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# Coordinates

Volume XXII, Issue 05, May 2026

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND



Technology advances in

# healthcare

and public health management

Permanent survey marks in New South Wales, Australia



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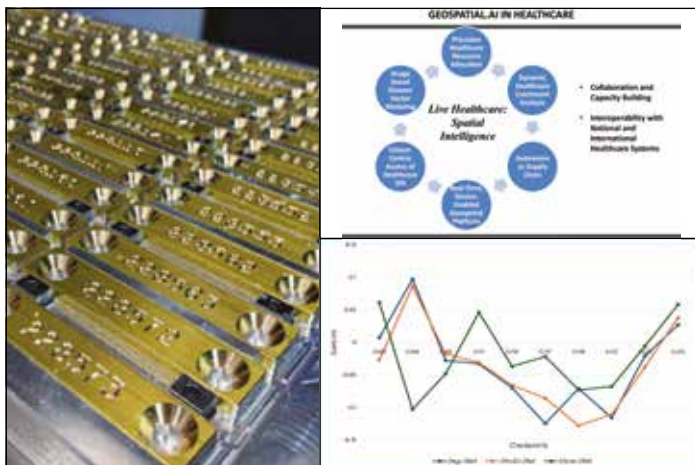
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An expanding Ebola outbreak in parts of Africa,  
And recent hantavirus cases linked to global travel,  
Underline how rapidly health risks can cross borders.  
Different viruses, different transmission patterns, but a common warning.  
Public health systems remain reactive while outbreaks grow increasingly interconnected.  
Ebola continues to test surveillance and fragile healthcare systems.  
The hantavirus incident, meanwhile, highlights how  
mobility networks can accelerate uncertainty.  
Cruise ships, airports, migration corridors, and dense urban  
hubs now compress geography for pathogens.  
Remote sensing, mobility analytics, and navigation-linked data,  
Can help model spread patterns, identify vulnerable zones, support contact tracing.  
Disease surveillance is no longer only medical,  
It is spatial, digital, and predictive.  
Public health security will depend on medical response,  
As well as on data intelligence.

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# Technology advances in healthcare and public health management

As we architect the next generation of Research Projects and National Health Data Stacks, our conclusion must be rooted in a “Phy-gital” reality where technology does not replace the Physician or experience, but empowers them with planetary-scale health insight intelligence.



**Dr. Mukund Kadursrinivas Rao**

Is an internationally recognized leader in space and geospatial technologies, with deep multidisciplinary expertise spanning technology, applications and policies in Earth Observation (EO) and Geographic Information Systems (GIS). With over four decades of experience across government, industry, academia, and consultancy, he has played a pivotal role in advancing the geospatial and space sectors. Having provided leadership to many national and international fora, his work effectively bridges scientific innovation, policy formulation and strategy development. He has voiced and articulated many forward thoughts, particularly in the real-world deployment of geospatial technologies to support societal development, informed governance and knowledge systems.

**D**isease has been a subject of fear and challenge in equal measures for humanity. Over centuries, many technology discoveries have changed the medical landscape - each medical discovery has brought us a crucial step closer to better understanding the complex mysteries of disease and medicine. Humans have been able to adapt to evolving and improved knowledge of human body and our environment and develop medical breakthrough treatments that have been instrumental in saving millions of lives; combatting deadly diseases; bringing relief, betterment and increasing longevity to human life.

In any human endeavour, technology has always been the primary catalyst for the expansion of human potential. In the realm of human biology, this relationship is at its most profound. Indian civilization was perhaps the world’s “first principle” of systemic health that modern technology is finally able to quantify at scale. For many centuries, medicine developed as an art of observation and intuition. Around 1800s, there was a major shift - the “Technology” of the 1800s introduced the stethoscope—a simple wooden tube that first allowed listening to the internal heartbeat symphony of the human body. Since then, the trajectory of healthcare has been defined by our ability to see further into the microscopic scales of human biology and create images of human body. Technology has transitioned healthcare from **episodic intervention** (treating the sick) to **continuous management** (maintaining wellness).

In my talk, I want to highlight key technology domains that are driving

progress and delivery in healthcare management, including digital health, artificial intelligence, biotechnology, and—crucially—geospatial technologies. To understand the sophisticated “prognostic” world we are building today for intelligent Healthcare, I would quickly trace the specific technological triggers that turned the tide of human history in healthcare, with the foundational mastery of the biological and chemical worlds.

## A] Technology in healthcare management – A retrospective

The technical foundations of Healthcare can be categorised into 5 broad stages:

- **The era of biological mastery (1800s)** - *The Vaccine-Anaesthesia-Antibiotics revolution*: For centuries, human healthcare was trapped in superstition and seen as the wrath of the Supreme. It was Vaccines that changed the concept - inoculations to tame the infamous smallpox virus by Edward Jenner brought on the usefulness and popularity of vaccines and helped to combat some of the world’s deadliest diseases, including smallpox, rabies, tuberculosis, and cholera and in our recent memory Covid pandemic. Similarly, General anaesthetics, in 1846 changed the field of surgery when William T. G. Morton successfully used ether as an anaesthetic during surgery, and thereon safer anaesthetics were developed, allowing millions of life-saving, painless surgical

operations to take place. In 1861, French microbiologist Louis Pasteur proved invasion of specific microscopic organisms - also known as pathogens – and then started the Germ Theory - marked a significant turning point in how diseases were treated, controlled and prevented – especially plague, dysentery, typhoid fever, Covid and many others. We are all grateful beneficiaries of Alexander Fleming’s penicillin, the world’s first antibiotic in 1928, by which the war against deadly bacteria began. It was a great healthcare technology tool that has served humanity – but, nowadays increasingly resistance to antibiotics is emerging and routes for new anti-bacterial treatments are being discovered.

- **The era of systemic medical-engineering (1950s – 1980s)** – *The hardware and software of human biology.* Organ transplants were first done in 1954 with successful kidney transplant done for first time; in 1963, the first lung transplant was carried out, followed by a pancreas/kidney in 1966, and liver and heart in 1967. Transplants have saved thousands of lives; transplant procedures have also become increasingly innovative and diverse, with doctors successfully completing the first-hand transplant in 1998 and full-face transplant in 2010! Just last year, in 2024, the first transplant of a genetically-edited pig kidney into a living human was accomplished.

Development of antivirals in 1960s revolutionised healthcare management further - Viral bonding with cells is so structural, isolating the virus (and not affecting the cells) was overcome by “molecular interference” for blocking the rapid reproduction of viral infections, and even stimulate the immune system to attack the virus. The development of effective antivirals has been significant in treating and controlling the spread of deadly virus outbreaks such as HIV/AIDS, Ebola and rabies.

- **The imaging revolution (1970s-90s)** – *Imaging and Digitisation of*

*Anatomy:* The technology of Medical imaging started a revolution in 1895, when William Rontgen created the X-Ray imaging – providing the first pictures of inner body parts. Then came Ultrasound for metabolic diagnosis in 1955, and in 1967, the CT scanner fused X-ray detectors and computers to diagnose many different types of disease. In 1973 Paul Lauterbur produced the first MRI - nuclear magnetic resonance images for detecting various metabolic life-threatening conditions. CT and MRI didn’t just show us organ images; they converted human anatomy into a **3D Visualisation System**. We began to visualise the “Body Map” and study the anatomy in spatial patterns, enabling the transition from “exploratory” surgery to “targeted” intervention. We stopped “cutting to see”; we saw images so that “surgery could be with precision”.

- **The era of regenerative & precision defense (1990s – Present)** - *Bio-Programming Health care.* In 1970s Stem cell therapy (*The Regeneration*) enabled renewal through cell division even after being inactive, and under certain conditions used to make any type of human cell. This technology has enormous potential in cancer treatment. However, ethical issues have also been raised for use of Stem Cell – especially in embryonic stem cells.

Immunotherapy (1970s) (*Precision Defence*) enabled stimulating the immune system to fight off a disease, particularly in respect to treating cancer. In the last decade, immuno-oncology has become one of the most revolutionary cancer therapies in existence. Without use of toxic chemicals (Chemo) to kill cancer; one can “train” the patient’s own immune T-cells to recognize and incinerate the tumor.

- **The genomic leap (2000s)** – *The Blueprint of the Cellular:* The completion of the Human Genome Project turned biology into an information science. The value wasn’t just in identifying the 3.3 billion base

pairs that make up a human; it was in the fundamental reclassification of biology in a digital code and emergence of Bioinformatics and Genomics surveillance. It provided the fundamentals for personalized medicine. The Human Genome Project was like the “GPS for the Cell.” It provided the static map of our body code; it gave us the Syntax of Life. In the past, we treated diseases by their location—breast cancer, lung cancer, liver cancer. Today, they can be treated by their Instructional Error – so, ‘cancer’ is seen not as a tumor, but as a corrupted line of digital code. The future is no longer just to cut or cauterize; it is to debug and repair the biology code – enabling newer painless treatment to emerge.

- **The continuous measurement era (2010s)** - *Advances in Device Technology & Measurement:* The proliferation of IoT democratized medical data; High-speed internet enabled tele-health, breaking the barriers of geography for the first time. In the past, a medical “measurement” was a single data point in time—a blood pressure reading at a clinic or a once-a-year blood test. Today, we have moved from snapshots to Body-Graphs – we look at the trend. “Smart Device” is a piece of strapped-hardware as a Software-Defined Medical Instrument. Next-Gen Wearables & “Invisible” Sensors that measure Continuous Glucose Monitors (CGM) provide a 24/7 metabolic map, revealing how specific foods or stress levels impact blood chemistry in real-time. Medical-Grade Smart Rings & Patches track Heart Rate Variability (HRV), blood oxygen saturation (SpO2), and even Electro-Dermal Activity (EDA) to predict the onset of illness or a cardiac event days before physical symptoms appear. Micro-Smart Implants are embeddable in the body sub-cutaneous and provide stream of observations throughout the day. A smartwatch doesn’t just record an irregular heartbeat; it runs an on-device algorithm to distinguish between harmless caffeine-induced palpitations and life-threatening Atrial Fibrillation (Afib). The Internet of Medical Things

(IoMT) is now a reality – the mobile “Connectivity” and software algorithms are the backbone of this device revolution.

One can see that in just 200-250 years, the human body is no longer a biological mystery; it has become the most complex data architecture in existence. So now, every clinical encounter—every ECG trace capturing the electrical rhythm of a heart, every CT and MRI slice mapping the 3D coordinates of our internal geometry, and every longitudinal blood report tracking the chemical signatures of our metabolism—is digitized into a monumental, trillion-parametric knowledge base. This “Human Body Graph” is not merely a collection of individual records; it is a multi-dimensional tapestry that spans across lifetimes, across diverse genetic lineages, and across the vast “Where” of our global geography. We have effectively spatially indexed the human condition in a unique human biology coordinate system. This colossal repository of high-fidelity health measurements represents the best setting for an ultimate frontier for Artificial Intelligence...the stage is perfectly set!!

