0.88 represents a significant advance, yet we must acknowledge that it will not, and should not, equal 1.

It is in this sense that fuzzy tolerance is not a compromise, but a new paradigm: it acknowledges individual differences and respects sensory experience while not relinquishing scientific explanatory power. The holistic education or liberal-arts education currently advocated (particularly in higher education) is, in essence, doing the very same thing: developing rational thinking while awakening sensory cognition, so that both the left and right hemispheres of the brain are truly brought to life. As we gradually narrow this margin of ambiguity, we do so not by suppressing the sensory, but by enhancing people's capacity to understand and express beauty, thereby allowing science and art to converge once more at a higher level.

You have skilfully applied Christopher Alexander's theory of structure in your research. How does this theory provide a central framework for using AI to analyse how alive and how beautiful traditional architecture is? What breakthrough significance does this hold for reconstructing our understanding of architectural aesthetics?

If we are to discuss the central role of Living Structure within this research—in both its felt and its analytical dimensions—I believe it first and foremost provides a wholly new theoretical foundation for aesthetics. Traditional aesthetics has long remained primarily at the philosophical level, relying on conceptual discussions, value judgements, and subjective interpretations; Alexander's notion of structure (which, in the context of perception, I prefer to describe simply as the experience of being more alive) approaches beauty from the perspectives of biology, psychology, and physiology, understanding it as an objective phenomenon directly related to the human body, emotions, and intuition. This represents a fundamental shift—beauty is no longer merely a subject of discourse, but becomes a structure or geometric property that can be perceived, experienced, and, to a large extent, characterised.

In this sense, its greatest value lies in the fact that, for the first time, it truly connects human emotion and intuition (that is, the holistic sense of a space being more alive) with the rational analysis of beauty. To advance this connection at the level of computation and verification, we refer to its analysable, modelable, and measurable aspect as structure, and have further developed a corresponding structural-geometric expression (living geometry, which may also be understood as fractal geometry under its third definition). I often use a metaphor to explain this: structure is to beauty as

temperature is to warmth. Before the invention of the thermometer, people could only describe warmth through sensation, yet found it difficult to compare or accumulate such experiences; the introduction of temperature as a physical quantity provided warmth with a measurable foundation for the first time. Similarly, structure offers a structural characterisation that can be discussed in mathematical and physical terms, helping us understand and explain more clearly why people perceive beauty.

Of course, one point requires particular emphasis here: just as a higher temperature does not necessarily mean greater warmth, a higher structural value does not necessarily imply greater beauty. What level of structural intensity is moderate, and what level induces a sense of comfort and pleasure? This question itself constitutes a new and highly valuable scientific topic—one that brings sensation and measurement back to the same table for discussion.

From the perspective of the history of scholarship, Alexander's contribution was truly groundbreaking. From the completion of his first draft in 1983 it took him a full 27 years to finally complete the four-volume theoretical system of *The Nature of Order*—an intellectual undertaking that few could match. Yet Alexander himself was well aware that one regret remained: despite the mathematical overtones of his initial definition, structure still lacked a rigorous, operational mathematical model.

It was against this backdrop that, in a 2015 paper, I attempted to introduce a truly mathematical expression on the theoretical foundations laid by Alexander. This model is both recursive and quantifiable, and serves as an extension and supplement to his ideas: Alexander revealed to us why the world exhibits structure, while my mathematical model makes it possible, for the first time, to answer to what extent a given space is more alive and to what extent it possesses the characteristics of structure.

In this sense, Living Structure—whether experienced as a space being more alive or formalised as analysable structure—serves not only as the theoretical foundation for using AI to analyse how alive and how beautiful traditional architecture is, but also represents a profound reconfiguration of the cognitive framework of architectural aesthetics: it transforms beauty from a purely subjective judgement into a scientific problem that connects nature, structure, and human perception—one that can be genuinely felt by people as more alive and, to a certain extent, calculated and explained as structure. This is precisely why I believe this theory holds particular significance in the present era, when technology and culture are rapidly converging.

You have conducted specific livingness tests and aesthetic measurements on seven major categories of traditional buildings, including residential, commercial, and cultural and educational structures. Are there common patterns in how structure is manifested across these different types of buildings? How can these data and indicators inform modern architectural design?

While these seven major categories of architecture appear to differ greatly in function and context—representing distinct types within the traditional Chinese architectural system—when

viewed from a deeper perspective they actually share striking commonalities: at the experiential level, they all convey a sense of being alive, comfortable, and enduringly pleasing; and at the level that can be analysed and quantified, they all embody the same set of living-structure principles.

In the book, we have conducted quantitative analyses of each specific case, using two indicators—livingness (L) and beauty (B)—to characterise their spatial and formal features. A very clear and highly consistent conclusion is that, without exception, these traditional buildings all exhibit significant structural characteristics, and their overall livingness levels are generally high. In other words, not only do they feel strongly more alive at the experiential level, they also demonstrate, in a computational sense, the common principle that “structure is alive” across types and scales. It can be said that it is precisely through the computable aspects of structure that we approach and explain people’s stable consensus regarding what feels more alive.

This commonality is primarily evident in three aspects. First, these buildings generally feature a rich and clear hierarchy of scales, progressing layer by layer from the overall layout to the details of components or substructures. Second, the number of small-scale substructures far exceeds that of large-scale structures, creating a stable and natural hierarchical order. Third, these structures are consistently centred on human perception, embodying a distinct human scale—and it is precisely for this reason that they are better able to evoke a profound sense of being more alive at the intuitive level.

In stark contrast to this are the widespread issues found in modernist architecture. As shown in Figure 5, the B-value (aesthetic quality) of modernist architecture and its derivative styles is, on the whole, significantly lower than that of traditional architecture. This is not due to deficiencies in materials, technology, or function, but to a lack of livingness at the structural level: modernist architecture often

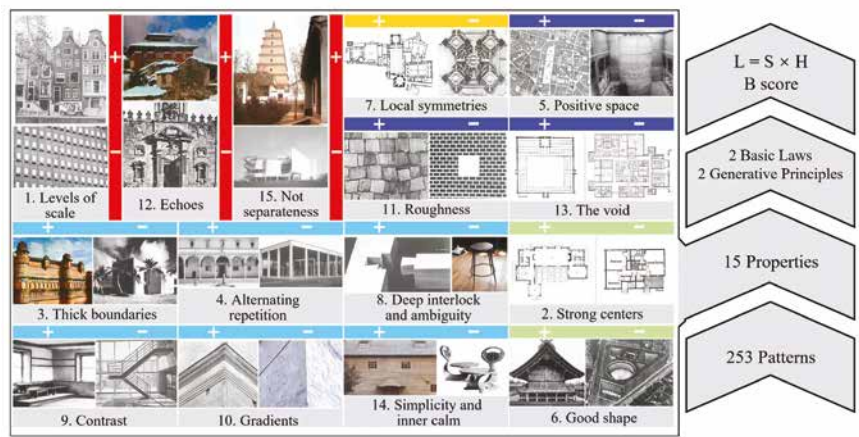


Figure 4. Multi-level theoretical framework of structure: from fifteen geometric properties, through two fundamental laws and two generative principles, to the computable L and B indices, together with 253 patterns that constitute the quantitative foundation of structural beauty.

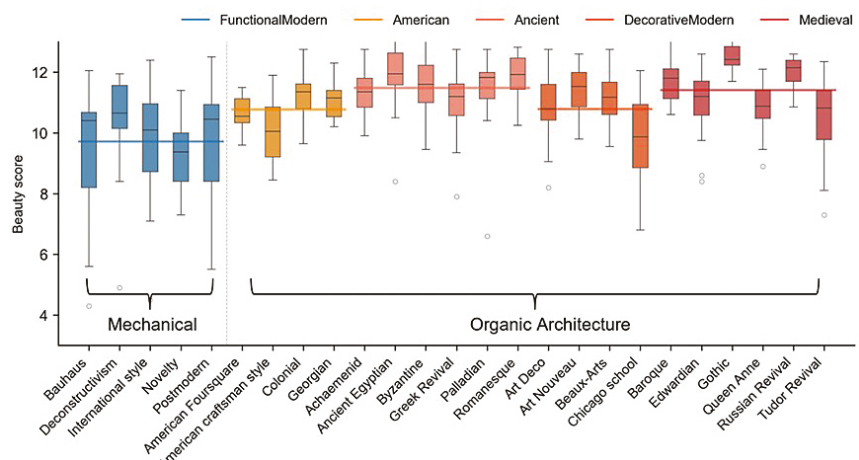


Figure 5. Distribution of structural-beauty scores across different building types: mechanistic architecture scores lower overall, while organic architecture—particularly traditional and classical buildings—exhibits higher and more stable performance

In my view, standardisation and individualisation are not truly contradictory. On the contrary, in traditional Chinese architecture the two have always existed in a relationship of mutual dependence and mutual generation.

features very few hierarchical levels, with a severe shortage of small-scale substructures—particularly substructures or component details smaller than one metre or half a metre. Consequently, while the architecture appears visually clean and grand, on a perceptual level it tends to evoke a sense of coldness and detachment—that is, the feeling of being more alive is difficult to activate.

From the perspective of structure, modernist architecture is often more object-centred than human-centred. The human body and senses struggle to find sufficient points of contact within it, and naturally find it difficult to generate feelings of pleasure, intimacy, and belonging. We present these data not to label traditional architecture, but to provide a practical counterpoint for contemporary architectural design: not through simple retro-style or formal imitation, but by reintroducing the fundamental principles of structure—increasing the hierarchy of scales, enriching small-scale substructures, and restoring the human scale—thereby reconstructing structural order at a calculable level and reawakening the sense

of being more alive at the perceptual level, so that architecture once again becomes a spatial system designed for people.

In this sense, the value of livingness testing and aesthetic measurement lies not merely in evaluating the past, but in providing a set of structural guidelines for future architectural design that are science-based and centred on human perception: using structure to underpin interpretable, generative design processes, and using the felt sense of being more alive to calibrate whether the final design truly moves and settles people.

The "aesthetic of dimensional stability" found in traditional Chinese timber architecture embodies the ancient wisdom of modular design. In the era of AI-generated design, how can we reconcile the tension between standardisation and individualisation? Is it possible to use algorithms to reconstruct the architectural logic of "harmony between heaven and humanity"?

In my view, standardisation and individualisation are not truly contradictory. On the contrary, in traditional Chinese architecture the two have always existed in a relationship of mutual dependence and mutual generation. Traditional Chinese timber-frame architecture does indeed possess a highly stable system of specifications and modular logic, but this does not imply uniformity. On the contrary, it is precisely within the constraints of these stable rules that an extraordinarily rich variety of spatial forms and architectural styles has developed across different regions, climates, and cultural backgrounds. In other words, individuality is not a negation of standardisation, but an adaptive outcome of the standard system within specific contexts—and this mechanism of generating diversity within unity is precisely the key to why traditional architecture feels comfortable, is pleasing to the eye, and invites one to linger; it can also be described as a quintessential expression of built form being more alive.

This is highly consistent with the "Living Structure + AI" design paradigm we propose today. Within this paradigm, the skeleton is universal: it corresponds to the structural order, scale hierarchy, and generative rules that can be identified and modelled—in other words, the computational core of structure. The skin, by contrast, is diverse: it can be generated by AI within structural constraints to produce highly personalised expressions based on regional culture, material properties, and aesthetic preferences, while still maintaining, as a whole, that intuitively perceptible harmony, stability, and charm—that is, the holistic resonance experienced when a space feels more alive.