## B] Generative AI – The future of healthcare

We are already witnessing the beginnings of **Generative AI era** in Healthcare!! Generative AI and Predictive AI are starting to significantly alter the healthcare landscape. AI is the “cognitive infrastructure” of modern medicine - it has moved beyond simple pattern recognition (like identifying a fracture on an X-ray) to content and medical knowledge synthesis.

### The AI awakening (2020s) – Democratization of Predictive and Precision Healthcare

Life science research institutions are teaming up with pioneering AI technology giants (Google, IBM and Apple, OpenAI, Claude, OpenDialog etc) to create more effective ways to deal with diseases and healthcare for patients. The current applications of AI in healthcare are broad, from disease diagnosis and drug discovery to personalised treatment plans, patient monitoring, and human-like chatbots.

Ambient Clinical Documentation that generate instant structured, compliant medical notes (SOAP notes); De Novo Drug Discovery to generate molecular structures that have never existed and reduce drug discovery process/time by half; Synthetic Patient Data that creates “synthetic” patient populations that mirror the statistical complexities of real humans etc are some visible AI developments in Healthcare management. Large Language Models (LLMs) and Neural Networks are outperforming humans in pattern recognition, from detecting early-stage carcinomas in radiology to predicting protein folding. AI is now performing **Multi-Modal Fusion**—taking a satellite image of a city’s air quality, a patient’s genomic predisposition, a MRI image, and their real-time heart rate to predict an asthma attack 48 hours before the first wheeze.

Some illustrative and sampling of useful Generative AI tools for Doctors and Health Workers are:

Tool	Function	Key Impact
Heidi Health / DAX Copilot	Ambient Scribe for clinical documentation	Automatically drafts clinical notes from audio consultations.
UpToDate Expert AI	Clinical Decision Support to Doctors	Provides citation-backed, evidence-based answers to complex clinical questions in seconds.
MONAI	Medical Imaging and Analytics	An open-source framework for AI-assisted radiology and medical image analysis (segmentation, detection).
OpenEvidence	Medical Literature Synthesis	Summarizes thousands of medical papers to give a physician the “bottom line” on a new treatment.

For Common Citizens, the following Generative AI tools are quite useful illustrations:

Tool	Function	Key Impact
Ada Health	Symptom Assessment	A “digital front door” that triages symptoms and suggests the urgency of care.
WHO S.A.R.A.H.	Digital Health Promoter; public health outreach and information delivery	A Generative AI avatar providing 24/7 advice on public health issues - nutrition, stress, and tobacco cessation.
Apple/Google Health (Agentic)	Personal Health Insights	Summarizes data from wearables (HRV, sleep, glucose) to warn of “prognostic signals” like upcoming illness.
Many Platforms - Medline, SAGE, Mayo Clinic Labs, Diagonpedia	Digital Medical Encyclopaedia	Curated medical e-library based on medical scholarship, clinical experience, and evidence-based insights into a single, structured digital platform.

## C] Geospatial technology: from mapping to planetary intelligence

Geospatial technology has moved beyond the era of static maps or a niche survey tool used for mapping resources, administration boundaries and topography. Today, it has matured into a **Live GIS Agentic Model** - a digital, searchable, and temporal 3D coordinate system where every square inch of our world is a living geospatial data point.

The “Eye in the Sky” has evolved from simple optical snapshots into a regime of Multi-modal Transparency. With 100s of high-revisit Earth Observation (EO) constellations and Synthetic Aperture Radar (SAR), operated by United States, China, Japan, Russia, and India, we can now detect the “daily heartbeat” of our people, our actions and changes in Earthscape—from the moisture levels in a forest that signal a zoonotic spillover to the urban heat islands that predict a spike in respiratory distress. Tremendous innovations are happening in Satellite

Imaging, some of the key ones are:

- **30-cm and Sub-30-cm Resolution on daily basis:** The commercial EO market is pushing towards 30 cm resolution (or better), offering unprecedented clarity to identify small ground objects, such as vehicles and detailed infrastructure, which is highly valuable for health assets mapping and urban planning.
- **Advanced Hyperspectral Imaging:** Beyond traditional multispectral imaging (RGB + NIR), future sensors will capture hundreds of spectral bands, allowing for precise chemical composition and object analysis of the Earth's surface. This will enable better detection of biota, minerals, pollutants, and methane leaks and contribute to Healthcare applications.
- **Next-Generation SAR (Synthetic Aperture Radar):** SAR technology is advancing to provide upto 1m high-resolution, day-and-night, all-weather imaging. This is critical for all-weather monitoring, as it can penetrate cloud cover to detect ground movement, such as in floods or landslides and in emergencies.
- **On-Orbit AI and Edge Computing:** Instead of transmitting massive amounts of raw data to the ground for processing, future satellites will feature AI-enabled, on-orbit data processing. This will enable satellites to filter out cloud-covered images, detect anomalies, and recognize objects in real-time, reducing bandwidth usage and increasing operational speed. In fact, we may get not just images but also processed information in real-time.
- **Increased Revisit Rates and Real-Time Data:** The growth of small satellite (CubeSat) constellations, such as those from Planet Labs, means higher frequency imaging, enabling near-real-time monitoring of rapid changes on Earth. Almost on daily basis, anywhere in the world!!!
- **Foundation for Geospatial.AI Architecture:** Future Geospatial. AI systems will integrate diverse image datasets—combining satellite optical, radar, and hyperspectral data with ground-based, drone,

and IoT sensor information and Health records—to create a holistic, unified view for Healthcare Management and be the foundation for the Generative AI LLMs.

- **Quantum Sensing and Advanced Communication:** Emerging technologies like quantum sensors will improve accuracy, while laser communications will offer higher bandwidth for transmitting data in 2-ways – to the satellite (in terms of ground information for Edge Processing) and from the satellite (to receive the processed information).

In the modern architecture of governance, GIS is no longer a desktop software or an “information System”; it is a Cloud-Native Utility of spatial intelligence. Mapping has migrated to the “Edge”, where mobile or device applications serve as bi-directional sensors, fusing crowdsourced human intelligence with authoritative spatial registries. In this new paradigm, the “Live Map” is the primary interface for the Internet of Medical Things (IoMT).

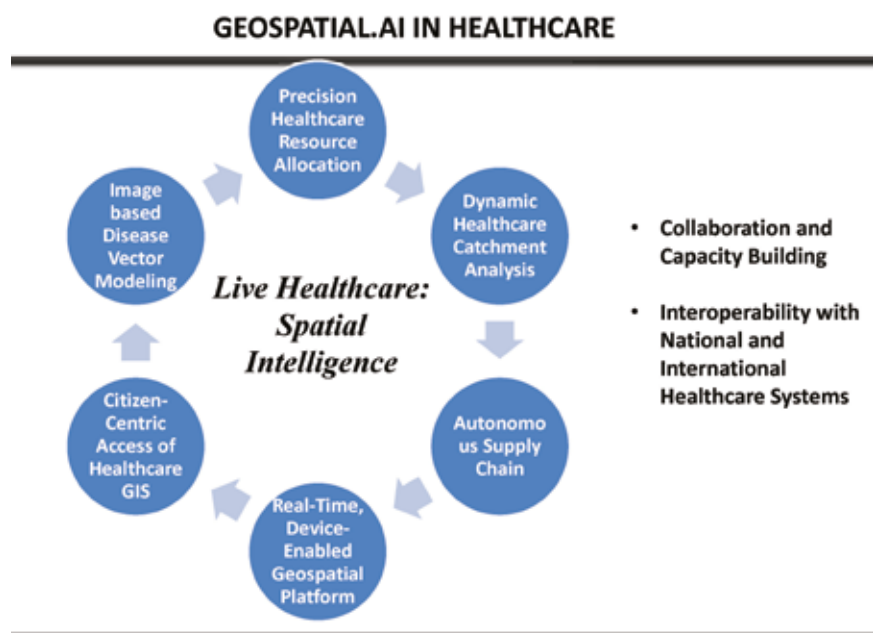
The true “Prophetic” shift, however, lies in the fusion of Generative AI and Geospatial technology. Geospatial AI (GeoAI) is now a reality that is beyond simple feature detection. By training Foundation Models on decades of satellite imagery and health

outcomes, we are building systems that don't just ask “What is there?” but “What will happen there?” or “When will it happen?”; we are automating the extraction of intelligence from terabytes of imagery in minutes, allowing us to predict the structural vulnerability of a city's health infrastructure years before a crisis hits.

The ultimate goal of using Geospatial. AI for Healthcare Management must not be just to treat maps and datasets as static repositories. Geospatial data and Health data and Medical knowledge will fuse into a “single data currency” for future Healthcare governance. We need to build an advanced spatial intelligence for Health and Healthcare—the ability to understand the “where” dimension of diseases/patients and convert it into actionable insights for efficient and quality Healthcare services.

## Geospatial Applications in Karnataka

In 2016, Government took the decision of establishing the Karnataka Geographic Information System (K-GIS) in support of scientific planning, proper decision-making for equitable governance, industrial development and citizen empowerment in the state. K-GIS has geo-tagged Health Assets and created a GIS



Dashboard to visualize statistics, generate reports and compose maps of user choice. Last year, Government decided to assimilate many emerging and advanced technological developments – especially, Generative AI modelling; Spatial (Data) Analytics (SA), Artificial Intelligence (AI) and Deep Learning (DL), Internet-of-Things (IoT), advanced computational and image vision etc to expand to K-GIS Ver 2.0, as a next generation, technological and state-wide GIS infrastructure to cater to the future needs of Karnataka’s governance, industrial development and citizen-centric services.

In a very stimulating study by IIIT-B, have defined GeoHealth Karnataka, a new end-to-end geospatial framework that incorporates advanced spatial analysis methods to assess healthcare accessibility by integrating high-resolution population rasters, mapping of healthcare facilities, travel-time estimation with friction surfaces. The study highlights Healthcare Infrastructure Gaps and need for focused interventions could improve accessibility for over 12 million underserved residents by up to 52%.

JSS AHER in a study of 2022 has also studied GeoAI and its potential for disease diagnosis, treatment planning, resource allocation and identifying health disparities.

### **Geospatial.AI in Healthcare - Live Healthcare Spatial Intelligence.**

Health is inherently spatial – it has a location tag – either by the location of the patient or by the location of disease treatments or by location of medicine sales or by location of environmental/ climate shifts in air/water/land qualities or location of drastic climate changes and patterns. It also has a geographic spread – in terms of a region. Hospital can have command area regions; pandemic can have a spread region; polluted water can have a region of vulnerability, and so on. Even the body images are in spatial character – in a unique body coordinate system and their own topology – thus geographic

coordinates twine with body coordinates data in the Geospatial.AI for Healthcare.