Therefore, what truly needs to be addressed in the AI era is not whether to standardise, but how to construct a

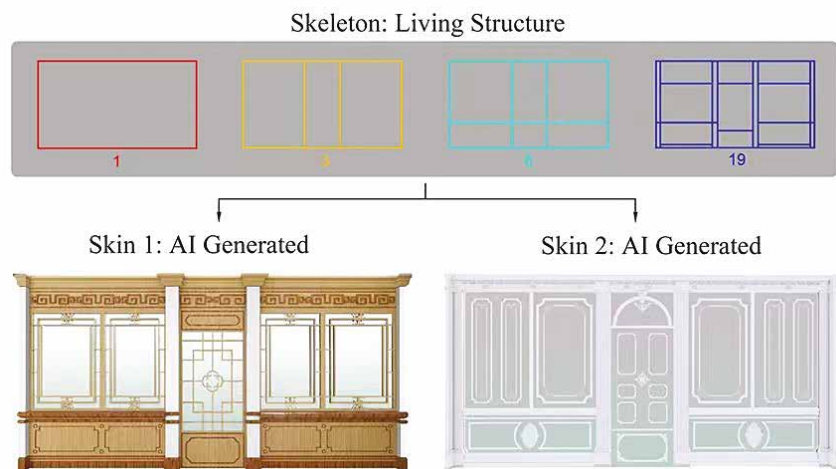


Figure 6. Structure-driven skeleton-skin generation: the skeleton determines the overall order and hierarchy, while AI generates diverse skin expressions within structural constraints.

standard that is itself alive: not a template that flattens differences, but a set of structural rules that permits variation, encourages diversity, and is capable of continuous evolution in response to environment and culture—in the language of structure, a generative, verifiable, and iterative system of rules; in experiential terms, an order that allows people to perceive what is right, natural, and appropriate across different contexts.

As for “the unity of heaven and man,” I believe it is not an abstract philosophical slogan but a logic of construction that can be clearly described and even algorithmised. What the felt sense of being more alive emphasises is precisely the harmony and resonance between people and their environment at the level of holistic perception; structure provides the scientific language to translate this resonance into structural rules and generative processes. Alexander once pointed out that the order found in nature and that found in human-made structures are, in essence, one and the same. He held that truly excellent architecture does not simply imitate the forms of nature, but rather follows the process by which nature generates order. When we interpret architecture through this dual lens—as something felt to be more alive and as analysable structure—we are in effect acknowledging that whether it be mountains and rivers, urban streets and alleys, or timber-framed roof trusses, they all adhere to similar hierarchical laws, relationships of scale, and principles of mutual adaptation. Consequently, reconstructing “the unity of heaven and man” through algorithms is not a digital replication of traditional wisdom, but rather a

rediscovery and regeneration of traditional construction logic within a technological context—and this is precisely the most valuable design path in the AI era.

When AI is able to accurately analyse the aesthetic proportions of flying eaves and bracket sets, will the role of the architect be diminished? What is the fundamental difference between the generative design approach of “Living Structure + AI” that you advocate and traditional computer-aided design (CAD)?

The crux of this issue does not lie in how powerful AI is, but in how we define the architect. If we continue to view the architect primarily as a figure engaged in drawing, modelling, and formal expression, then it is indeed foreseeable that this aspect of the work will rapidly diminish, or even be gradually replaced by technology. However, if instead we understand the architect’s role through Alexander’s framework of Living Structure—simultaneously as something that can be directly felt by people as more alive and as analytical structure that can be modelled—then the situation is precisely the opposite: the architect’s role will not only not be diminished, but will in fact be significantly strengthened.

Within this framework, the architect’s core responsibility is no longer to draw an aesthetically pleasing form, but to judge which spatial structures truly feel more alive: whether they are people-centred, whether they make people feel comfortable, willing to linger, and

consistently perceived as beautiful. This is a highly comprehensive judgement process that occurs primarily at the level of holistic human perception and intuition, and cannot simply be replaced by automation.

This also explains the fundamental difference between generative design—which combines structure with AI—and traditional CAD. Strictly speaking, the “D” in CAD does not stand for “design” but for “drawing.” It addresses how to render pre-conceived ideas visually, but does not itself engage in judging the quality of the design. CAD cannot tell you whether a proposal is better at evoking a human experience of being more alive—whether it is warmer, more intimate, or more pleasing. The generative design approach I advocate, based on Living Structure + AI, is what comes closest to design in its true sense: its core purpose is not to replace the architect, but to provide architects with an objective support system based on structure—helping us, within the constraints of structural laws and generative parameters, to create and refine, in a more stable and interpretable manner, spaces that people can feel as more alive.

Within this framework, design is no longer merely a matter of personal opinion or preference, but a result that can be collectively perceived by the majority and, to a large extent, collectively validated. This judgement is more akin to a doctor diagnosing an illness—a judgement based on observable symptoms, structural evidence, and experience—rather than one based entirely on immediate taste, as a young child decides whether they like McDonald’s.

Furthermore, the quality of architecture is not beyond articulation; while the feeling of being more alive presents itself primarily through sensation, the structure underlying it can be measured and compared using the livingness index L and the beauty index B. L and B are not opinions but, rather, closer to facts: the extent to which a space possesses a recognisable structural order, and the extent to which it can be consistently perceived as

AI will not replace architects but will prompt them to undergo a transformation of role: from creators of form to guardians and catalysts of what makes spaces feel more alive, and simultaneously judges of structure and shapers of order.

By leveraging digital technologies and incorporating the theory of structure, we can create high-precision, real-world 3D models of architectural components, façades, and even urban spaces, and achieve their individualisation.

beautiful. We use the computable aspects of structure to approximate and interpret the perceptible experience of being more alive.

Consequently, AI will not replace architects but will prompt them to undergo a transformation of role: from creators of form to guardians and catalysts of what makes spaces feel more alive, and simultaneously judges of structure and shapers of order. Viewed from this perspective, generative design based on Living Structure + AI does not undermine the architect's authority but represents a return to the core: it restores the architect to the centre of the design process, enabling them to perform truly irreplaceable work—creating spatial structures for humanity

that are alive, warm, aesthetically pleasing, and capable of sustainable evolution.

Will the Liveable City Laboratory at the Hong Kong University of Science and Technology (Guangzhou) become a new arena for testing the theory of Living Structure? What core modules should the architectural-aesthetics education system for the intelligent era, as you envisage it, include?

Yes, the Liveable City Laboratory was established precisely on the basis of this unified theory of Living Structure—understood both as the felt experience of a space being more alive and as analytical structure that is computable, modelable, and measurable. We are not merely living in a digital age; more accurately, we are in

an era of digital intelligence. Against this backdrop, digital technology and artificial intelligence are jointly transforming the way we understand, design, and evaluate architectural and urban spaces, and also providing unprecedented conditions for empirical research into Living Structure in both its felt and its analytical dimensions.

At the Liveable City Laboratory, we are committed to establishing a comprehensive closed-loop system for research and education. By leveraging digital technologies and incorporating the theory of structure, we can create high-precision, real-world 3D models of architectural components, façades, and even urban spaces, and achieve their individualisation. On this basis, we identify the structural hierarchies and nested substructures of spaces, and quantify their livingness. Subsequently, through AI-driven redesign and retrofitting within structural constraints, we enable spaces to become progressively more alive at the structural level. More importantly, this process does not end with the completion of the design but returns to the human experience itself: by using physiological and behavioural data—such as eye-tracking, heart rate, and skin conductance—we verify whether structural modifications truly align with people's overall perception, comfort, and sense of well-being. In other words, we use computable structure to explain and support what people feel as more alive.

We have always emphasised that design is not merely an outcome but a process that can be continuously optimised and evolved. Guided by this philosophy, the laboratory is exploring the development of design robots that can assist designers in a substantive way, undertaking two core tasks: first, to explain why something is beautiful (making the intuitive feeling of being more alive comprehensible); and second, to quantify just how beautiful it is (using a system of living-structure indicators to achieve comparability and verifiability). Within the cycle of explanation–measurement–redesign–reverification, we progressively enhance spatial quality while simultaneously improving people's capacity to



Figure 7. Logo of the Liveable City Laboratory (LivableCityLAB), Hong Kong University of Science and Technology (Guangzhou).

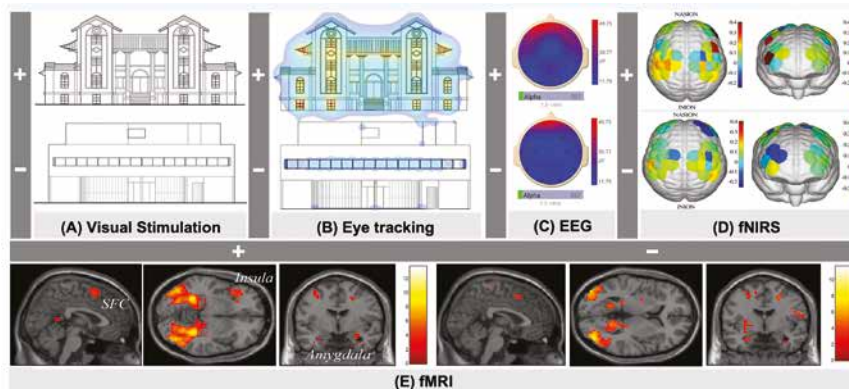


Figure 8. Human spatial-perception experiment within a multimodal neural-measurement framework, combining eye-tracking, electroencephalography (EEG), functional near-infrared spectroscopy, and functional magnetic resonance imaging to characterise neural and behavioural responses to spatial stimuli.

understand and perceive both beauty and the feeling of being more alive.

In the realm of architectural-aesthetics education, we envision an interdisciplinary, human-centred system. Its core modules include: digital modelling and spatial expression; AI-assisted structural evaluation and generation mechanisms; the establishment of livingness and beauty metrics together with their mathematical models; and the incorporation of cognitive-science and neuroscience methods (such as eye-tracking, electroencephalography (EEG), and magnetic resonance imaging) to capture human physiological and psychological responses. This system is fully aligned with our advocacy of holistic education: it develops both the left hemisphere's rational analytical and computational abilities (structure) and awakens the right hemisphere's holistic intuition and sensory experience (so that a space feels more alive), thereby enabling architecture and urban design to truly return to a people-centred approach.

In this sense, the Liveable City Laboratory is not only a new arena for putting the theory of Living Structure—in both its felt and its analytical dimensions—into practice, but also an important experimental platform for exploring new paradigms of architectural aesthetics in the era of digital intelligence.

Has the Liveable City Laboratory recently applied "Living Structure + AI" to any specific projects? For example, in the regeneration of older neighbourhoods, how can AI be used to optimise designs while meeting the diverse needs of different groups such as children and the elderly?

Yes, "Living Structure + AI" has already entered the practical phase of real-world projects at the Liveable City Laboratory. We have currently launched five or six practical projects on the campus of the Hong Kong University of Science and

Technology (Guangzhou), primarily carried out through coursework and student design projects. These cover a variety of types, including classrooms, office spaces, meeting rooms, student accommodation, and public-activity centres. A particularly telling phenomenon is that the students participating in these projects come from very diverse backgrounds, ranging from postgraduates specialising in architecture and urban planning to first-year undergraduates with virtually no prior experience in architectural design. However, after only a few weeks of systematic training, they are able to engage in real-world design within this framework: on the one hand, using the AI-supported structural method to identify, quantify, and interpret the hierarchy and substructures of a space; on the other hand, through the refinement of design proposals and the evaluation of user experiences, they learn how to make spaces feel more alive. This demonstrates that the method does not rely on individual

talent or extensive experience, but constitutes a new design paradigm that is learnable, replicable, and teachable.