Some of the unique applications in Geospatial Healthcare arena are:

- **Disease vector modeling:** Satellite imagery is used to map disease vectors by geospatial integration of environmental factors like temperature, humidity, rainfall, and vegetation, which dictate the habitat and breeding of mosquitoes, ticks, and flies. Satellite Based Environmental Surveillance is undertaken by analyzing data from satellite images to map land cover, water bodies, and urbanization, identification of high-risk areas for diseases like Malaria, Dengue, Rift Valley fever, and Cholera is possible. Using satellite data stagnant water bodies and vegetation indices (NDVI) are quickly mapped and integrated with clinical records and daily weather data; this allows health officials to predict Malaria and Dengue outbreaks 2-3 weeks before they hit urban centers. Disease vectors for Tse-tse flies for sleeping sickness in Africa have shown positive vector mortality rates correlation with mean monthly NDVI values from satellite images. High Resolution Spatial Epidemiology analysts integrate disease case counts with environmental, demographic, and mobility layers. During the Ebola outbreak in West Africa, GIS supported contact tracing, mapping of transmission chains, and optimization of treatment center placement. During COVID, many nations, including India, created GIS Dashboards of infections, O2 availability, hospitals saturation etc – in fact the Johns Hopkin University COVID Dashboard was the most unique example of GIS application in COVID management.
- **Precision healthcare resource allocation:** In the classical model of public health, resource allocation is driven by historical averages and administrative boundaries—a “top-down” approach that often results in simultaneous surpluses and catastrophic shortages. Today, Precision Resource Allocation

(PRA) has transformed into a real-time, predictive discipline that treats medical supplies, oxygen, and human capital as a fluid, geolocated inventory on a Geospatial platform. The PRA leverages spatiotemporal Load Balancing and integrating live feeds from Hospital Management Information Systems (HMIS) with traffic data and weather models, one can now predict “surge clusters” before they overwhelm a hospital facility.

- A critical evolution is **Dynamic Healthcare Catchment Analysis**. We no longer view a hospital’s reach as a static circle on a map. Using Isochrone Mapping—which measures travel time rather than distance—we account for real-time urban congestion, jammed or flooded roads, or infrastructure bottlenecks real-time. This ensures that a “Precision Dispatch” system doesn’t just send the nearest ambulance, but the one with the fastest optimized path to a facility that has the exact specialized capacity (e.g., an available Cath Lab) required for that specific patient. Furthermore, the “Cold Chain” for vaccines and temperature-sensitive biologics has been revolutionized by IoT-GIS Integration. Every vial is now a “connected node” on a map. We aren’t just tracking where the vaccine is; we are monitoring its thermal integrity via satellite-linked sensors. If a refrigeration unit fails in a remote district, the system automatically triggers a Geospatial Re-routing Logic, identifying the nearest functional cold-storage point and recalculating the logistics to salvage the batch. During the COVID-19 pandemic, GIS dashboards were the “Command and Control” centers, identifying oxygen-deficit zones and optimizing the supply chain in real-time.
- For a hospital or a state health department, an important frontier is the **Autonomous Supply Chain**. We are looking at a future where drone swarms, guided by high-resolution 3D terrain models, perform “Last-Mile Precision Drops” of blood units or anti-venoms to inaccessible terrains. Medically, the “Golden

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Ultimately, the future of healthcare and public health management in India will not be just defined by the sophistication of individual technologies, but only by the **prophetic intelligence** of our Healthcare experts – without the expert’s intelligence, the future AI models will be mechanistic and a black-box

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efforts like K-GIS and national efforts at democratization of Geospatial data, driven by India’s 2022 Geospatial Mandate, can bring to reality that no citizen is “off the geospatial grid” and no health crisis remains “uncared.”

## D] Some directions for future geospatial for healthcare

Technology is the only path forward for effective Healthcare because we face a global paradox: medical knowledge is expanding exponentially, yet healthcare systems are struggling under the weight of growing and aging populations and increasing chronic diseases. It is only technology that becomes a systemic necessity for:

- **Addressing the Manpower Deficit:** No nation can train doctors fast enough to meet the 1:1000 ratio recommended by the WHO. AI-driven triage and automated diagnostics would act as “force multipliers” for overworked healthcare systems – but under watchful “eyes” of human healthcare experts.
- **Economic Sustainability:** Modern healthcare costs are unsustainable. By moving toward **Predictive AI**, we can intervene when a patient is “pre-diabetic” or “pre-hypertensive,” saving costs in long-term healthcare and hospitalization.
- **Equity of Access:** Technology is the only tool capable of delivering “Level-5” specialist expertise to every citizen – say, in a primary health center in a remote village via Tele-medicine-enabled remote diagnostics and healthcare.

Looking 10-20 years ahead, we will move toward a “Post-Clinic” Era, where the primary site of healthcare shifts from the hospital to one’s “Living Environment” (home, personalised care). Every citizen will likely have a Physiological Digital Twin – a Generative AI model of “you”, updated in real-time by bio-sensors/devices; Doctors will test drug dosages on your digital twin first to see if it causes a reaction before prescribing

Hour” Optimization would require Geospatial network analysis to help locate ambulance hubs so that 90% of the population can be reached within 8–10 minutes, significantly improving survival rates for acute cardiac events.

- Transition from static health paper-records to a **Real-Time, Multi-Device-Enabled Geospatial Platform** is a reality —the “command and control” center for Healthcare in next few years. In this paradigm, healthcare will be no longer a building you visit; it is a continuously updated, high-fidelity digital twin of the community’s collective biology. Modern healthcare would thus become an interconnected network of thousands of “living nodes”: patient wearables tracking vital prognostic signals, hospital assets like ventilators and beds and lab instruments tagged with spatial sensors, and the precise, real-time locations of doctors and nurses mapped across the facility.

Imagine a futuristic Geospatial.AI Healthcare Dashboard that “breathes” with the city: it visualizes a sudden cluster of respiratory distress signals in a specific neighbourhood, correlates it instantly with a localized spike in PM2.5 air quality detected from pollution and climate sensors, and automatically triggers an alert to the nearest hospitals and health units. On the clinical floor, the dashboard acts as an health-traffic control system, dynamically routing patients to the least-congested diagnostic bays and “paging” the nearest available specialist based on their real-time

indoor geospatial coordinates (IPS). This dashboard would provide a “God’s-eye view” for Healthcare managers to manage outbreaks, while simultaneously offering a “Precision View” for the expert doctors and clinicians and smoothen the life of the patient to utmost levels.

- **Citizen-Centric Access of Healthcare GIS services** - democratize spatial and healthcare data for use at the grassroots level—empowering citizens, Health officers at Panchayats, and local institutions, hospitals, emergency centres, pharma units and many others. The Geospatial Healthcare Platform would provide predictive medical analysis and spatial analytics for various Healthcare problems.
- **Collaboration and Capacity Building** by establishing a robust interaction for Geospatial. AI ecosystem between medical community and Geospatial.AI community and close-looping doctors, hospital managers, health officers, health professionals, medical colleges/academia, and health field staff to build and extend robust Healthcare services for future;
- **Interoperability with National and International Healthcare Systems** - Spatially explicit early state-/national level warning systems are essential for healthcare management. Interface with NMC and WHO for Policies and Regulations; ISRO for space-assets for telemedicine and the Digital India Geospatial Ecosystem for seamless AI technology exchange and collaboration is called for. State

medication. The “Pharmacy in a Box” will be a reality with Generative AI and advanced chemical synthesis and we may see the rise of decentralized drug manufacturing. Instead of mass-produced pills, AI will design a personalized daily formulation that combines hypertension medication, vitamins, and a new anti-inflammatory, 3D-printed at your local pharmacy or even at home. Predictive Public Health will become hyper-local where AI will integrate satellite data (air quality, humidity, land, water, climate, disease vector patterns etc) with anonymous community health “signals” (e.g., a sudden spike in cough-syrup purchases in a specific zip code) to predict and ring-fence an outbreak before it becomes a pandemic. The Death of the “Average” will be the most profound shift away from “standard of care.” Medicine will be N-of-1. We will no longer say “This drug works for 70% of people.” We will say “This drug works for YOU because of his specific genetic markers and current environmental stress level.

For a premier academia and research Agency (such as JSSAHER), the next few years must be defined by **Actionable Implementation**, starting with robust pilot projects:

- **Unified Health Data Exchange (UHDX):** Build a secure, blockchain-backed Health Data Stack. Research is only as good as the data; we need anonymized, longitudinal data from our citizens to train Indian-centric AI models.
- **The “Tele-Health” Initiative:** Leverage India’s prowess in space and mobile technology to develop an advanced “Tele-medicine and Tele-Robotics” system linked with advanced wearable diagnostics and Predictive AI analytics.
- **Standardization for Interoperability:** Define Standards that every medical device, from a village BP monitor to a metro hospital’s MRI or CT scan or Blood Report or Surgical Procedure - all speak the same digital language (FHIR standards).

### Space Medicine: The Ultimate Proving Ground

I have also suggested to JSS to lead the way and create a Vision for “**Space Medicine: The Ultimate Proving Ground**”. With India planning Gaganyaan and Bharatiya Antariksha Station (BAS) orbiting around Earth, it is not far when Indians will be flying in and from Space. So understanding and building healthcare systems for Space environment becomes very critical and JSS should lead the way.

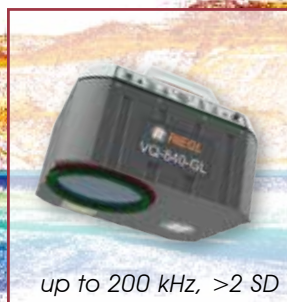
But when we discuss Space Medicine, we are not merely talking about the health of human astronauts alone; we are actually talking of an “Extreme Health Laboratory for Terrestrial Innovation”. In Space’s isolation, every health resource will be finite, and every biological signal needs to be amplified and analysed so that instant care and treatment can be administered in Space. This constraint forces us to develop the most precise, low-power, and reliable medical measurement and analytics technologies

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for Space – in fact, the wearables were first successfully tried out on space astronauts in the 1960-1980 timeframe.

On other hand, all the technologies of Space Medicine would be actually the ultimate proving ground for “Frugal Healthcare High-Tech on Earth,” where we learn to manage complex health conditions with optimised measurement systems and maximum intelligence analytics—a Predictive AI model that can also be perfectly suited for the rural and remote stretches of the Indian subcontinent and its people. The innovations born from space—such as Digital Twins of Humans or Tele-robotic surgery with active latency compensation—are tools of tomorrow’s Earth-bound clinics and healthcare. After all if Healthcare is REMOTE for human astronauts in space; so is it for millions of citizens/patients in rural areas too!! While we learn how to “re-program” the body’s response to extreme space environments remotely, the same technology can translate directly into treating the “extremes” of remote patients, aging population, chronic disease, and environmental stress.

By integrating AI, Space-grade reliability with Geospatial precision and embedding into modern Healthcare, we would be building a system where the “Space-to-Symptom” link is instantaneous, intelligent and ensuring that HEALTHCARE SPECIALIST’s touch can reach the patient “remotely”, as effectively as in a hospital, even in the furthest corners of space orbits or the farther rural villages in the state or even on Himalayan peaks - as if they were all in the same room.

## E] In conclusion

The technology in healthcare has undergone a fundamental shift; we have moved from the **Era of Discovery**—where we celebrated the isolation of Penicillin and the first mapping of the human genome—to the **Era of**

**Intelligent Integration.** The points that I have highlighted—from the precision of satellite images and drone-derived digital twins to the “n-of-1” biological blueprints provided by genomic sequencing—are no longer disparate technological silos. They are the converging threads of a single, **Cognitive Healthcare Intelligence.**

Ultimately, the future of healthcare and public health management in India will not be just defined by the sophistication of individual technologies, but only by the **prophetic intelligence** of our Healthcare experts – without the expert’s intelligence, the future AI models will be mechanistic and a black-box. As we architect the next generation of Research Projects and National Health Data Stacks, our conclusion must be rooted in a “Phy-gital” reality where technology does not replace the Physician or experience, but empowers them with planetary-scale health insight intelligence. We are standing at the threshold of a world where geography is no longer a barrier to specialist health care, where “average” treatments are replaced by “absolute” precision, and where the **Real-Time Autonomous Healthcare Dashboard** serves as a silent, vigilant guardian for every citizen.

## Referred materials:

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- WHO GIS Centre for Health - <https://www.who.int/data/GIS>
- CDC (2020–2024) Public Health Surveillance and GIS Applications
- European Centre for Disease Prevention and Control (ECDC) GIS and Remote Sensing for Public Health - <https://www.ecdc.europa.eu/en>
- McKinsey Global Institute (2023) The Future of AI in Healthcare - <https://www.mckinsey.com/>

industries/healthcare/our-insights/generative-ai-in-healthcare-current-trends-and-future-outlook

- Nature Medicine, various issues (AI diagnostics, genomics, public health modeling)
- The Lancet Digital Health (Digital public infrastructure and national digital health strategies)
- The top 10 medical advances in history - <https://www.proclinical.com/blogs/2021-6/the-top-10-medical-advances-in-history>
- Karnataka - GIS - <https://kgis.krsac.in/kgis1/portal.aspx>
- Geospatial AI for Health: A New Era of Insight, Intelligence, and Impact - <https://www.esri.com/en-us/industries/blog/articles/geospatial-ai-for-health>
- Geospatial AI - <https://www.esri.com/en-us/geospatial-artificial-intelligence/overview>
- Analysis of geospatial data services for healthcare - <https://www.infosysbpm.com/blogs/geospatial-data-services/geospatial-data-for-healthcare.html>
- Geospatial Artificial Intelligence (GeoAI): Applications in Health Care - [https://journals.lww.com/jhas/fulltext/2022/10000/geospatial\\_artificial\\_intelligence\\_\\_geoai\\_\\_4.aspx](https://journals.lww.com/jhas/fulltext/2022/10000/geospatial_artificial_intelligence__geoai__4.aspx)
- GeoHealth Karnataka: A Geospatial Framework for Comprehensive Healthcare Accessibility Analysis - <https://dl.acm.org/doi/10.1145/3748777.3748798>
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*The article is based on the keynote address titled “Geospatial Technologies for Healthcare and Public Health Management,” delivered during the Faculty Development Program (FDP) at JSS Medical College, Mysuru, India, on March 3, 2026. The keynote was shaped by insightful discussions and valuable inputs from Dr. H. Basavanagowdappa, Vice-Chancellor; Dr. Narayanappa, Principal; Dr. Vishal Gupta, Dean (Academics); and Dr. Madhu, Professor and Head. ▢*

# GNSS (SBAS) Constellation Specific Monthly Analysis Summary: April 2026

The analysis performed in this report is solely the author's work and his 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.

Satellite Based Augmentation Systems (SBAS) enable high integrity GNSS navigation for all phases of flight, including precisionlike approaches with vertical guidance. In the Asia–Pacific region, several SBAS implementations are progressing at different maturity levels. This article presents a consolidated analysis of four systems—GAGAN (India), MSAS (Japan), KASS (Republic of Korea), and SouthPAN (Australia/New Zealand). The study combines (i) observed Horizontal and Vertical Protection Level behavior from a representative day in April 2026, (ii) officially declared SBAS service capabilities and supported aviation procedures, and (iii) spaceweather

conditions on the analysed day. The results provide a coherent view of current SBAS readiness across the Asia–Pacific region, excluding the mature WAAS and EGNOS systems.

## 1. Observed Performance Analysis

**GAGAN** exhibits significant degradation during disturbed conditions. Horizontal Protection Levels (HPL) increase from nominal values (~10–30 m) to peaks approaching 75 m. Vertical Protection Levels (VPL) show extreme behaviour, reaching values above 150 m and peaking near 200 m.

The major disturbance event observed around 33,000–36,000 seconds is not directly correlated with satellite geometry, indicating a strong ionospheric driver. Compared to the quiet-day baseline, the system shows approximately three-fold VPL inflation, confirming high sensitivity of equatorial SBAS to geomagnetic activity.

**MSAS** demonstrates comparatively stable behaviour under disturbed conditions. HPL remains largely unchanged (~11–18 m), while VPL increases moderately, reaching peaks of approximately 40 m.

The absence of extreme spikes indicates robustness of MSAS in midlatitude ionospheric conditions. Compared with the

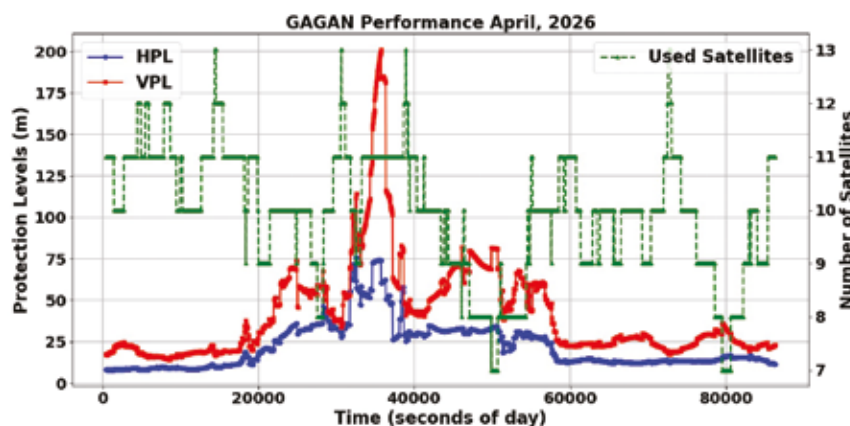


Figure 1: GAGAN performance in terms of achieved protection levels throughout the day of year 093, 2026.

quiet scenario, degradation is present but limited, with VPL increases remaining within operational tolerances.

**KASS** maintains stable horizontal performance (HPL ~10–15 m), but shows noticeable VPL excursions reaching up to ~90 m. These peaks occur partly during reduced satellite counts, indicating combined geometry and ionospheric effects.

Compared to the quietday baseline (VPL <30 m), the increase is substantial, highlighting moderate sensitivity to disturbed space weather conditions.

**SouthPAN** shows the most resilient performance among the analysed systems. HPL remains highly stable (~6–10 m), while VPL mostly stays within 13–22 m, with occasional peaks up to ~30 m.

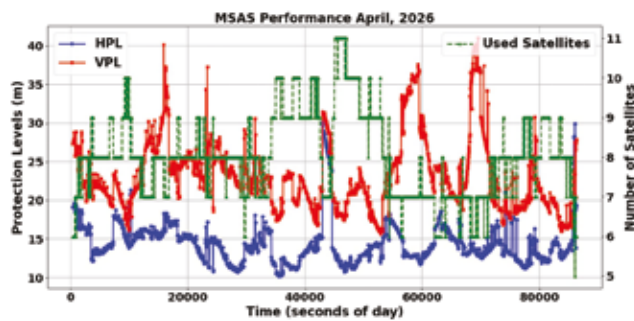


Figure 2: MSAS performance in terms of achieved protection levels throughout the day of year 093, 2026.

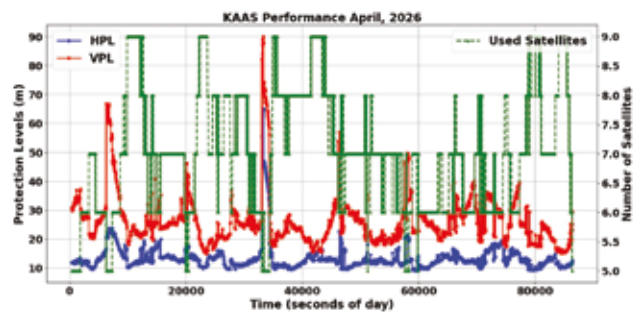


Figure 3: KASS performance in terms of achieved protection levels throughout the day of year 093, 2026.

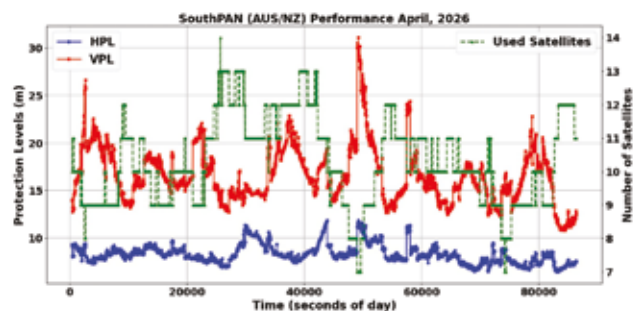


Figure 4: SouthPAN performance in terms of achieved protection levels throughout the day of year 093, 2026.

High satellite availability (typically 9–13 satellites) contributes to robust geometry, while limited VPL inflation indicates effective ionospheric handling. Compared to the quietday scenario, degradation is minimal.

## 2. Officially Declared Performance and Supported Procedures

GAGAN is officially certified for RNP 0.1 and APVI with declared APV availability over most of the Indian landmass. MSAS supports enroute and limited terminal operations but does not declare APVI or LPV nationwide. KASS officially supports RNP APCH including LPV with published horizontal and vertical alert limits of 40 m and 50 m respectively. SouthPAN is designed to support APVI, LPV, and LPV200 and has published target VPL values below 35 m over its primary service region.

## 3. Space Weather Conditions on DOY 093, 2026

On 03 April (DOY 093) 2026, geomagnetic activity reached **storm-level conditions with Kp values up to approximately 5–6**, indicating a minor to moderate geomagnetic storm. Such conditions are known to induce enhanced ionospheric variability and degrade SBAS ionospheric modelling performance.

## 4. Conclusions


The results clearly show that stormtime degradation predominantly affects the vertical domain. Systems operating in equatorial and lowlatitude regions (GAGAN) are most impacted, while midlatitude systems (MSAS, KASS) and advanced architectures (SouthPAN) demonstrate higher resilience.

SouthPAN maintains nearnominal performance even during disturbed conditions, highlighting the importance of redundancy and system design. Conversely, GAGAN shows severe degradation, indicating sensitivity to ionospheric disturbances.

## Data sources and Tools:

<https://cdsis.nasa.gov> (Daily BRDC, RINEX OBS); [http://ftp.aiub.unibe.ch/CODE\\_MGEX/CODE/](http://ftp.aiub.unibe.ch/CODE_MGEX/CODE/) (Precise Products); BKG “SSRC00BKG” stream; IERS C04 ERP files

SBAS Mentor, ESA

gLAB GNSS, <https://gage.upc.edu/en/learning-materials/software-tools/glab-tool-suite>  
serenad-public.cnes.fr (SBAS data) 

# Comparative study of Digital Terrain Models (DTM) Using DRTK 2 Drone and GNSS methods

The result from the GNSS processing method achieved the best performance in terms of absolute error evaluation.