Building on this foundation, we are currently establishing the Structural Aesthetics Learning Centre, with the aim of engaging more teachers and students in this ongoing process of research and practice, thereby moving the training of perceiving when something is more alive and the computational methods of structure from the classroom into long-term practice. At the same time, the laboratory's work is not confined to the campus. We have already launched specific neighbourhood-regeneration and spatial-renovation projects in locations such as Dongchong Town in Nansha District, Guangzhou. In these renovations of older neighbourhoods, the advantages of combining structure with AI are particularly evident: through quantitative analysis and redesign of spatial structure, we can address the



Figure 9. Example of structure-driven "skeleton-skin" interior renovation: while preserving the same structural skeleton, the refinement of details and interfaces enhances the living quality and beauty of the space.

differing needs of various groups within a single framework, while enhancing the perceived wholeness and approachability of the space at the experiential level (so that it feels more alive). For example, by introducing more small-scale, low-risk, and perceptible substructures, we enhance the safety and appeal of children's activity spaces; simultaneously, through clear hierarchical structure, continuous boundaries, and comfortable scales, we improve legibility, sense of security, and willingness to linger for older people.

In these projects, AI does not replace design decisions but serves as a tool for structural cognition and validation: it helps us continuously test, optimise, and validate proposals at the level of structure, thereby ensuring that the design maintains overall order and interpretability while also being consistently perceived by different groups as friendly, comfortable, and inviting—that is, as more alive.

Your research spans multiple fields, including geographic information, computational art, and urban governance. In advancing research on Living Structure, what is the greatest obstacle to interdisciplinary collaboration? Is there a need to establish a new academic evaluation system?

The greatest obstacle encountered in advancing research on Living Structure—understood both as the felt experience of a space being more alive and as its computable structural order—is not primarily technical. Rather, it lies in people themselves, and in long-standing academic inertia and habits of thought.

In the current mainstream discourse, cities and buildings are often treated as objects of display or stages for performance, pursuing visual impact, formal novelty, and short-term attention, rather than returning to the fundamental question of people-centred experience. Against this background, the new paradigm we propose—on the one hand, emphasising

the felt dimension of Living Structure, including wholeness, comfort, and a sense of life; and on the other hand, emphasising its analytical dimension as structure, including structural order, hierarchical nesting, and computable laws—can appear less conspicuous and is not always readily accepted. This is not because it is invalid, but because it challenges both existing aesthetic discourse and established systems of evaluation: the aesthetic habit of speaking only about style, and the technical habit of speaking only about indicators.

For precisely this reason, I believe it is necessary to establish a new system of academic and design evaluation. Current academic assessment often focuses excessively on the number of papers, journal rankings, or even publication in a small number of top journals. Yet for architectural and urban research, the more important questions should be: can the research and design truly be implemented? Do they genuinely improve spatial quality? Do they enhance people's everyday experience and well-being? To put it more directly, we should not be satisfied with writing papers only in journals; we should also write them on the earth.

At the level of design, a new evaluation system is equally needed. The felt dimension of Living Structure reminds us that what truly matters is not whether a space looks novel, but whether people are willing to stay there, whether it is comfortable, and whether it can withstand long-term experience. Its analytical dimension—structure—meanwhile, provides a way to explain

and calculate that experience: by using objective structural indicators to measure and compare the livingness of architectural and urban spaces, it offers a common basis for discussing and verifying design quality. This standard is universal in principle, but in application it must fully respect local differences. Different cultural traditions, climatic conditions, and material systems should all give rise to distinct formal expressions within the same logic of structure. In other words, what should be unified is not the outer form of architecture, but its underlying structural logic; what should be diverse is the specific expression of that logic across different regions, cultures, and environments.

In the interdisciplinary educational environment of HKUST (Guangzhou), how do you integrate the methodology of "Living Structure + AI" into teaching, particularly in programmes such as Urban Technology and Governance (UTGO), so as to cultivate the next generation of urban innovators with a mindset that combines technology and human-centred thinking?

At HKUST (Guangzhou), we do not merely teach "Living Structure + AI" as an abstract theory; rather, we treat it as a methodology that permeates the entire process of research, teaching, and student development, systematically embedding it into curriculum design, project practice, and scientific research. The experiential dimension emphasises people's intuitive sense of spatial wholeness and the everyday feeling of being more alive in a space, while the analytical dimension—structure—emphasises the structural laws that can be analysed, measured, and generated. Together, these two dimensions constitute the complete "Living Structure + AI" paradigm.

In interdisciplinary master's programmes such as Urban Technology and Governance (UTGO), we emphasise

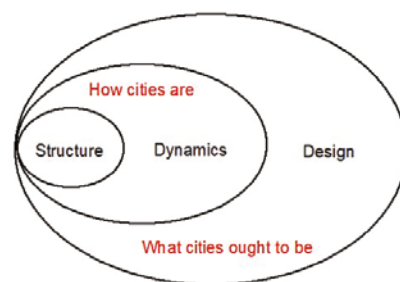


Figure 10. Three levels of urban cognition: from what the city is (structure and dynamics) to what the city ought to be (design).

starting from real-world urban problems, guiding students to address three progressively deeper questions: what is the city's spatial structure (Structure or morphology), how does the city evolve over time (Transformation), and how should the city become better (Ought to be liveable or more liveable). The first two questions rely more heavily on technology and models, while the third must return to people-centred value judgements and perceptual experience—that is, to the question of how people live, linger, and feel comfortable and content within the city; in short, whether the city itself feels more alive. “Living Structure + AI” provides precisely such a bridge: it uses computable structural indicators and generative mechanisms to approximate, explain, and help people more clearly sense when a space is more alive.

It should be noted that the vast majority of relevant master's programmes internationally—including those in urban science, planning, or architecture at some of the world's leading institutions—tend to focus on the first two questions; the third is often, intentionally or unintentionally, excluded from core teaching or relegated to practical fields such as design and planning, remaining relatively disconnected from serious research.

The uniqueness of the UTGO programme lies precisely in our explicit assertion that urban education must not stop at asking “what a city is” and “how a city functions,” but must directly address the question of “what a city ought to be”—a question that is, in fact, the most crucial one. Within our framework, these three questions are not arranged as a linear sequence but constitute a nested, holistic system: an understanding of urban form provides the foundation for understanding urban evolution and transformation; an understanding of the laws governing urban evolution must ultimately serve the assessment of the city's future direction. In other words, design, planning, and governance are not supplementary elements external to research, but a natural extension of the research logic.

In this process of integration, Living Structure—in both its felt and its analytical dimensions—serves as the crucial link that reconnects these three levels. Structure and its 15 attributes are not merely a theoretical framework for describing spatial geometric characteristics, but a language for understanding the laws governing urban evolution and transformation; meanwhile, the felt experience of being more alive reminds us that these structural principles must ultimately translate into a sense of comfort, pleasure, belonging, and meaning that people can genuinely experience. The development and renewal of cities is, at its core, a process that hinges on whether this logic of structural evolution is respected: which structures can continuously make the city feel more alive, and which will gradually weaken the connection between people and their environment. In this sense, the question of “what a city ought to be” can be fully addressed within the same structural framework—whether a city is more liveable, more resilient, and more sustainable, and whether it is better able to respond to people's emotions and everyday experiences. These judgements are not subjective notions divorced from structural and evolutionary laws, but are founded on a systematic understanding of the correspondence between the computable laws of structure and the perceptible outcomes of a space feeling more alive.

In practice, students engage directly in the assessment and enhancement of livingness across various campus spaces through coursework and their final dissertations. Drawing on the rich and complex real-world urban contexts of the Guangdong–Hong Kong–Macao Greater Bay Area and the Yangtze River Delta region, students typically spend six months to a year deeply engaged in practical projects, testing the methods they have learnt in real environments: they employ digital modelling and AI tools to analyse spatial structure, use living-structure indicators to evaluate and iterate proposals, and through repeated comparison and refinement come to understand that technology is not a means of showcasing complexity, but a tool for

determining whether a space is structurally more rational and, in terms of experience, closer to what people can perceive as more alive. The crux of this teaching process lies not in whether students possess a background in architecture or design, but in whether they have mastered the ability to integrate structured thinking with human-centred judgement.

I therefore hope that UTGO and its associated courses will cultivate not merely students with outstanding technical skills, but a new generation of urban innovators capable of establishing connections between AI, spatial structure, and human perception—individuals who understand both technology and people, and can make responsible judgements between the two.

You have long been following the transformation of the discipline of urban planning and design. In this shift from “building cities” to “governing cities,” and from “cold technology” to “warm wisdom,” why has AI technology emerged as a key driving force? In your view, what disruptive possibilities might the integration of living-structure theory and generative AI bring to architectural design and urban governance?

The reason AI has become a key driving force in this transformation lies, first and foremost, in the fact that it has transformed the way we understand and evaluate space. Within the “Living Structure + AI” framework, AI plays at least two fundamental and crucial roles. First, based on the attribute system of structure, it computes and evaluates the aesthetics and order of architectural and urban spaces. Second, through computer vision and data analysis, it automatically extracts substructures and hierarchical relationships within a space. These two capabilities mean that spatial judgements—which were previously highly dependent on

For thousands of years, Chinese building practices have not been founded on abstract models; rather, through long-term interaction with nature, climate, materials, and people, they have produced a spatial logic that places great emphasis on scale, hierarchy, and overall feeling.

experience and intuition, and primarily based on a holistic sense of a space being more alive—can, for the first time, be systematically analysed, compared, and accumulated. In other words, we are beginning to use the computable aspects of structure to approximate and explain what people perceive, at a right-brain level, as more alive.

More importantly, the potential of AI extends beyond evaluation. With the development of generative AI, it is gradually entering the realm of actual design. Currently, large language models can already comprehend the 15 attributes of structure at a linguistic level, yet this process remains largely a black box—we know it is functioning, but we struggle to clearly explain its internal mechanisms. What we anticipate for the future is the gradual transformation of this black box into a transparent system that is interpretable, controllable, and iterative: enabling AI not only to generate proposals but also to continuously refine existing spaces within the structural constraints of structure—through repeated evaluation, adjustment, and feedback, elevating a design from “acceptable” to “better” and then to “very good,” and ultimately producing, within human experience, a clearer and more stable sense of being more alive.

In this sense, what AI addresses is not the “0 to 1” innovation often emphasised in traditional design, but rather the “1 to 10” and “10 to 100” enhancement of quality. In reality, most cities and buildings do not emerge from nothing; rather, they consist largely of existing spaces that are not sufficiently beautiful or liveable. The combination of structure and generative

AI enables us, for the first time, to systematically address questions such as: How can we make an unattractive building more beautiful? How can we restore harmony to a space that is disconnected from its surroundings, allowing people to perceive it as more alive? How can we achieve continuous improvement in spatial quality through redesign and renovation, rather than demolition and reconstruction?

It is precisely in this process that the disruptive value of AI begins to emerge—it is no longer merely “cold technology” but becomes a form of “warm intelligence” that serves human perception, emotion, and quality of life. As AI moves from a black box toward transparency, and from form generation toward structural optimisation, it will not only reshape the methods of architectural design but profoundly transform the logic of urban governance: shifting from one-off construction to continuous adaptation, and from technology-driven to people-centred approaches—enabling the structural order of space to be seen, measured, and improved, and ultimately manifested more authentically in daily life as something that feels more alive.

In the long term, the closed-loop integration of the felt experience of being more alive (perceived holistic order) and structure (computable, generative structural laws), supported by generative AI, may not result in a single style or formal paradigm, but rather a new mechanism for urban evolution: allowing cities to be understood and cared for like living organisms, and to become increasingly liveable through a continuous process of generation, feedback, and regeneration.

Your experience working with the International Cartographic Association and on leading international journals has given you a broad international academic perspective. In your view, what unique Eastern perspectives can research into the structure of traditional Chinese architecture offer to the current fields of urban science and architectural aesthetics?

Judging by developments in international urban studies, current research focuses primarily on two issues: first, how to accurately describe and model cities, treating them as computable physical systems; and second, how to assess the mechanisms underlying urban evolution. However, a more fundamental question has long been overlooked: how to make cities genuinely better—particularly for people—so that they feel more comfortable, more approachable, and more inviting in everyday life; in other words, so that they are perceived as more alive.

It is precisely on the basis of this understanding that the Liveable City Laboratory has articulated a clear mission and vision: our mission is to drive people-centred urban regeneration and governance by integrating AI, geographical analysis, and the theory of structure (computable, modelable, and measurable); our vision is to shape urban environments that genuinely promote human well-being and development. In this process, we collaborate with students, communities, and practitioners, striving to translate research findings into actionable strategies, digital tools, and spatial interventions—using the computable aspects of structure to explain and help people more clearly perceive when a space is more alive—rather than remaining confined to abstract models.

Traditional Chinese architecture offers significant insights for this shift. For thousands of years, Chinese building

practices have not been founded on abstract models; rather, through long-term interaction with nature, climate, materials, and people, they have produced a spatial logic that places great emphasis on scale, hierarchy, and overall feeling. In other words, this architecture is first and foremost something genuinely experienced by people as more alive; at the same time, its stable and repeatable hierarchical orders provide extremely rich and authentic case studies for understanding and modelling the characteristics of structure on a rational level.

It must be emphasised that structure and its 15 attributes do not represent an Eastern or Western cultural stance, but a universal law of order—discovered and summarised by Christopher Alexander—that is present in both natural and human-built environments. The value of traditional Chinese architecture lies not merely in its cultural distinctiveness but in the fact that it systematically embodies this universal law through long-term practice: at the perceptual level it feels strongly more alive, while at the structural level it exhibits structure that can be identified and measured. Through the research pathway of “Living Structure + AI,” we are not only reinterpreting traditional Chinese architecture, but also providing an important supplement to international urban studies and architectural aesthetics—a new research-and-design paradigm that reconnects spatial analysis with genuine human experience.

This work represents a milestone. What are your next steps in this area of research? Are you considering combining the living-structure model with virtual reality (VR) or the metaverse to create future immersive spaces imbued with the essence of traditional Chinese wisdom?

This book is indeed a summary of our work to date, but it is only a beginning.

We are already planning a second volume, in which the research perspective will expand from traditional Chinese architecture to traditional architecture and urban spaces in diverse global cultural contexts. The aim is to verify the applicability and manifestations of Living Structure as a universal spatial principle within a broader context: both to validate the universal experience, across cultures, of spaces being perceived as more alive, and to examine the structure that can be modelled and calculated based on cross-scale structural laws.

In terms of technical approach, virtual reality (VR) will become a crucial tool. In the future, before actually constructing or renovating a space, we will be able to use immersive experiences to allow people to “step into” different design proposals, compare spatial perceptions before and after renovation, and simultaneously collect data on the human experience. These biometric data reflect human intuition, emotion, and physical response, offering a closer approximation of people’s direct sense of a space being more alive; they can also be used to verify whether the quantitative results of structure align with actual experience, thereby forming a closed loop of measurement, experience, and validation.

From a broader perspective, this research direction is also highly aligned with the overall transformation of China’s urban development. Ten years ago, at the Central Urban Work Conference, General Secretary Xi Jinping emphasised the need to avoid bizarre and eccentric architecture, stating that urban development should return to a human scale and to the unity of function and beauty; at the Central Urban Work Conference held in 2025, this direction was further clarified as a shift from large-scale construction to intelligent

governance, and from the mere pursuit of scale and speed to a systematic, scientific, intelligent, and people-centred model of urban development.

Against this backdrop, our focus is not on how to create novel and unconventional forms, but on how to ensure that cities and buildings remain consistently and sustainably people-friendly: enabling people to feel continuously comfortable, connected, and secure within them—in other words, allowing spaces to feel demonstrably more alive in everyday experience—and at the same time, through quantifiable, verifiable, and iterative methods, transforming this people-friendliness into operational living-structure rules and tools. True innovation does not lie in superficial novelty, but in whether it genuinely enhances the quality of human life. Stylistic variations such as wearing underwear as outerwear or socks as gloves do not constitute true innovation, nor do they foster a lasting and stable sense of space.

From a longer-term perspective, I also hope to drive a broader social transformation: ensuring that architecture is no longer the exclusive preserve of architects and that design no longer belongs solely to designers. Through the framework of Living Structure—which can be felt, understood, and engaged with—the general public can rely on their intuition to discern whether a space is “alive” and pleasing (an experiential judgement of how alive it feels), while also participating in discussions and renovations using relatively objective structural language and metrics (the application of structure). This will be a process of elevating the aesthetic literacy of the entire population.

Acknowledgement

The interview was originally conducted in Chinese by Wen Aiping and the transcript was subsequently published in *Beijing Planning Review*, Issue 1, 2026, pp. 198–206. ▴

"Geodesy is often invisible to society, yet it underpins modern positioning, navigation, mapping, Earth observation, and environmental monitoring."

— says Maj. Gen. (Dr.) B. Nagarajan. As India modernises its geodetic infrastructure and expands its geospatial capabilities, he explains why geodesy has become central to scientific research, national development and infrastructure resilience.



Maj. Gen. (Dr.) B. Nagarajan is one of India's foremost geodesists, with over four decades of experience spanning government service, research and academia. A Ph.D. in Geodesy and Surveying from The Ohio State University, USA, he has made seminal contributions to satellite geodesy, gravimetric geodesy, geodynamics and the modernization of India's geodetic infrastructure. During his tenure as Director of the Geodetic and Research Branch of the Survey of India, he led several landmark initiatives, including the redefinition of India's horizontal and vertical geodetic datums, development of a new geocentric coordinate system, modernization of the national tide gauge network for tsunami warning, and high-resolution geoid modelling. A recipient of the Indian Society of Geomatics' National Geomatics Award (Technology), he is currently a Visiting Professor at the National Centre for Geodesy, IIT Kanpur, where he continues to contribute to geodetic research and capacity building.

After spending several decades with the Survey of India and now serving in academia, how has your perspective on geodesy and its role in national development evolved?

Geodesy in India historically evolved through institutions such as the Survey of India, where the primary focus was national mapping, triangulation, datum establishment, and boundary definition. The classical Everest Datum and the Great Trigonometrical Survey formed the backbone of India's geospatial infrastructure for several decades.

Today, the discipline is gradually transitioning from purely operational surveying toward research-driven geodesy within universities and scientific institutions. Academic groups are now actively working on GNSS geodesy, crustal deformation, atmospheric sensing, sea-level studies, gravity field modeling, and satellite geodesy. This transition represents a shift from static mapping toward dynamic Earth system monitoring. Modern geodesy now integrates geophysics, remote sensing, atmospheric science, hydrology, and space science.

Institutions such as IIT Kanpur and the National Centre for Geodesy are helping bridge operational and scientific geodesy.

The emergence of continuous GNSS networks has further accelerated this transformation. Young researchers increasingly view geodesy not merely as surveying, but as a quantitative Earth observation science. This evolution is essential for India's future needs in infrastructure development, climate studies, and geohazard monitoring.

How would you assess the current status of geodesy in India, and how does it compare with developments in other parts of the world?

Globally, geodesy has rapidly advanced through space-based systems such as GNSS, DORIS, SLR, VLBI, InSAR, and GRACE. Countries in Europe, the United States, China, and Japan operate dense geodetic observing networks with real-time analysis capabilities. India has made significant progress through initiatives such as GNSS-CORS networks, NavIC development, and crustal deformation studies.

However, compared to leading global geodetic programs, India still faces limitations in network density, data integration, and long-term coordinated infrastructure. Many Indian geodetic datasets remain fragmented across institutions. Real-time geodetic products and national-scale geophysical integration are still under development. There is also limited visibility of geodesy within mainstream scientific and policy ecosystems. At the same time, India possesses major strategic advantages due to its tectonic setting, monsoon



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dynamics, equatorial ionosphere, and extensive coastline. These conditions provide globally important natural laboratories for geodetic research. With coordinated national programs, India can emerge as a major contributor to global Earth observation science.

Why is India's transition from the Everest Datum to a modern geocentric reference frame so important, and what are its practical implications?

The Everest Datum served India for many decades and was designed primarily for classical terrestrial surveying. It was locally optimized and not fully geocentric, making it incompatible with modern satellite positioning systems. The introduction of GNSS fundamentally changed positioning science by requiring Earth-centered global reference frames such as ITRF and IGS. India is therefore transitioning toward modern geocentric coordinate systems compatible with GPS, Galileo, GLONASS, BeiDou, and NavIC. This shift is essential for precise navigation, deformation monitoring, and satellite orbit determination.

Modern geodesy requires millimeter-level consistency across space and time. Horizontal and vertical datums adopted decades ago no longer satisfy present-day scientific and engineering requirements. Geocentric frames also allow integration of Indian observations with global geophysical datasets. The transition is not merely technical; it represents a conceptual change from static mapping to dynamic Earth monitoring. Institutions such as the National Centre for Geodesy play an important role in supporting this modernization effort.

Despite its importance, geodesy often remains behind the scenes. Why do you think it has not received the visibility it deserves in India's geospatial ecosystem?

Despite its strategic importance, geodesy often receives less visibility compared to fields such as remote sensing, artificial intelligence, or space exploration. Many decision-makers interact with geodetic products daily without recognizing the underlying science. Accurate positioning, navigation, mapping, infrastructure monitoring, and disaster assessment all depend on geodesy. India's rapid infrastructure growth makes high-precision geodetic frameworks increasingly important. However, geodesy remains underrepresented in university curricula and interdisciplinary programs. Funding and institutional visibility are also relatively limited compared to its national importance. Awareness is gradually improving through CORS initiatives, satellite missions, and GNSS applications. The increasing use of drones, autonomous systems, and precision agriculture is also expanding its relevance. National programs can further strengthen visibility by linking geodesy to societal applications and national development goals. A stronger geodetic ecosystem is essential for scientific sovereignty and future geospatial independence.

How have satellite technologies and other recent technological advances transformed the practice of geodesy in India?

Modern geodesy has been transformed by satellite and computational technologies. Continuous GNSS observations

now allow real-time monitoring of crustal motion and atmospheric variability. InSAR enables centimeter- to millimeter-scale surface deformation mapping over large regions. Satellite gravimetry missions such as GRACE provide insights into groundwater changes and mass redistribution. Cloud computing and high-performance processing have dramatically increased data handling capabilities. Geodesy today is increasingly multidisciplinary and data-intensive.

In India, technologies such as NavIC, dense CORS networks, and low-cost GNSS receivers are expanding observational capabilities. Modern software environments also enable automated processing pipelines and large-scale analysis. Integration between geodesy, GIS, atmospheric science, and geophysics is becoming increasingly routine. These technological transformations are redefining geodesy from a surveying discipline into an Earth system science.

Artificial intelligence and machine learning are reshaping many scientific disciplines. How do you see these technologies influencing the future of geodesy?

Artificial intelligence and machine learning are becoming increasingly important in geodesy. AI methods can help detect anomalies, classify signal quality, and identify subtle geophysical patterns within large datasets. In GNSS applications, machine learning can support multipath detection, TEC modeling, ambiguity quality assessment, and data gap handling. AI is also useful for deformation pattern recognition in GNSS and InSAR time series. Large national geodetic networks generate massive datasets that are difficult to analyze manually. Machine learning therefore provides powerful tools for automation and predictive modeling. However, geodesy remains strongly physics-based, so AI must complement—not replace—physical understanding.