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## Abstract

The spatial representation of the Earth's surface, as well as the surfaces of other geometric objects, involves a series of representation models. Digital Terrain Models (DTMs) represent the natural surface of the land without the structures or vegetation that cover it. Today, photogrammetry, with the advent of drone technology, has advanced working methods in precision topography and allows for much more efficient DTMs. However, there are several sources of errors in positioning due to instrumental, procedural, and environmental factors that arise during the process. The objective of this study is to validate the relevance of new drone technology in its application to topography, particularly in the production of DTMs. For this purpose, a DJI Phantom 4 Pro RTK drone was used to acquire 392 images in an area with difficult topography (8 ha), supported by 12 previously established ground control points (GCPs) whose altitudes were determined by a precision direct leveling operation. The processing was carried out using two photogrammetric processing software (Pix4D and Agisoft Metashape) to compare their performance on DTM accuracy. Then, GNSS surveys in real-time mode (RTK) were carried out to produce three-dimensional models to be used for comparison and validation purposes. The vertical error of the three digital terrain models (DTMs) was evaluated by comparing them with direct leveling campaign data on the ground. We found that the result from

the GNSS processing method achieved the best performance in terms of absolute error evaluation. Between the results provided by the two software programs, Agisoft offers slightly better results than those obtained with Pix4D.

## 1. Introduction

The advent of drone technology and its use for civilian applications have given new impetus to photogrammetry. Geographic sciences have benefited greatly in the fields of cartography, topography, land use planning, etc. Drones have become the tools of choice for data acquisition in general, and particularly in areas with difficult access [1]-[3]. They offer many advantages over other data collection tools, such as total stations and GNSS receivers [4] [5]. Indeed, collecting an infinite number of points from the image does not require contact with the terrain to be measured, providing an economical acquisition solution and, above all, high accuracy.

However, it is important to emphasize that both planimetric and altimetric accuracy are dependent on certain parameters such as flight height, focal length, pixel size given by the manufacturer, ground control points, etc. [6] [7].

The aim of this study is to compare, on the one hand, the DTM data resulting from the processing of two photogrammetric software programs (Pix4D & Agisoft Metashape) and, on the other hand,

the latter with the DTM obtained from data collected by the GNSS method. The direct leveling technique, which remains the most accurate method for obtaining altitude to date, was used to determine the calibration points and reference points. These latter were used for the comparative study of the different DTMs. The entire methodological approach is summarized in Figure 1.

## 2. Presentation of the Study Area

Senegal is located in the far west of Africa and is bordered by the Atlantic Ocean. It lies between latitudes 12° and 17° North and longitudes 11° and 17° West. Administratively, the country is divided into 554 local authorities, 46 departments, and 14 regions [8]. The city of Thiès is located 70 km from the capital, Dakar, in the region of the same name. With an area of 1,873 km<sup>2</sup>, it is bordered to the north by the department of Tivaouane, to the west by the department of Rufisque and the Atlantic Ocean, to the south by the department of Mbour, and to the east by the department of Bambey [9] (see Figure 2).

Our experimental site is located within the Thiès classified forest, east of the Sindia road, and covers an area of 8 hectares.

It is a former laterite quarry, which gives it a good profile for calculating DTMs and, more importantly, for estimating variations in its elevation values.

## 3. Data Acquisition

This constitutes the fundamental phase for any study project using spatial data. To carry out this work, we used various technological tools. The Leica NAK 80 optical level was used to establish altimetric reference points. For the acquisition of photogrammetric data (point clouds and orthophotographs), many recent aerial imaging drones are equipped with GNSS RTK receivers available on the market [10]. In this study,

the DJI Phantom 4 RTK drone was used and a CHCNAV i 50 dual-frequency GNSS receiver for high-precision point determination (see Figures 3-5). It is important to note that GNSS RTK positioning is currently used in various fields, including surveying, mapping, roads, and various networks [11] [12].

### 1. Image Acquisition

Using the photogrammetric method requires consideration of several parameters that affect data quality and accuracy: flight altitude [13] [14], image overlap [15] [16], drone flight speed [17], flight path configuration (single or double grid)[18] [19], nadir or oblique image acquisition [20]-[22], in addition to the number and distribution of GCPs [23] [24]. In this study, the parameters used are listed in Table 1.

Before taking the pictures, it is necessary to carry out the planning stage, which allows delimitation of the study area, definition of the parameters of the flight plan (flight height, overlap, flight speed, etc.), and marking. The latter consists of establishing a set of well-distributed points in clear locations with markers so that they are visible in the images to be taken. These support points will be used during the aerotriangulation, which is a process aimed at determining the transformation (translation and rotation) to be

applied to the point clouds in order to convert from local coordinates to the coordinate system of Senegal [25]. As part of this study, the coordinates of these points in planimetry and altimetry were determined using geodetic methods (direct leveling, GNSS survey) to ensure high accuracy. Twelve (12) points were defined in the study area, and the resulting coordinates are shown in Table 2.

The Senegal West African Navigation (SWAN) permanent station network was used to establish the planimetry points, and a point from the 1953 General Leveling of West Africa (NGAO 53) was used to determine the reference

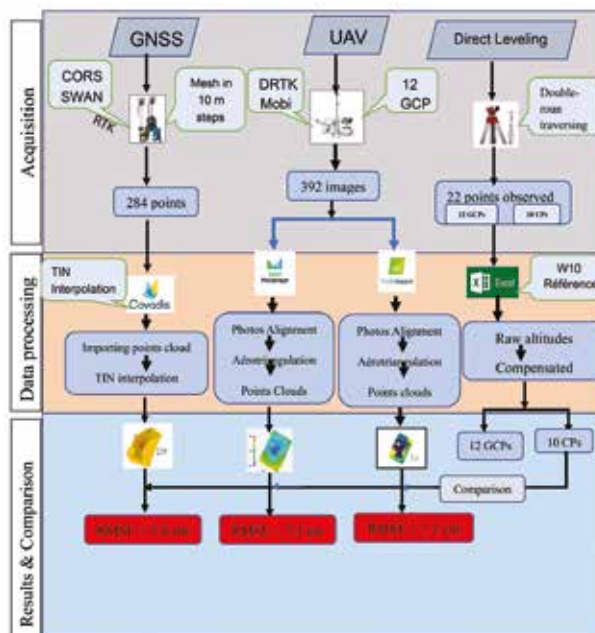


Figure 1. Methodological approach.

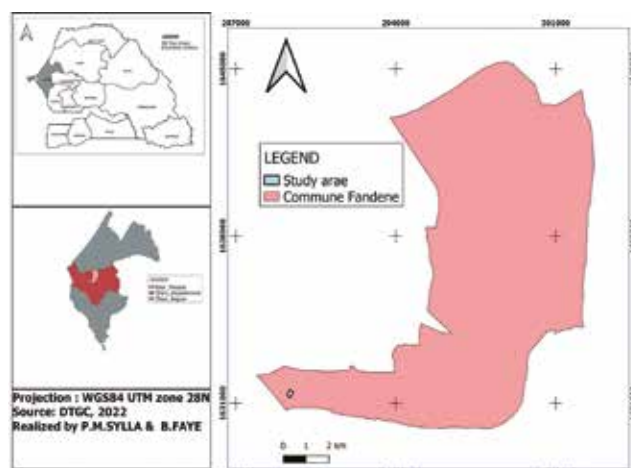


Figure 2. Location of the study area.

altimetry. These Ground Control Points will be used for absolute orientation.

Following this planning phase, the photography mission is carried out, and the order to trigger the shots is automatically sent by the drone's integrated controller, knowing its approximate position thanks to real-time GNSS positioning [26].

## 2. Acquisition of point patterns using



Figure 3. DJI Phantom 4 RTK.



Figure 4. GNSS receiver.



Figure 5. Optical level.

## GNSS

Today, GNSS RTK positioning is used in various fields, including surveying, mapping, and civil engineering.

GNSS technology was chosen as the second method for collecting elevation data to create a digital representation of the relief of our study area. Obtaining a Digital Elevation Model (DEM) is based on the interpolation of elevation data to create a surface representing the terrain. As part of this study, it was decided to perform a GNSS measurement mesh to obtain a consistent representation of the relief. Several meshing methods exist, namely the square/rectangular mesh, the hexagonal mesh, the regular triangular mesh, and the arbitrary triangular mesh. Given the morphology of the study area, which is quite hilly with steep slopes, the varied mesh with irregular steps varying from three (03) to ten (10) meters over the entire area was chosen. The surveyed points were attached to the Senegalese Reference Network (RRS04) from point S10 located within the Iba Der THIAM University of Theis, whose coordinates were obtained by the static method.

Table 1. Image capture program parameters.

Number of pictures	392
Average flight altitude	50 m
Ground resolution	1.35 cm/px
Longitudinal overlap	80%
Lateral overlap	70%
Coverage area	7.99 ha
Flight speed	3.9 m/s
Coordinate system	WGS 84/UTM zone 28N (EPSG: 32628)

Table 2. GCP coordinates.

Points	E (m)	N (m)	H (m)
Cr03	289362.006	1631369.93	100.611
Cr05	289273.791	1631326.44	97.353
Cr06	289315.317	1631318.56	98.237
Cr09	289263.39	1631362.92	99.201
Cr12	289408.173	1631274.71	98.674
Cr14	289360.726	1631563.47	103.658
Cr15	289363.968	1631514.92	105.367
Cr16	289422.725	1631512.83	97.387
Cr19	289413.822	1631479.75	97.828
Cr22	289283.648	1631426.38	105.13
Cr24	289381.567	1631416.98	104.201
Cr26	289476.715	1631430.04	103.933

For the densification of the mesh points numbering three hundred and ninety-two (392), RTK GNSS positioning was chosen for its good accuracy. When used correctly, GNSS RTK positioning is an effective measurement method, with errors of approximately 1 cm in terms of positioning accuracy [27].

## 3. Acquisition by direct leveling

Since the direct leveling method remains the most accurate for determining the altitude of a point [28], it was chosen for the validation of Digital Terrain Models (DTM) produced using new drone technology and the GNSS method. The round-trip method was used from the W10 reference point. This reference point is one of the points in the base polygon attached to the 1953 General Leveling of West Africa (NGAO 53) for the Thiès-Sindia road widening project of the Eiffage Senegal company. To determine the altitudes of the calibration points, two routing methods were used. First, the double-station routing to reach the study area, then a radiation routing taking into account the distribution and proximity of the calibration points (see Figure 6).

## 4. Data Processing and Results

The data processing phase plays a crucial role in DTM acquisition, as a large portion of the results depends on it. Thus, data from drone, GNSS, and direct leveling acquisitions will be successively processed using the existing methodologies we have chosen.