In India, AI can help optimize CORS networks, improve atmospheric modeling, and enhance disaster monitoring

systems. There is also strong potential for integrating geodetic and environmental datasets for climate-related studies. The future likely lies in combining physical geodetic models with intelligent data-driven systems.

India has relatively few trained geodesists. How serious is this challenge, and what steps are needed to build the required human resources?

One of the major challenges in India is the limited number of formally trained geodesists.

Many universities do not offer dedicated geodesy programs or advanced satellite geodesy training. As a result, expertise is often concentrated within a few institutions and specialized research groups. Modern geodesy requires knowledge of mathematics, physics, satellite systems, computation, and Earth science simultaneously. This interdisciplinary nature makes training demanding but also highly valuable.

There is a growing need for experts in GNSS processing, reference frames, gravity modeling, and geodetic data science. The expansion of CORS networks and geospatial technologies will further increase this demand. Young researchers often enter geodesy indirectly through remote sensing, geophysics, or civil engineering backgrounds. Strengthening academic curricula and national training programs is therefore essential. Developing human resources may ultimately be more important than developing instrumentation alone.

What role do you see the National Centre for Geodesy playing in advancing geodetic research, education, and national geodetic infrastructure?

The National Centre for Geodesy has the potential to become a central platform for advancing modern geodesy in India.

Its role extends beyond data collection toward national coordination, standards, training, and scientific leadership. NCG can help unify fragmented geodetic efforts across institutions and agencies. It can support the development of consistent national reference frames and integrated observing systems. The Centre also plays an important role in promoting research in GNSS geodesy, gravity studies, crustal motion, and atmospheric applications.

Capacity building and student training are equally important responsibilities. NCG can act as a bridge between operational agencies, academia, and international geodetic organizations. It

Establishment of DORIS station

- IDS approved the establishment of a DORIS station at NCG, IIT Kanpur.
- Part of the Saptarshi Proposal submitted to DST, Government of India.
- Collaboration between IIT Kanpur, IGN (France), and CNES (France).
- CNES provides equipment, IIT Kanpur handles infrastructure (civil & electrical works).
- Operational since March 2026.



also provides an opportunity to strengthen India's contribution to global geodetic infrastructure. Long-term continuity and open scientific collaboration will be key to its success. To promote geodesy education and research in India, several Regional Centres for Geodesy (RCGs) have also been established at IIT Bombay, IIST Thiruvananthapuram, Anna University Chennai, MANIT Bhopal, MNNIT Prayagraj, and ISM Dhanbad under the broader framework of NCG supported by the Department of Science and Technology, Government of India.

Infrastructure Enhancement Plans



How important is international collaboration for India's geodetic programme, and what benefits does it bring?

Geodesy is fundamentally a global science because Earth systems do not follow national boundaries. Reference frames, satellite orbits, sea-level studies, and tectonic processes all require international coordination. Organizations such as the International GNSS Service (IGS) and the International Association of Geodesy (IAG) provide essential global frameworks. India benefits greatly from participation in these international scientific collaborations. Global data sharing improves reference frame accuracy and scientific reliability. International partnerships also provide access to advanced methodologies and training opportunities.

For India, collaborations are especially important in areas such as ionospheric science, crustal deformation, sea-level monitoring, and gravity studies. Joint projects help ensure compatibility between Indian and global geodetic products. They also increase the international visibility of Indian research. To strengthen participation in international geodetic missions, a Geodesy Village incorporating techniques such as VLBI, GNSS, DORIS, SLR, InSAR, quantum gravimetry, and time-frequency standards is being developed at IIT Kanpur.

Looking ahead, what is your vision for the future of geodesy in India over the next decade?

Over the next decade, India has the opportunity to build a fully integrated modern geodetic infrastructure. This includes dense multi-GNSS CORS networks, modern geocentric reference frames, gravity infrastructure, and real-time geodetic services. Integration of NavIC with global systems will strengthen national positioning capabilities. Geodesy will increasingly support climate monitoring, groundwater studies, disaster management, and smart infrastructure. AI-driven processing and automation will improve scalability and operational efficiency. Open-data policies and coordinated national frameworks

will be important for scientific growth. Training the next generation of geodesists must remain a central priority.

India can also become a global leader in low-latitude ionospheric and monsoon-related geodetic research. Closer integration between academia, government agencies, and industry will accelerate progress. The ultimate vision is for geodesy to become a core national scientific infrastructure supporting both science and society.

Finally, what message would you like to leave for policymakers, researchers, and young professionals about the future of geodesy in India?

Geodesy is often invisible to society, yet it underpins modern positioning, navigation, mapping, Earth observation, and environmental monitoring. India stands at an important stage where traditional surveying foundations are converging with advanced space-based geodesy. The combination of modern technology, scientific collaboration, and national institutional support creates a major opportunity for growth.

At the same time, challenges remain in awareness, training, infrastructure integration, and sustained long-term investment. The National Centre for Geodesy can play a transformative role in addressing these gaps. India's unique geographic and geophysical setting gives it exceptional scientific importance within global geodesy.

Future progress will depend not only on instruments and satellites, but also on developing strong scientific communities. Geodesy is increasingly becoming a key component of Earth system science and national infrastructure resilience. With coordinated vision and sustained effort, India can emerge as a major global contributor to modern geodesy. The coming decade may therefore represent a defining phase for geodesy in India. ▴

GNSS (SBAS) Constellation

Specific Monthly Analysis

Summary: August 2026

The analysis performed in this report is solely his work and own opinion.



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

This article continues the monthly performance analysis of the GNSS/SBAS constellation. Readers are encouraged to refer to previous issues for foundational discussions and earlier results. The focus for this month’s issue is the atomic time generation and GNSS synchronization. A sample data from BIPM learning platform is used to demonstrate how clock ensemble produces atomic time that can be the national laboratory time or the GNSS system time. It is solely for educational purposes.

masers and cesium standards—to realize their local timescale, **UTC(k)**, which is then compared and steered toward **Coordinated Universal Time (UTC)**. This ensemble approach ensures continuity and stability, as no single clock can provide perfect performance across all timescales. Applications of such timescales extend from **GNSS synchronization** and **telecommunications** to **metrology**, where nanosecond precision defines the accuracy of global systems. The ensemble average, computed through weighted clock data, forms the laboratory’s provisional timescale (**UTC(k)-TA**), which is later aligned with UTC through international comparisons coordinated by the **BIPM**.

1. Atomic timescale generation: A practical overview

The generation of a local atomic timescale, **Temps Atomique (TA)**, lies at the heart of modern timekeeping and navigation. Laboratories worldwide maintain ensembles of atomic clocks—hydrogen

2. Example Clock Ensemble

The initial plots of the raw clock data (Figure 1) illustrate the **phase evolution** of individual clocks relative to a chosen reference. Each curve represents a clock’s time difference over Modified Julian

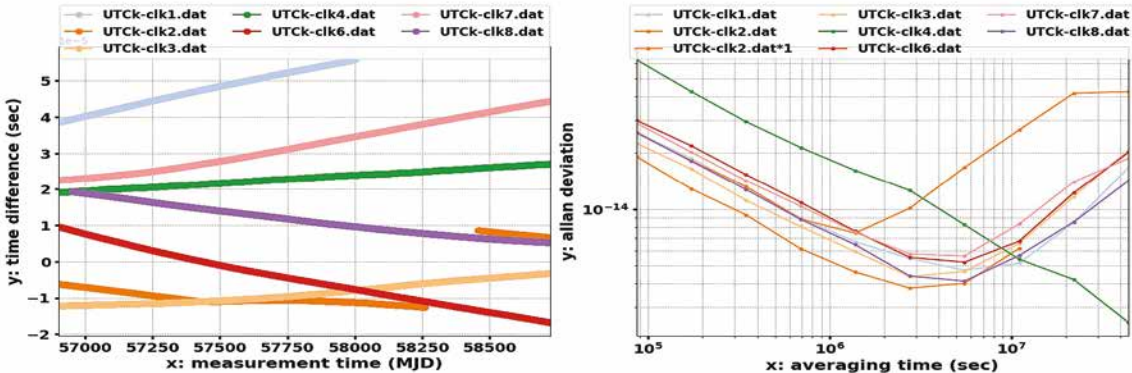


Figure 1: The phase evolution of the clocks in a representative ensemble (left). The stability analysis through allan deviation (right).

Date (MJD), revealing distinct frequency drifts—some clocks run slightly faster, others slower. The slopes of these lines correspond to frequency offsets, while their spread indicates the diversity of the ensemble. The accompanying **Allan deviation** plot characterizes each clock’s stability: maser-like clocks exhibit excellent short-term stability (low deviation at small averaging times), whereas cesium clocks dominate long-term stability (low deviation at large averaging times). In this ensemble, `clk3` and `clk8` behave as hydrogen masers with superior short-term precision, while `clk4` and `clk7` resemble cesium standards, offering long-term robustness. `clk2` shows a discontinuity and could impact the ensemble if not treated carefully. Together, these behaviors define the foundation for constructing a smooth, weighted atomic timescale.

3. Weighted TA Generation

Two ensemble averaging cases demonstrate the impact of weighting. In the first case, random weights were assigned, including high weight to a discontinuous clock (`clk2`), resulting in a **jump in the averaged timescale** (Figure 2)—a clear sign of instability. The averaged curve failed to remain continuous, showing how improper weighting can distort the ensemble output. In the second case (Figure 3), weights were redistributed to favor the most stable clocks: higher weight for `clk3` (maser-like short-term stability), moderate for `clk4` and `clk7` (cesium-like long-term stability), and minimal for noisy clocks. By assigning higher weight to `clk3` for short-term precision, emphasizing `clk4` for long-term robustness, and keeping moderate weights for `clk5` and `clk7`, the ensemble average achieves a balance that suppresses noise while maintaining continuity. The resulting **UTC(k)-TA** curve became smoother and more stable, lying below most individual Allan deviation traces. This demonstrates how careful weighting suppresses noise and drift, producing a continuous and reliable timescale. However, the

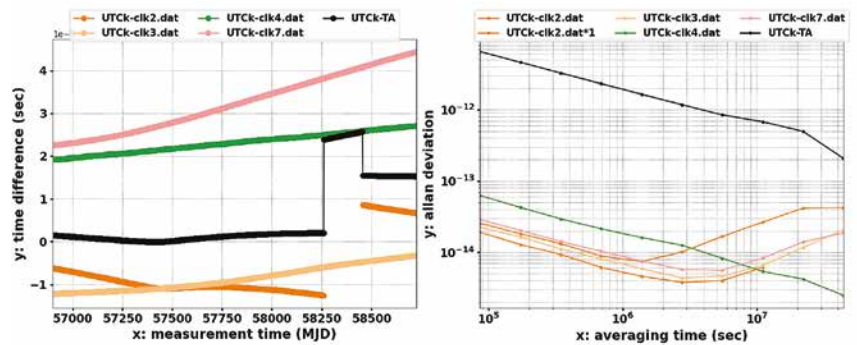


Figure 2: Generated TA from the clock ensemble where clock 2 is provided more weight (left). Black line is the generated TA which shows a jump due to outlier in clock 2. The stability analysis using allan deviation shows TA performs worse than other individual clock (right).

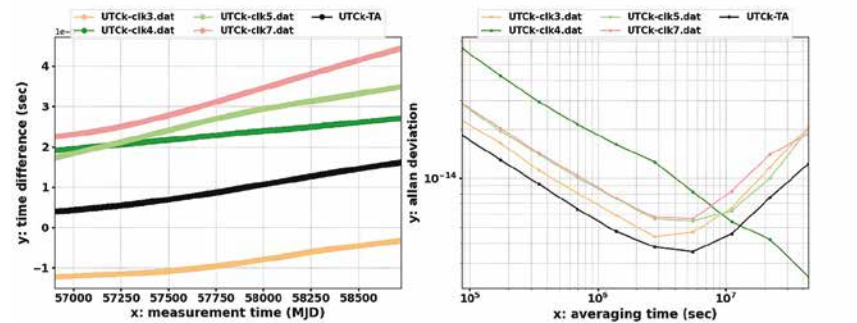


Figure 3: The second case of clock ensemble averaging where stable clocks are provided more weight. The allan deviation also shows the TA is more stable and outperforms other individual clocks in short-term and long-term (except clock 4 which is a bit better in longer-term stability).

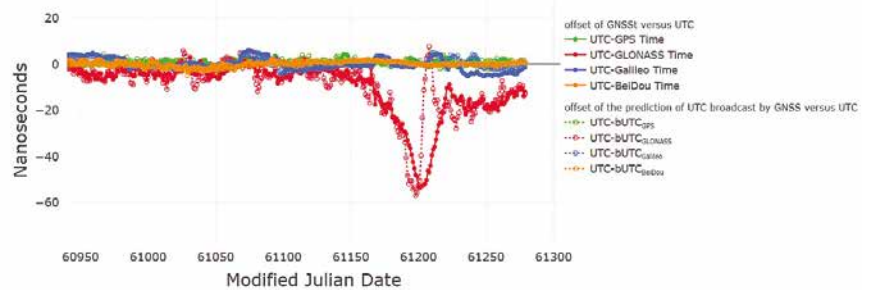


Figure 4: UTC-GNSS Time retrieved from BIPM webai (https://webtai.bipm.org/database/canvas_gnss.html).

process must remain dynamic—weights should adapt as clock performance evolves to prevent discontinuities when clocks join or leave the ensemble.

4. GNSS-UTC Offset and Synchronization

Each **GNSS constellation**—GPS, Galileo, BeiDou, and GLONASS—maintains its own internal system time using the same ensemble principle. The control segment averages multiple atomic clocks, applying

stability-based weights to generate **GPS Time (GPST)**, **Galileo System Time (GST)**, and **BeiDou Time (BDT)**. These system times are continuously **steered toward UTC** using frequency adjustments derived from for example **GNSS common-view comparisons**, monitoring links coordinated by national laboratories/ BIPM. The GNSS–UTC offset plot (Figure 3) shows these relationships: most systems remain within a few nanoseconds of UTC, confirming precise steering. The exception, GLONASS, exhibits a temporary excursion around MJD ≈

61200, likely due to a control-segment anomaly. The dotted curves represent the **broadcast UTC corrections (bUTC)** included in navigation messages, enabling receivers to convert system time to UTC in real time. Thus, the GNSS-UTC offsets are the operational link between constellation timescales and the global UTC framework—the same principle applied when steering a laboratory's UTC(k)-TA toward UTC.

Note that UTC-GNSS constellation specific offset analysis was provided as monthly graph in the mycoordinates up until January 2026. Viewers are encouraged to go through them and also check BIPM web interface for latest data.

5. Conclusion

The ensemble averaging process is fundamental to atomic timescale generation and a diverse set of clocks generate more robust and reliable time. But it is not without challenges. Weighted TA computation can become problematic when clocks exhibit discontinuities or when members of the ensemble are replaced, causing abrupt changes in the averaged output. Such events can introduce phase jumps or distortions that compromise continuity. To mitigate this, laboratories employ **prediction-based approaches**, where the timescale is extrapolated using past stability data and frequency trends rather than instantaneous averaging. This predictive steering ensures smoother transitions and resilience against clock changes. The next article will explore this **prediction method**, detailing how it enhances the robustness of UTC(k) generation and supports global synchronization across GNSS and metrology networks.

Data sources and Tools:

https://webtai.bipm.org/database/canvas_gnss.html

Allantools, Python

elearning, BIPM, Timescale Algorithms and their Applications

Software: https://github.com/TheBIPM/Time_scale_course_material

UAV Navigation enhances VNS01

UAV Navigation—Grupo Oesía has announced major software enhancements to its VNS01 Visual Navigation System, introducing advanced terrain referenced navigation (TRN) and satellite map matching algorithms to improve navigation accuracy during operations in GNSS-denied environments and over previously unflown routes. www.uavnavigation.com

A2Z Drone Delivery launches Longtail Dual

A2Z Drone Delivery has launched its latest multi-mission commercial drone, the A2Z Longtail Dual.

The aircraft's added battery redundancy combines with integrated smart battery features to improve fault tolerance for rapidly expanding long-range beyond-visual-line-of-sight operations. The dual-battery design also expedites charging when the aircraft is perched on the company's drone docks. www.a2zdronedelivery.com

RIEGL launches miniVUX-4UAV lidar sensor

RIEGL has introduced the miniVUX-4UAV, a lightweight lidar scanner for UAV-based mapping and surveying, debuting at Intergeo 2026 in Munich, Germany.

The sensor offers selectable laser pulse repetition rates of 100, 200, 300 and 400 kHz. Within a 120-degree field of view, it captures up to 133,333 measurements per second at scan speeds of up to 150 scans per second. Overall specifications include a 360-degree field of view and up to 200,000 measurements per second.

A more tightly focused laser beam — with a footprint measuring 125 mm by 50 mm at 100 m — delivers spatial resolution with 12 mm accuracy and 8 mm precision, according to the company. The miniVUX-4UAV incorporates RIEGL's echo signal digitization and online waveform processing.

Drone-testing centre to come up in Chintamani

Chintamani in Karnataka state, India is set to get a dedicated drone-testing centre, with the state govt approving a Rs 42.8-crore project at Jeedarahalli aimed at building infrastructure for testing and developing unmanned aerial systems. The centre will come up on 19.3 acres of govt land and is expected to provide testing and validation facilities for drone manufacturers, startups, research institutions and other industry stakeholders. Drone Federation India has been identified as the implementation partner.

The facility will have dedicated testing areas, segregated airspace and a runway measuring about 1,000 metres in length and 23 metres in width. It is also expected to have a control centre, laboratories, repair and testing facilities, warehousing and training infrastructure. The centre will enable testing of drones for flight performance, endurance and safety, besides advanced operations such as beyond-visual-line-of-sight (BVLOS) flights, subject to regulatory approvals. The project is also intended to support training, research and development and the commercialisation of drone technologies. <https://timesofindia.indiatimes.com>

Terminal-to-mainland cargo drone mission over Singapore's waters

Last month ADLC flew the complete terminal-to-mainland cargo drone mission over Singapore's waters, connecting the Maritime Drone Estate with a marine terminal on Pulau Sebarok. It's the first time a permitted operator has flown this profile in one of the world's busiest and most tightly regulated ports.

ADLC holds the only CAAS permit in Singapore (and Asia) covering both BVLOS operations and dangerous goods transport. The demonstration shows how petroleum cargo samples, which today travel by launch boat and van, could instead move by. <https://adlc.eu>

ISRO launches GSLV-F17 carrying EOS-05

Indian Space Research Organisation (ISRO) recently launched the GSLV-F17 rocket successfully carrying the EOS-05 Earth observation satellite.

The GSLV-F17 lifted off from the Satish Dhawan Space Centre in Sriharikota, Andhra Pradesh, at 2:55 am IST on September 4 in a pre-dawn launch and subsequently placed EOS-05 into its designated sub-geosynchronous transfer orbit.

Mission Director Thomas Kurian described the launch as a significant milestone for the GSLV programme. He said it was the 19th flight of the GSLV and carried a specially configured Earth observation satellite capable of providing near-real-time imaging. He said EOS-05 was the heaviest satellite placed by the GSLV into a geosynchronous transfer orbit, or sub-GTO, and credited the success to years of preparation and the efforts of scientists, engineers and other teams involved in the mission. The satellite is expected to provide a continuous view of the country from an altitude of nearly 36,000 km, supporting advanced imaging and observation applications.

Space42 launches Future Spacers Programme

Space42 based in UAE, has launched the Future Spacers Programme to strengthen the country's space talent pipeline. The programme aims to support the UAE's knowledge economy by encouraging young people to pursue careers in STEM, artificial intelligence, data management and emerging technologies. Emirati students will gain up to 16 weeks of experience at Space42 facilities.

The inaugural cohort includes students from Khalifa University of Science and Technology, Mohamed bin Zayed University of Artificial Intelligence (MBZUAI) and Zayed University, along

with students from schools identified by the Abu Dhabi Department of Education and Knowledge (ADEK). satelliteprome.com

China completes two space launch missions in one day

China recently carried out two successful space launches within hours of each other, sending a new batch of low-orbit internet satellites and a pioneering pair of commercial interferometric synthetic aperture radar (InSAR) remote-sensing satellites into preset orbits.

The first launch took place at 8:32 am at the Hainan commercial spacecraft launch site, where a Long March 12 carrier rocket lifted off and accurately sent the 25th group of low-orbit internet satellites into scheduled orbit. Hours later, at 10:40 am, a Kuaizhou-11 Y3 solid carrier rocket blasted off from the Jiuquan Satellite Launch Center in Northwest China, successfully sending two satellites into preset orbit. www.globaltimes.cn

EU and Korea deepen cooperation

The European Commission and the Republic of Korea have agreed to strengthen cooperation on secure satellite connectivity and explore future integration with IRIS2, the EU's secure connectivity constellation. For the Republic of Korea, this could open access to the programme's architecture, while the EU space industry could draw on Korean industrial expertise.

The agreement sets up a working group to exchange information on existing and forthcoming secure connectivity programmes, explore joint applications and use cases, and assess technical solutions for cooperation at system level with IRIS2. The working group brings together the Commission, the European Space Agency, and the Republic of Korea's Defense

Acquisition Program Administration and Agency for Defense Development, alongside representatives from other agencies and national authorities. The first phase of IRIS2 is scheduled for launch by the end of 2029. In August 2026, the conclusion of negotiations on the programme's governance, technical set-up and financing confirmed the system architecture and shortlisted the main suppliers for the programme. eu-space.europa.eu

China releases first nationwide geometric benchmark imagery

China's Ministry of Natural Resources has released its first complete set of geometric benchmark imagery covering the entire mainland territory, providing a unified high-precision reference for satellite remote sensing data, reported by CCTV News. The imagery, with a resolution better than 0.5 meters, serves as a national "spatial scale" that allows images from different satellites to be accurately aligned and calibrated. Officials said the development resolves long-standing inconsistencies that have hindered the growing commercial remote-sensing sector.

At the ministry's Land Satellite Remote Sensing Application Center, staff demonstrated the difference with side-by-side comparisons. Without the benchmark, images of the same area captured by different satellites often failed to match: roads appeared discontinuous or shifted, and features did not align. After calibration using the new benchmark imagery, building footprints, road lengths and directions became consistent and precise. The release comes as China's commercial remote-sensing satellite constellation expands rapidly. Inconsistent geometric references had constrained industry growth by complicating data fusion and raising production costs. The new benchmark acts as a base map that can be used to correct raw satellite data, ensuring precise registration across sources. www.globaltimes.cn/page/202608/1369422. 

Galileo HAS ready to increase efficiency of farming tasks

In a collaboration between the European GNSS Service Centre (GSC) of EUSPA, Hemisphere GNSS and Case New Holland, experts from all entities tested the Galileo HAS service to assess its suitability for precision agriculture applications. The working width used for the test was 2.55 m, while the test area covered approximately 20,000 m² with a perimeter of about 740 meters. During the 3-hour test, the teams collected GNSS data to later analyse the pass-to-pass and absolute accuracy metrics. Pass-to-pass accuracy is the relative precision of a guidance system to maintain a consistent distance between adjacent, parallel machine passes within a short timeframe (usually 15 minutes). It is crucial for reducing gaps and overlaps during planting, spraying, and harvesting.