### 1. Processing of drone-acquired data

Photogrammetric data processing has evolved significantly in recent years. This evolution has resulted in the existence of more than forty (40) different software programs and photogrammetric tools, both open source and commercial, for processing photogrammetric data [29]. For the purposes of this study, Agisoft Metashape [30] and Pix4D [31] were chosen for processing. Our choice was based on the fact that they are the most

well-known and widely used software programs in the professional environment in Senegal. On the other hand, it was necessary to be able to compare the final results of these two software programs. However, we can note that all these photogrammetric processing programs generally follow the same five-step process for generating a DEM: (1) feature detection and matching; (2) triangulation; (3) generation of a dense point cloud; (4) 3D reconstruction; (5) generation of MNS and orthophotos [32] (see Figure 7).

Figure 8 and Figure 9 illustrate the results obtained with Pix4D and Agisoft Metashape software, respectively. We can see similar altitudes in the same areas. We note a variation in altitudes from 95,756 m to 107,215 m.

## 2. Processing of GNSS data

GNSS data, through automated operation, allow the generation of a DEM for relief modeling. However, the accuracy of this operation depends on the input data, the type of interpolation, etc. After determining the altitudes of the 284 points of the previously created mesh, the Covadis software [33] was used to generate the DEM. The latter uses Delaunay triangulation, which is a local deterministic interpolation method. It constructs the DEM from a mesh of contiguous and non-overlapping triangles from a point dataset [34]. The advantage of this method is that it guarantees that all input points are included, that there are no holes in the mesh, and that the triangles do not overlap. The result obtained is shown in Figure 10.

## 3. Leveling Data Processing

The processing of data from direct precision leveling follows a rigorous approach to determine precise and compensated altitudes of the leveled points. The observations were carried out according to the standards of precision geometric leveling. From the raw data (back and front readings), the raw elevations and then the raw altitudes were calculated. Based on the length of the path and the number of elevations, the tolerance was calculated according to the regulations in force in Senegal, represented by Equation (1) below [35].

$$T_r = 4\sqrt{9L + L^2} \text{ pour } n < 16$$

$$n = \frac{\text{nbre of elevation changes}}{L}; L: \text{path length.} \quad (1)$$

The calculated closure deviation (Raw Altitude – Known Altitude) equals –9 mm. Being less than the tolerance ( $\pm 12$  mm), we proceeded to compensate the raw altitudes of the 22 points. The altitudes vary between 90.563 m and 105.367 m.

## 4. Comparative Analysis

The notion of quality is a comprehensive

term that must be adapted to the intended purpose or application. This notion of quality encompasses several components or criteria. These include genealogical components, logical consistency, completeness, semantic accuracy, and geometric precision.

For a DEM, quality and precision depend on many variables. The first is related to the size of the area and its morphology [36], land cover types, lighting conditions, and object color contrast [37]. The second is related to the drone data collection systems and their characteristics, the camera and its calibration [38], and the type of drone (multicopter or fixed-wing), which may be a drone equipped with a high-quality GNSS/RTK receiver [39]. However, when comparing two models of a substantially horizontal terrain, a statistic on the deviations along the vertical component  $z$  is a simple but sufficient solution [40]. It constitutes the main component when assessing the quality of a DTM. It quantifies the variation between the points on the ground surface and those obtained by the model.

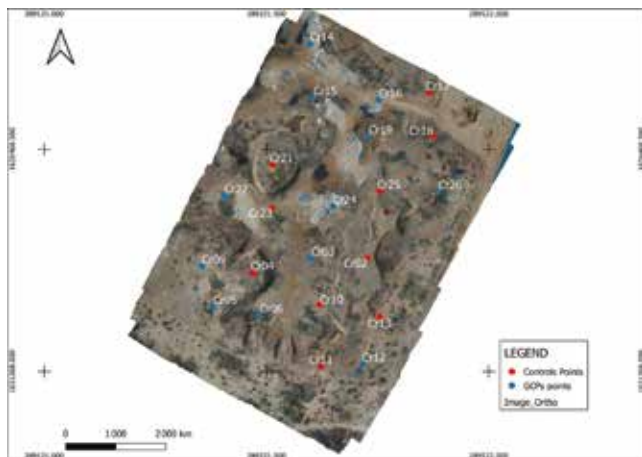


Figure 6. Distribution of GCPs and control points.

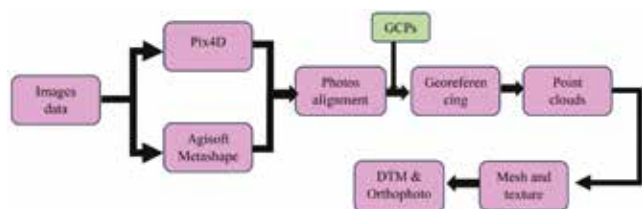


Figure 7. Drone data processing steps.

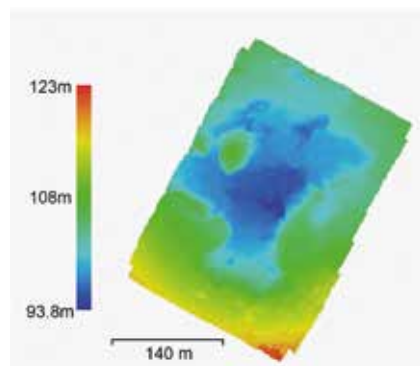


Figure 8. MNT obtenu avec Pix4D.

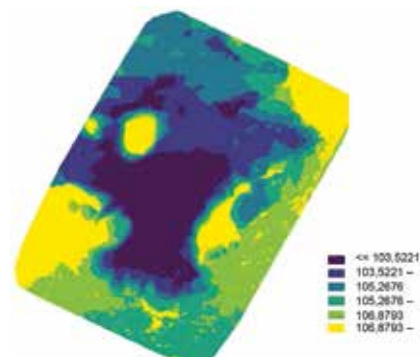


Figure 9. MNT obtenu avec Agisoft.

As part of our study, this geometric component was evaluated. Thus, we opted to conduct the comparative study along two axes: first, we analyzed the differences obtained between the two DTMs obtained with the processing software (Agisoft Metashape, Pix4D). Next, we evaluated the quality of the DTMs provided by the photogrammetric method and the GNSS method. The ten reference points whose elevations were obtained by direct leveling served as a reference for comparing the homologous points after processing with the Agisoft Metashape and Pix4D software and those from GNSS receivers. The results obtained are shown in Table 3.

The analysis of Table 3 shows that the comparative study between the variations in the altitudes of the selected points reveals fairly small differences between Agisoft Metashape and Pix4D compared to the reference points. For Agisoft Metashape, the differences vary from 7 mm to 12.5 cm, while for Pix4D, the small-est is 1.8 cm and the largest variation is 12.8 cm. From these results, we can affirm that in our case study, the Agisoft software is better suited to the calculation of the DTM. However, it should be noted that the processing time with Agisoft (6 h 55 mn) is relatively longer than the time taken with Pix4D (5 h). However, we note that these variations are not obtained on the same points compared to the different models (Figure 11).

Following these results, we opted for the calculation of the EMQ in the different models to better understand the overall precision. The EMQ formula retained after calculating the altitude differences of the sample is given by the following equation:

$$EMQ = \sqrt{\frac{\sum_{i=1}^n (H_i^{drone} - H_i^{level})^2}{n}} \quad (2)$$

With:

$H_i^{drone}$ : Calculated altitude of the  $i$ -th point of the sample.

$H_i^{level}$ : Reference altitude of point  $i$  of the sample.

$n$ : the total number of samples.

The results obtained are recorded in Table 4 and show that the differences are slightly smaller between the reference points with the Agisoft software than with the Pix4D software.

We then evaluated these results obtained by the photogrammetric method with those from the GNSS method. The analysis of the altitude differences in Table 3, Table 4, and Figure 12 shows us that the results obtained with the GNSS method are closer to the reference values obtained by direct leveling and are therefore more precise than those of the photogrammetric method. Indeed, the differences with the GNSS method vary from 6 mm to 10.3 cm. For the overall evaluation of the different models, the RMSE with the GNSS method is 5.83 cm compared to 7.18 cm for Agisoft Metashape and 7.26 cm for Pix4D.

## 5. Discussions

The results of this study allowed us to evaluate the different methods used to obtain a Digital Elevation Model. Our study shows that the accuracy of point clouds varies depending on the methodology and tools used. We used a relatively rugged study area, an abandoned quarry, which does not allow us to generalize the

results. It would be interesting to conduct the same work with study areas with different morphologies (very rugged, rugged, relatively flat, etc.) to gain a better appreciation of the quality between the different tools and methods used.

The unique feature of our study lies in the fact that the reference points were determined using GNSS planimetry and direct leveling altimetry.

Our results can be considered quite satisfactory compared to work carried out in different areas by other authors. For example, Jaouad El Atiq & Abderrazak El Harti [41] obtained a Digital Terrain Model (DTM) of a mountainous area above the road connecting Demnate to Ait Bouguemez, in the province of Azilal, Morocco, using a DJI Phantom 4 RTK drone and Agisoft Metashape software for point cloud processing. The RMSE of 5 cm obtained for this study, relative

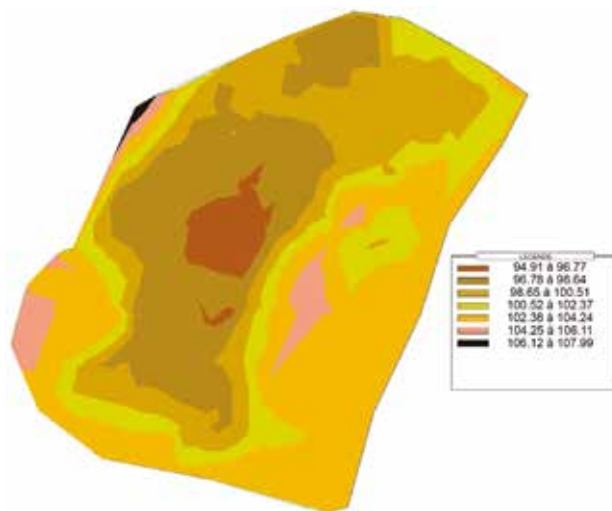


Figure 10. DTM obtained using the GNSS method with Covadis software.

Table 3. Differences between the reference elevations and those obtained from the three methods.

Points	Z_Réf	Z_Agisoft	Z_Pix4D	Z_GNSS	ZAgi-ZRef	ZPix4D-ZRef	ZGnss-ZRef
Cr02	97.423	97.43	97.396	97.484	0.007	-0.027	0.061
Cr04	104.412	104.509	104.498	104.309	0.097	0.086	-0.103
Cr10	98.43	98.402	98.412	98.382	-0.028	-0.018	-0.048
Cr11	97.306	97.273	97.275	97.352	-0.033	-0.031	0.046
Cr13	102.265	102.195	102.199	102.228	-0.07	-0.066	-0.037
Cr17	101.569	101.444	101.483	101.547	-0.125	-0.086	-0.022
Cr18	104.926	104.855	104.798	104.853	-0.071	-0.128	-0.073
Cr21	104.668	104.552	104.557	104.6	-0.116	-0.111	-0.068
Cr23	99.246	99.225	99.208	99.24	-0.021	-0.038	-0.006
Cr25	104.041	104.068	104.079	104.099	0.027	0.038	0.058

to the morphology of the terrain studied, justifies the relevance of our results.