Test campaign

The test campaign aimed at proving that the tractor consistently maintained the specified path accuracy during consecutive passes. This would show that HAS can optimise agricultural operations by reducing costs associated with overlaps (reworking the same area), leading to savings such as reduced fuel consumption, minimal input waste and improved crop yield.

For the test setup, in addition to the onboard guidance system, an independent antenna was mounted on the tractor cab. This antenna was connected to two positioning solutions: one based on the Galileo HAS and another based on an RTK solution.

An RTK base station deployed for the occasion provided the rover with precise RTK corrections and enabled generating a “reference path” against which to compare the tested Galileo HAS, in this case based on corrections obtained directly from the Signal in Space (SIS) via the Galileo E6 band.

The driving was performed in automatic mode, with manual intervention required only for turning at the end of each pass. The autosteering system of the tractor would then automatically reconnect with the following path, as calculated at start-up.

Test results

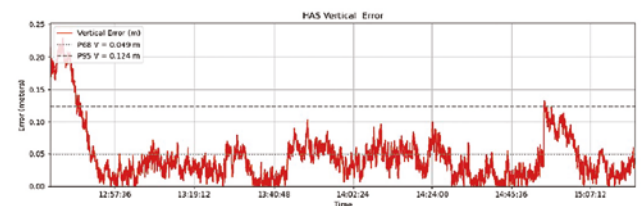
The test began with the GNSS receiver in Cold Start mode, requiring it to obtain ephemerides and process satellite

data before achieving precise positioning. The convergence time was calculated and is shown as the red area in the image below. The green area shows when the tractor started along the predefined paths and hence when the data was used for the pass-to-pass accuracy calculation.

The data analysis showed that the Galileo HAS system consistently maintained horizontal errors of 3-6 cm.

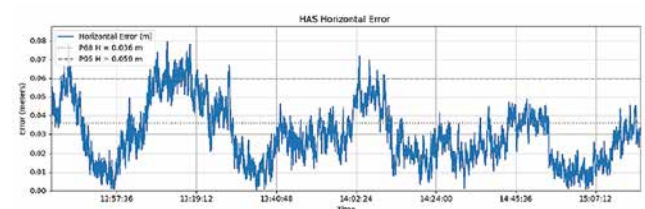
With a 95% horizontal error of 5.9 cm and its maximum value below 8 cm, the error remains well below the 20 cm HAS accuracy target.

As regards the vertical axis, the 95% vertical error was 12.4 cm, with its maximum value below 25 cm, (remaining well below the 40 cm HAS accuracy target).



Galileo HAS signal vertical error

The horizontal error of the HAS service relative to the RTK reference baseline is shown in the following figure.



Galileo HAS signal horizontal error

Regarding the pass-to-pass accuracy, the analysis shows an overall pass-to-pass accuracy of 1.18 cm, demonstrating highly stable performance throughout the test period.

Year-to-Year accuracy was not part of this testing campaign but will be analysed in the next testing campaign.

The Galileo HAS service is an open, standardized correction service distributed directly via Galileo E6 or the internet (with global coverage) and the test campaign results confirm its potential to generate savings to farmers in terms of fuel consumption, fertilizers, seeds, and other inputs, by reducing overlap in field operations. www.euspa.europa.eu



Converge time and data set during the test

Singapore launches digital twin playbook

The Infocomm Media Development Authority (IMDA) Singapore has launched the nation's first Digital Twin for Enterprises Playbook, targeting the persistent challenge many organisations face: converting vast data streams into tangible value for their operations and growth.

The new playbook is intended as a step-by-step guide, walking business leaders through the process of identifying relevant digital twin use cases, evaluating data readiness, establishing robust governance frameworks, and executing projects with lasting business impact. The guide responds to a common pain point: while data collection is widespread, the leap from analysis to action remains elusive for many enterprises.

At the heart of the playbook is a clear explanation of what digital twins are and how they can be leveraged by businesses. Digital twins are virtual replicas of physical assets, systems, or processes, allowing teams to simulate real-world operations in a digital environment. The playbook distinguishes between asset, system, and process twins, and highlights two key uses: design and prototyping, as well as operational optimisation. For design purposes, digital twins enable companies to simulate and refine ideas before committing significant resources to physical builds. For process optimisation, these technologies can reveal inefficiencies and support continuous improvement.

The playbook also includes a framework to help organisations assess whether digital twin solutions align with their operational needs, business objectives, and current data maturity. This self-assessment is aimed at ensuring that investments in digital twins are both practical and impactful. A significant portion of the IMDA's guide is dedicated to demystifying the technical foundation of digital twin deployments. It outlines the critical hardware required, such as

sensors and Internet of Things (IoT) devices, which collect real-time data from physical assets. The middleware layer, including application programming interfaces (APIs), is explained as the glue that connects hardware to advanced analytics and visualisation software. On the software side, the guide covers platforms for analytics, artificial intelligence, and visualisation, illustrating how these components come together to create a functional digital twin.

NASA tests FALCON technology

NASA's Starling mission has marked another milestone in spacecraft autonomy by using a new system that determines a satellite's position in orbit by referencing other objects in space, instead of relying on a navigational network.

The FALCON (Fast Autonomous Lost-in-space Catalog-based Optical Navigation) technology demonstration is a step toward spacecraft being able to operate more independently. As NASA prepares for more missions beyond Earth's orbit, technologies like FALCON can support lunar satellite swarms, distributed science missions, and human exploration.

Traditional satellite navigation depends on GPS signals, but those can be unreliable or unavailable in lunar or deep space environments. The FALCON payload is a joint flight experiment by NASA and EraDrive, a startup spun out from Stanford University. It combines EraDrive's Era-Core flight software and embedded algorithms with Starling's cameras and an onboard catalog of known satellites to support GPS-independent navigation and space situational awareness.

The FALCON demonstration tested two complementary capabilities that made creative use of Starling's onboard star-tracker cameras, standard instruments that identify bright objects in space to inform a spacecraft's orientation and position. In position, navigation, and timing experiments, it matched objects that the spacecraft's cameras observed

– including other spacecraft and orbital debris – to a catalog of known space objects maintained and made publicly available by the U.S. Department of War. FALCON then used the observed and verified objects as reference points to determine Starling's orbit.

In separate experiments, FALCON successfully refined the orbit estimates of the space objects observed by Starling's cameras. The mission team loaded the full catalog of approximately 20,000 space objects and their predicted orbits onto the spacecraft. FALCON then correlated that data with the observations of other space objects made by the spacecraft's cameras to estimate Starling's location – and the locations of other space objects – with even greater precision than the current catalog data. During a three-day period, FALCON improved the known orbits of more than 200 objects without intervention from operators on the ground.

The self-orbit determination capability made possible through FALCON is a first for spacecraft using optical cameras to navigate by their relative position to other objects in space. Separately, the catalog-update experiments produced better object position predictions onboard Starling than those provided by ground stations.

Coordinated networks of multiple GPS-free satellites will be critical to support surface operations for future human exploration of the Moon or Mars. For science missions, knowing the precise location of each spacecraft is necessary for aligning measurements taken from multiple points in space. And for space traffic management, autonomous navigation and catalog updates can reduce reliance on ground networks and enhance collision avoidance.

The FALCON experiment highlights NASA's role in fostering commercial innovation. What began as a University SmallSat Technology Partnerships project evolved into a startup, EraDrive, that is now commercializing its Era-Core software and related hardware for broader applications. www.nasa.gov 

Cohda's C-V2X platform now fully certified in US

Cohda Wireless's MK6 On-Board Unit (OBU) has been certified by the OmniAir Consortium, the U.S. industry association promoting interoperability and certification for intelligent transportation systems, tolling and connected vehicles. This follows the MK6 RSU's OmniAir certification in July 2024, the first LTE-V2X (PC5) device certified for deployment in the United States by OmniAir. cohdawireless.com

Q-CTRL achieves quantum gravimetric navigation demonstration

Q-CTRL has successfully navigated a maritime vessel without GPS using a new form of software-ruggedized quantum gravimeter. Through a series of trials in the Coral Sea off the East Coast of Australia, it performed autonomous gravity mapping and GPS-free quantum-gravimetric navigation, achieving the key metric of one nautical mile positioning accuracy. This demonstration comes as the race intensifies to develop secure capabilities for missions where GPS is unavailable or compromised. q-ctrl.com

Rx Networks expands TruePoint. CM network RTK service

Rx Networks has launched TruePoint. CM, its network real-time kinematic correction service, in North America and Latin America, targeting professional users who need centimeter-level GNSS positioning at scale. The service is also available in Europe, Brazil, Australia and New Zealand, with additional regions planned. rxnetworks.us

Trimble acquires Terasat Japan

Trimble has acquired Terasat Japan, one of the largest virtual reference station (VRS) network operators in the country.

Terasat Japan delivers GNSS corrections using data from the Geospatial Information Authority of Japan (GSI) Continuously Operating Reference

Stations (CORS) network, which spans more than 1,300 stations across the Japanese archipelago. www.trimble.com

Bourns introduces LTCC diplexer

Bourns recently announced the Model FDP2009N122157H4, its LTCC diplexer designed for RF front-end integration in GNSS L-band applications where signal isolation, low insertion loss, and compact layout are required. The device integrates distributed inductive and capacitive elements within a monolithic ceramic structure, reducing interconnect parasitics and maintaining consistent RF performance across dual frequency bands.

GNSS receiver architectures require separation and recombination of multiple L-band signals while preserving signal integrity under low-power operating conditions. Discrete filter implementations introduce layout sensitivity and parasitic effects that can degrade isolation and increase insertion loss, particularly in compact designs. As PCB density increases, routing complexity and component count also increase, adding variability across manufacturing and operating environments. Integrating filtering structures into a single component reduces these dependencies and improves repeatability across operating temperature and frequency ranges. The LTCC approach addresses these constraints by embedding the filtering network into a stable dielectric structure with controlled electrical characteristics. bourns.com

Microchip advances space-grade timing

Microchip Technology has expanded its atomic clock portfolio with the radiation-tolerant Space CSAC-SA65, a Chip Scale Atomic Clock designed to deliver precise timing for space systems. The device provides a compact, low-power alternative to traditional radiation-hardened timing solutions, helping developers reduce size, weight, power and cost while maintaining accuracy. Building on the heritage of Microchip's Space CSAC-SA45, the Space CSAC-SA65 extends radiation

tolerance to at least 30 kRad and operates in extended temperature ranges from -40°C to +80°C. www.microchip.com

NorthStandard partners with PntGuard™

NorthStandard has entered a partnership with SGM Technology to offer its members the innovative PntGuard™ platform for authenticating ship position signals in real time on preferential terms, to help them overcome incidents of GNSS jamming and spoofing.

The agreement entitles NorthStandard Members to access PntGuard at a 15% discount, in line with the global marine insurer's commitment to offer groundbreaking Loss Prevention solutions that address emerging operational challenges. north-standard.com

EagleNXT launches new flagship sensor Altum-PT Pro

AgEagle Aerial Systems Inc. has unveiled the Altum-PT Pro, a new flagship sensor in its MicaSense portfolio. It provides research-grade inputs by capturing synchronized multispectral, panchromatic, and high-resolution radiometric thermal data in a single payload. The Altum-PT Pro introduces the FLIR Boson 640R radiometric thermal sensor along with supporting firmware updates and internal hardware adjustments, while retaining the core multispectral and panchromatic capabilities. EagleNXT.com

US Navy next-gen jammer program

Marotta Controls has been awarded two contracts in support of the Next Generation Jammer – Low Band (NGJ-LB) Engineering and Manufacturing Development program for the U.S. Navy.