Francisco *et al.* studied the accuracy of Digital Terrain Models on a cut embankment located along the N-340 road, in the province of Almería, southeastern Spain, between the city of Almería and Aguadulce. They used the same flight altitudes (50 m), number of GCPs (10), and software (Pix4d mapper Pro) as our study. Although their study did not use independent measurements to determine the reference altimetry, their result of 4.9 cm RMSE is comparable to ours, which is 7.1 cm for almost the same flight parameters [42]. Dense point clouds from a LiDAR and a UAV in uncovered areas with little vegetation (0 - 20 cm) were used by Salach A. & al [43] to carry out a comparative study of DTMs from reference data surveyed by GNSS-RTK. The results obtained are very close, with 0.11 m for the RMSE of the lidar and 0.14 m for the points of the UAV platform. These results

are within the range of the variation of altitudes calculated within the framework of the different methods used in our study and confirm the relevance of our approach.

Yilmaz, C. S. & al [44] studied the generation of high-resolution digital terrain models from point clouds based on drones. The accuracy of the produced DTM was studied using the test points measured by the GNSS RTK technique. These test points were established in flat areas, sloping areas, and near surface objects; the RMSE obtained is respectively 5 cm, 18.4 cm, and 19.2 cm. The result for the sloping terrain, which is closest to our study area, the abandoned quarry, is twice as high as our calculated RMSE and gives credibility to both our methodology and the results obtained.

## 6. Conclusions

This study allowed us to assess the benefits of using drone technology in surveying, particularly in producing a DTM for a given area. Indeed, our results are very satisfactory when compared to both traditional and GNSS methods. However, we should remain cautious while waiting to test this new technology in study areas with varied morphologies to develop a definitive solution.

However, given the speed, cost, and efficiency offered by this new technology, and the importance of DEMs, which are currently considered commodities, particularly in design projects

(roads, drainage, etc.) and spatial analysis, we recommend its use.

In addition, this study made it possible to combine our conventional surveying practices with modern photogrammetric data processing practices using two software programs (Pix4D and Agisoft), and to quantify the difference between the resulting DEMs.

The production of these results constitutes an encouraging first study for the determination of altimetry and the production of DEMs. Looking ahead, it would be interesting to study them across study areas of different morphologies and sizes using the latest technologies, such as CORS stations and D-RTK2.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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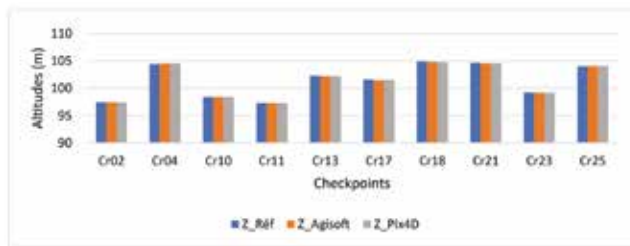


Figure 11. Variations between the altitudes of the drone and the level.

Table 4. EMQ calculated for each method.

SOFTWARE	RMSE	Bias	Standard deviation ( $\sigma$ )	LE95
Agisoft	0.0718	-0.0333	0.0670	0.1314
Pix4D	0.0726	-0.0381	0.0652	0.1277
GNSS	0.0583	-0.0192	0.0580	0.1137

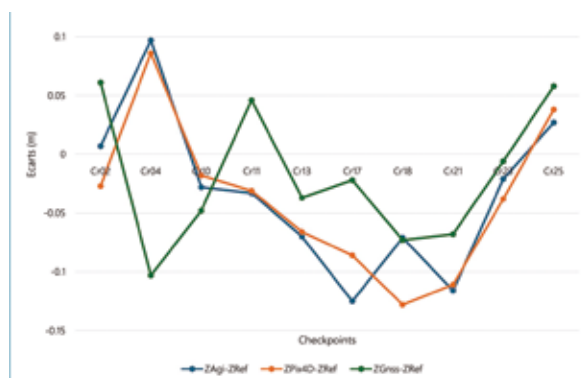


Figure 12. Variations between altitudes with different methods.

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# Permanent survey marks in New South Wales, Australia

This paper outlines the journey of permanent survey marks, from manufacture via distribution and preparation of locality sketch plans through to their initial digital occurrence on public record.



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**D**CS Spatial Services, a unit of the NSW Department of Customer Service (DCS), is responsible for the establishment and maintenance of the survey control network in New South Wales (NSW), which comprises more than 250,000 survey marks on public record made available to users via the Survey Control Information Management System (SCIMS). SCIMS is a relational database built on three elements: the SCIMS database schema, SCIMS2000 (the forms that allow for interaction and workflows), and SCIMS Online (the customer interface).

Permanent Survey Marks (PSMs) are stable and durable marks (uniquely identified by a combination of letters and numbers), providing a direct connection to the Geocentric Datum of Australia 2020 (GDA2020, see Harrison et al., 2024) and the Australian Height Datum (AHD, see Janssen and McElroy, 2021), as legislated by the Surveying and Spatial Information Act 2002. The form and style of PSMs are prescribed by the Surveying and Spatial Information Regulation 2024 (SSIR) and repeated in Surveyor-General's Direction No. 1: Approved Permanent Marks (SGD1, see DCS Spatial Services, 2026).

The SSIR also prescribes the requirements for density, general location and construction for each PSM type. Some PSMs are made up of individual components such as brass plates, screws, cover boxes and pins. DCS Spatial Services takes responsibility for the procurement, sale and distribution of PSM hardware to the surveying industry in NSW.

This paper traces the journey of everyday survey marks, from manufacture and assigning of numbers, via distribution,

preparation of a locality sketch plan and metadata stored on public record, through to their initial digital occurrence in SCIMS, current at the time of writing. While trigonometrical stations are listed as approved PSMs, they are constructed exclusively by public authorities and therefore not discussed here. Similarly, the physical installation and construction techniques, measurements and accuracy determinations are also not covered.

## Form & style of PSMs

The design of PSMs ensures stability and durability in all environments (rural and urban), ease of locating, space for an identifying number, a distinct point for repeatable occupation (horizontally and vertically) and maintains quality during mass production. To achieve this, design drawings that include broad installation instructions were prepared and included in legislative documents, specifically the SSIR and SGD1.

For everyday use, two main types were developed: the State Survey Mark (SSM) and the Permanent Mark (PM). SSMs allow for quicker installation at ground level, generally at street corners along the kerb or footpath. PMs include more substantial marking, particularly in rural situations but also for higher accuracy control traverses, due to higher stability and less likelihood of destruction during construction works.

Urban PSMs (types 2 & 15) were developed for installation in either existing structures (such as already built kerbs, gutters or footpaths) or the same structures while these are

being constructed (Figures 1 & 2). Smaller than their rural counterparts, this allows for easier installation, with only a battery-operated hammer drill, 5 mm masonry drill bit, hammer and epoxy resin required versus core drillers running off generators. This was the main reason behind the development of the smaller PSM type 15 (stainless-steel disc and pin). It should be noted that PSM type 15 should only ever be used in an urban situation, while PSM type 2 (brass plaque in concrete) can be used in either a rural or urban environment.



Figure 1: PSM type 2 (urban & rural SSM).



Figure 2: PSM type 15 (urban SSM).



Figure 3: PSM type 1 (rural & urban SSM).



Figure 4: PSM type 1 in situ.

Rural PSMs were designed to account for not having existing structures for installation, thus being more robust. PSM type 1 (brass plaque in concrete) was designed for the two prongs on its stem to be bent out during installation in the setting concrete, providing mechanical fixing with no bonding agent required (Figure 3). These marks were primarily installed by NSW government agencies during the AHD levelling field work in the 1960s and have stood the test of time (Figure 4).

PSM type 16 (brass plaque in concrete) was developed in response to increased damage to type 1 and 2 PSMs. The ‘nipple’ that defines the height reference point is vulnerable to damage from slashers and lawn mowers, making any previously determined coordinates or height suspect. The metal alloy used in manufacturing type 1, 2 and 16 PSMs is malleable enough for slight modification (a distinct advantage) but can be damaged ‘relatively’ easily. DCS Spatial Services intends to phase out type 1 and 2 PSMs due to this vulnerability, replacing these with type 15 and 16 PSMs. Type 1 and 16 PSMs can also be used in an urban situation, with type 16 having a minimalist design that could be used in town centre streetscapes.

The dome of PSM type 16 still allows for a high point of the mark whilst



Figure 5: PSM type 16 (rural & urban SSM).



Figure 6: PSM type 16 in situ.

minimising its profile and removing the step of the ‘nipple’ (Figures 5 & 6). The size of the type 16 is a combination of both PSM type 1 and type 2, so no change in tools is required for installation. The hole drilled into the stem allows for a nail to be put through to provide mechanical fixing in setting concrete.

PSM types with the PM prefix can also come in a variety of forms but have two consistent features: a cover box and a brass number plate for identification (Figure 7). Each PM type is designed for installation without any existing structures. The plastic cover box was developed to cater for significant cost increases of the cast iron cover box and safety, weighing less than 2 kg versus 7.5 kg per unit. However, the plastic cover box does have the limitation of reduced strength, so it should not be installed in trafficable areas.

Again, different monument types allow for different environments (Figure 8). A galvanised star picket will not last long in coastal environments, soils with high acid sulphate, saline or alkaline levels or even soils with high water content. In these situations, PSM type 4 (stainless-steel pin in concrete) is preferred despite the extra volume of concrete required. PSM type 6 (galvanised star picket in soil) has the advantage of non-bespoke monumentation. As star pickets are readily available from retailers across the state, they are not supplied by DCS Spatial Services and its distributors.

Most surveyors install PSMs in relation to cadastral or infrastructure surveys. Over the years, some PSM types have undergone design evolutions and others have been discontinued entirely (London, 2026). While discontinued PSMs are no longer approved for installation, existing ones (in SCIMS) can still be used as such because they were legally approved at the time of installation.

## Manufacture of PSMs

DCS Spatial Services has an annual operating budget assigned specifically



issued. From mark number 87,200 onwards, the number is unique (i.e. if there is an SS212100, there cannot be a PM212100), primarily due to occurrences of the same number but different mark types being located very close to one another and causing confusion. In this context, it should be noted that SSMs are referred to as SS in SCIMS, due to the SCIMS schema only allowing 2-digit identifiers for the mark type.

For PSM type 1 and 2, an auto-advancing sequential 6-digit stamping



Figure 10: PSM type 1 mould topside.



Figure 11: Sand blocks with molten alloy poured.



Figure 12: Stack of freshly cast type 16 PSMs ready for final staging.

die is utilised. A jig is used to seat each SSM in place for orientation, then a hydraulic press pushes the die onto the SSM with a set force. As the press lifts, the number is advanced by one.