The company will provide technical expertise for a ram air turbine power-generation system under a subcontract with CFD Research Corporation, with a direct award from L3Harris Technologies, the NGJ-LB prime contractor. marotta.com

Sparc AI launches Overwatch Patrol for foot soldiers

Sparc AI has launched Overwatch Patrol, a dismounted positioning application that delivers continuous location to soldiers and security personnel in environments where GPS is jammed, spoofed, degraded or simply unavailable.

The solution was initially designed for navigation for military grade phones. The new version now sits on the Overwatch Positioning Network, Sparc AI's cloud-based positioning service, and can be delivered to any mobile device. sparcai.co

Mapbox introduces location infrastructure for AI

Mapbox has introduced a new set of services and capabilities designed to give AI applications, agents and developer tools a more accurate understanding of the physical world. AI struggles to understand location and often fails to provide useful location information, producing generic recommendations that ignore real surroundings and intent. Mapbox closes the location gap by giving applications, agents, and developers access to current, precise location infrastructure built on an agentic mapping engine. www.mapbox.com

Leica Geosystems launches X-PAD portfolio

Leica Geosystems has introduced the Leica X-PAD portfolio, which combines field software, surveying instruments and connected services for routine surveying applications.

The portfolio is built around X-PAD workflows previously used by GeoMax customers and is designed to support a range of everyday field surveying tasks.

Topcon and Proceq collaboration

Topcon Positioning Systems and Proceq are collaborating to integrate Proceq's ground-penetrating radar (GPR) systems with Topcon's GNSS solutions and mass-data workflow

software for infrastructure and construction applications across Europe, the Middle East and Africa (EMEA).

Trimble introduces ST30 smart target

The Trimble ST30 smart target is a new-generation surveying system that integrates optical and subscription-based GNSS functionality into a single smart target solution. It introduces key innovations, including tilt compensation and automatic rod height measurements. It also offers fully integrated, high-accuracy GNSS functionality, giving surveyors a dual-use tool for both optical and GNSS applications. www.trimble.com

Calian adds three GNSS antenna models

Calian has expanded its precision positioning PNT antenna lineup with three new products - the Accutenna 4 pole mount antenna (AC4990PXF), the CR8894PXF+ controlled reception pattern antenna (CRPA) and the AJ979XF+-MAR full-band anti-jamming antenna. www.calian.com

DriftLoc navigation algorithm released

Aeron Systems has launched DriftLoc, a navigation algorithm designed to deliver reliable inertial positioning for extended periods without access to GNSS. It uses real-time algorithms to estimate and continuously correct changing sensor errors. Designed to run on an inertial measurement unit (IMU) and modest embedded processor, the technology combines a physics-driven kinematic model with Bayesian estimation and statistical signal processing. www.aeronsystems.com

TrustPoint + EnduroSat US to build 40 sats for PNT constellation

TrustPoint, a builder of a C-band satellite navigation system in low-Earth orbit, has already launched and operated free-flying satellites carrying its C-band GNSS payload. The satellites will be

delivered in three tranches, moving TrustPoint from demonstrated on-orbit flight heritage to constellation-scale deployment. SpaceWERX is the innovation arm of the U.S. Space Force and a division within AFWERX. EnduroSat gives TrustPoint the speed and scale it needs to deliver the next 40 satellites quickly. www.trustpointgps.com

Mirai Aerospace signs MoU with GreenValley

Mirai Aerospace Systems and Software Solutions has signed an MoU with the US-based GreenValley International Inc to strengthen India's geospatial and LiDAR (light detection and ranging) remote sensing manufacturing base. The initial pact covers local assembly, manufacturing, technical support and the development of AI-driven LiDAR applications. www.ptinews.com

Dubai Municipality deploys smart robot for geospatial surveys

Dubai Municipality has deployed a smart robot to carry out geospatial surveys, using LiDAR technology and smart cameras to collect accurate location data with limited human intervention.

The system can continuously gather field information, including precise coordinates, panoramic images, video and three-dimensional data. The information is used to keep Dubai's spatial databases up to date and support infrastructure projects, asset management, urban planning and government decision-making. The technology is also designed to make surveying safer and more efficient. gulfnews.com

Matrix Geo Solutions Wins 3 year contract from Adani Infra

Matrix Geo Solutions Limited has secured a three-year Annual Rate Contract (ARC) from Adani Infra for geospatial, LiDAR, drone surveying, mapping, and allied technology-enabled services. The agreement provides a framework to undertake

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ICL-GNSS 2026,

6 - 8 October

Rome, Italy

<https://events.tuni.fi>

3rd Annual International Geotechnical Innovation Conference

12 - 13 October

Jeddah, Saudi Arabia

<https://geotechnicalinnovationconference.com>

47th Asian Conference on Remote Sensing

12 - 16 October 2026

New Delhi, India

<https://acrs2026.in>

GoGeomatics Expo 2026

26 - 28 October

Calgary, Alberta, Canada

<https://gogeomaticsexpo.com>

ICRS-GISA-26

30 - 31 October

Barcelona, Spain

<https://iser.org.in>

November 2026

Trimble Dimensions User Conference

9 - 11, November 2026

Las Vegas, USA

www.trimble.com

United Nations World Geospatial Information Congress (3rd UNWGIC)

16 - 19 November

Jeddah, Saudi Arabia

<https://ggim.un.org/3UNWGIC>

Geoworld

23 - 26 November

Dubai, UAE

<https://www.geoworldevent.com>

Pacific Islands GIS & Remote Sensing User Conference

30 November - 4 December 2026

Suva, Fiji

<https://pgrsc.org>

December 2026

IEEE India Geoscience & Remote Sensing Symposium

01 - 04 December 2026, Hyderabad, India

<https://ingarss2026.co.in>

ICESSG 2026

24 - 25, December

Barcelona, Spain

<https://waset.org>

February 2027

Geo Week 2027

23 - 25 February

Salt Lake City, UT, USA

www.geo-week.com

assignments for Adani Infra during the contract period against specific project requirements and work orders.

It also creates scope for the company to support geospatial requirements across projects and business verticals.

Net Insight announces Zyntai TimeNode access

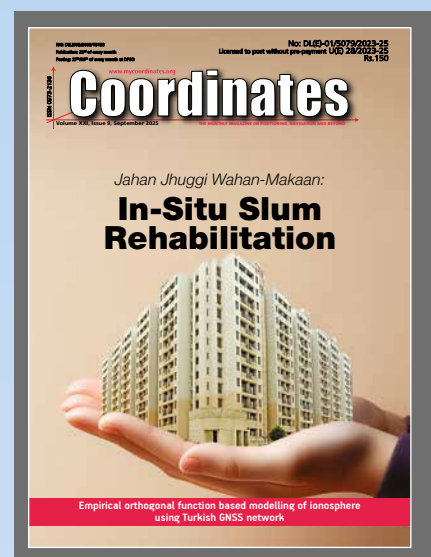
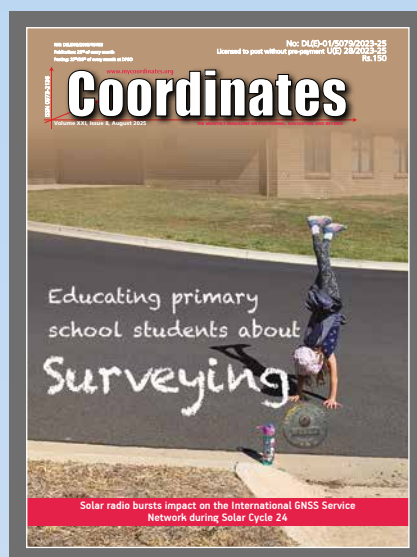
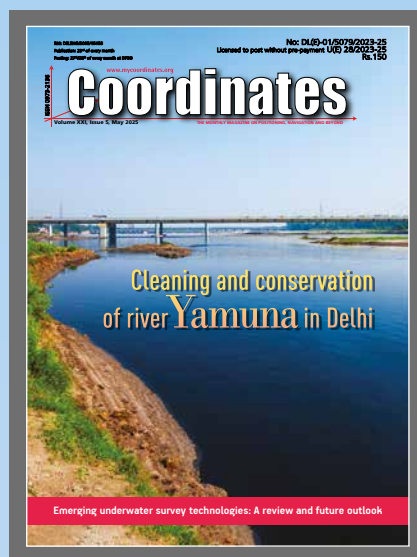
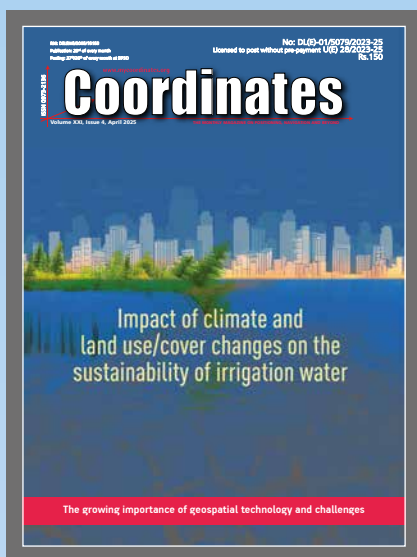
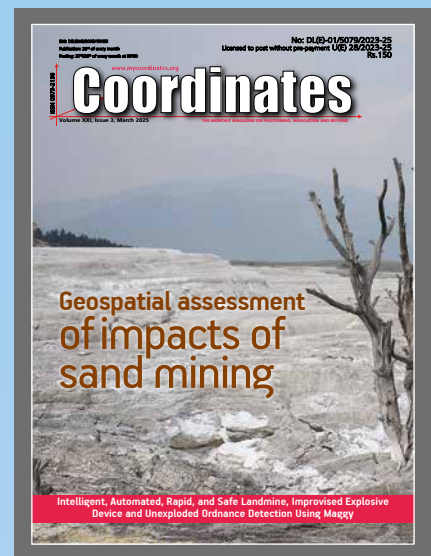
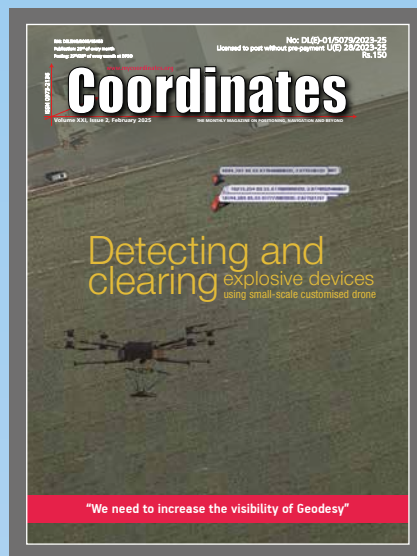
Net Insight has announced Zyntai TimeNode Access, a compact, access-optimized PTP Grandmaster designed to bring resilient timing to distributed edge sites over existing packet infrastructure. Built for 5G, media, power and other mission-critical networks, it combines local GNSS with secure, network-delivered timing without requiring the underlying access network to be PTP-aware. netinsight.net

Genesys International bags World Bank-funded contract

Genesys International has secured a ₹ 283 crore World Bank-funded contract to develop a comprehensive 3D digital twin and spatial intelligence platform for Ahmedabad city in India.

The project will create a unified digital foundation for urban planning, infrastructure management and civic service delivery across approximately 625 sq km of Ahmedabad. It will digitally map land parcels, properties, roads, water networks, sewerage systems, stormwater drainage infrastructure and other critical civic assets. As part of the initiative, around 25 lakh properties will be surveyed, geocoded and assigned unique digital identities. This will create a property-level spatial database for the city and provide a common digital platform for managing information related to land and civic infrastructure.

An elevation model will be developed using orthophotography, with support from the establishment of 40 primary and 200 secondary survey control points to improve the accuracy and consistency of the city's geospatial database. ▽



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