PSM type 16 has added complications because no auto-advancing dies exist to enable an even stamp into its curved surface. DCS Spatial Services had specific tooling manufactured to seat individual number stamps with shims to correctly orientate the stamp (Figures 13). Again, a jig is used to individually seat the SSM at the correct orientation, and then a hydraulic press is used to push the stamps down. As the press is lifted, an operator must manually replace the current digit(s) with the next number(s).

### Type 15 SSM manufacture

PSM type 15 development was based on an existing product used for marking by various industries. The general design of a stainless-steel washer and nail with unique features stamped into the disc has been used in marking footpath seating limits for outdoor eating, identifying the location of underground utilities and as boundary and cadastral reference mark tokens. The type 15 is unique because it includes an individual number for each disc and a hole drilled into the head of the nail to allow for seating of a surveyor's pole.

The first batches of type 15 PSMs were created using dies to cut and stamp in the one process. The nails are modified off-the-shelf products with the recess drilled into the top as per specifications. The most recent

batches saw a different supplier and technique with Computer Numeric Control (CNC) cutting and engraving used for the manufacture of the discs.

### PM brass number plate & screws

The brass number plate used for PMs was traditionally created from bar stock with the countersunk holes drilled into them on jigs. Once the blank plates were received, they were sent off for stamping as per the process outlined earlier. This required two lots of procurement for the two different activities and suppliers. The most recent batches have used CNC cutting and engraving with one supplier. The bar stock is placed into jigs for seating during engraving (Figure 14).

These brass plates are also procured for Cadastral Reference (CR) marks having a cover box placed over them and a number allocated for inclusion in SCIMS. The number range of 500,000 to 599,999 has been assigned to CR marks exclusively for ease of identification. It is not intended for all CR marks to be included in SCIMS (as we would quickly reach 7-digit figures), but there are special cases warranting their inclusion. Number plates can also be generated ad-hoc for SSMs that have ended up being covered due to construction or general build-up of material. In these cases, a cover box can be placed at ground level over the top of the SSM and the number identified on a plate.

The screws used for affixing the brass plate to the lid of the cover box are 5/16 British Standard Whitworth (BSW) thread at a 1/2 inch length, with a flat-head screwdriver groove. Not being a common off-the-shelf product, they are made via machining from bar stock of either 316-grade stainless-steel or brass. The stainless-steel option is used for harsher environments with increased probability of corrosion (due to the adhesion of the screw with the cast iron rather than the number plate corroding).

## Type 4 PM stainless-steel pin

The 200 mm long stainless-steel pin used for PSM type 4 is created from a 316-grade stainless-steel bar with a machining jig to cut the shape, rotating at high speeds with a lubricant to keep the product cool. This method is very common and used in a variety of manufacturing processes, hence the product has been sourced from several different suppliers (Figures 15).

## Cast iron cover box

The cast iron cover boxes used for PMs and other marks are manufactured in a similar process to the type 1, 2 and 16 PSMs. Because of their weight and size, they are not stocked in large quantities at distributors and instead kept in backorder at the supplier. They are delivered to distributors in crates of 50, weighing around 375 kg and representing its own challenge

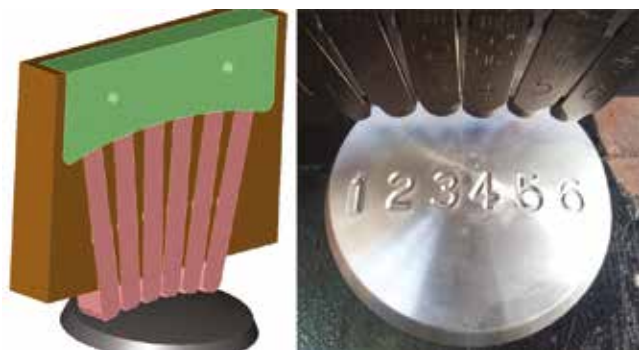


Figure 13: Stamp press block design (left) and proof of concept (right) for stamping a PSM type 16.

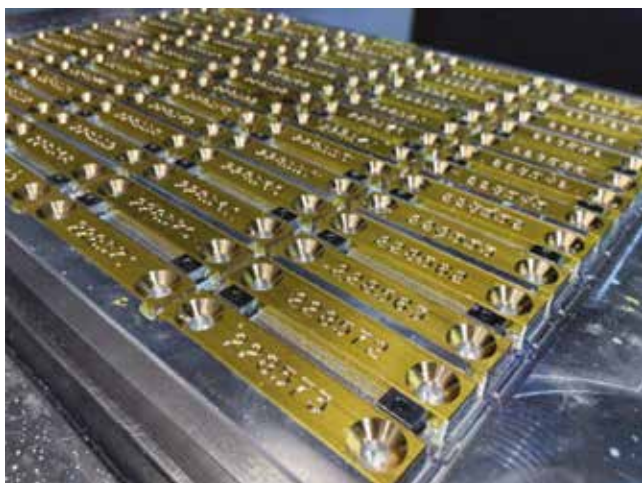


Figure 14: Jig and final product for PM number plates.



Figure 15: PSM type 4 stainless-steel pin (the domed top with a hole drilled into it for seating a surveyor's pole can be seen on the right).

in manoeuvring and storing. Consequently, DCS Spatial Services does not deliver cast iron cover boxes, and they are only available via pick-up from a distributor. For large orders, we recommend ordering a crate of 50 delivered directly to an organisation if storage capacity is available.

## Plastic cover box

Plastic cover boxes are manufactured using injection moulding. Similar to the casting process, there are initial set-up costs to create the mould. The difference in the moulds for plastic injection is that rather than the mould being one piece creating a cavity in the sand, the plastic moulds are two pieces squeezed together to create a void within the mould to be filled. As we have two separate components to a cover box (i.e. box and lid), there are a total of four moulds.

Plastic pellets are dried, heated and compressed to a molten state and pushed into the moulds. The plastic has additives introduced for colour and ultra-violet light stabilisation. The box and lid are then drilled out for the introduction of a hinge, for which a stainless-steel pin is used to help find the monument with a metal detector when obscured by grass or soil.

## Distribution of PSMs

PSM hardware is distributed and sold through DCS Spatial Services regional offices or partnered local private firms, with the SCIMS team under the Office of the Surveyor-General responsible for overall coordination. The full list of distributors is maintained as an appendix in SGD1 and subject to change regularly. The current price list is updated at the start of each financial year and available on the DCS Spatial Services website.

Customers order hardware either by emailing the SCIMS team or contacting the local distributor. Payment is made by account system with invoices emailed on a monthly basis. For each order, a mark issue spreadsheet is prepared by the distributor, recording the customer and hardware ordered and including calculations with checks in place to ensure correct quantities. The data entry for numbered marks is for the first and last numbers issued, with the quantity automatically calculated.

These mark issue sheets are then sent to the SCIMS team for entry into the Survey Services Database (SSDB), which not only records who PSMs were issued to and at what cost but also generates the sales file for uploading into the accounting system that automatically sends out the monthly invoices. The SSDB is also used for tracking general distribution (where stock is) and to record when a Locality Sketch Plan (LSP) has been received for an issued mark.

The SSDB has gone through many versions over the years, starting out as a spreadsheet, transitioning to a relational database built in Microsoft Access with macros, and is now a Microsoft PowerApps application. Since financial year 2017-18, on average 2,960 numbered marks are distributed to industry per year (23,700 total to financial year 2024-25). In the same time period, we received an average of 2,415 LSPs from industry (19,326 total to financial year 2024-25).

## LSPs and SCIMS initialisation

The SSIR requires that the Surveyor-General be notified within 2 months of the placement of a new PSM or by the same day a plan is lodged for registration (generally via LSP lodgment to the SCIMS team). Guidelines for the preparation and lodgment of LSPs can be found in Surveyor-General's Direction No. 2: Preparation of Locality Sketch Plans (SGD2). LSP forms and templates in different electronic formats are available on the DCS Spatial Services website (DCS Spatial Services, 2026).

LSPs provide connection to real-world features to help locate the survey mark. They are extremely useful for finding marks in rural and remote areas, especially when dealing with a lack of mobile phone coverage or low sky visibility limiting the use of real-time positioning services. The main advantage of LSPs in urban environments is determining if the mark has been relocated or disturbed (changes in the surrounding features and the measurements to those are strong indicators).

The SCIMS team performs quality assurance on the submitted LSP, including:

- Does the mark already exist in SCIMS?
- Does the LSP comply with SGD2 specifications, i.e. could someone find the mark from the information given?
- Is the LSP free of errors?
- Has the LSP been submitted by the same organisation that purchased the mark?
- Converting the supplied file into the

required format and specifications (\*.tiff, black & white, 200 dpi).

- Ensuring the file name matches the mark type and number.

The SCIMS team then uses EDMARK, an in-house mapping product, to plot the new mark. This provides quality assurance on the correctness of the information supplied on the sketch, such as coordinates, street names and suburb. EDMARK also enables calculation of a height value from the statewide Digital Elevation Model (DEM), helping to validate the height value supplied or providing a height when none was supplied.

The plotted marks first sit in a staging table within SCIMS2000 and are checked again by another staff member to ensure no gross errors are present (e.g. incorrect sketch loaded for a particular mark). Then they are loaded into SCIMS, allowing the public to order the mark's coordinates and LSP through SCIMS Online or associated webservices and (mobile) applications.

All marks plotted with EDMARK have the one source ID (job number) in SCIMS and are given an accuracy Class U (i.e. unknown) both horizontally and vertically. This intentionally low accuracy classification reflects the fact that the coordinates supplied have not gone through a rigorous least squares network adjustment to determine Class and Positional Uncertainty (PU).

In this context, it should be noted that customers have the opportunity (and are encouraged) to submit static Global Navigation Satellite System (GNSS) datasets of at least 2 hours duration collected on the new mark to DCS Spatial Services via its Customer Hub for inclusion in the monthly SCIMS update based on AUSPOS, Geoscience Australia's free online Global Positioning System (GPS) processing service (Maile et al., 2026). Assuming sufficient data quality and appropriate sky view conditions, this generally results in updating the coordinates and accuracy classification of the mark to Class D (i.e. established

in a cadastral context) in a timely manner (Janssen and McElroy, 2022).

Once stored in SCIMS, the team completes the remaining metadata entries for the new mark in SCIMS2000 and the SSDB. This includes date placed, placed by (organisation), monument type (generally PSM type), monument location (generally ground level) and LSP date.

Sometimes the first notification of the placement of a PSM occurs when DCS Spatial Services is processing a Deposited Plan (DP) for entry into the Digital Cadastral Database (DCDB). The coordinate schedule on the plan identifies the PSMs shown on the plan and issued to accurately plot the boundaries. If the PSMs shown in the coordinate schedule are not present in SCIMS, this is flagged with the DCDB team and results in the SCIMS team being notified. The SCIMS team then uses the DP information to plot the mark and sends a request to the surveyor for the submission of an LSP. If a surveyor comes across a PSM in SCIMS and discovers that no LSP is available, no LSP has been submitted by the organisation or surveyor that placed the mark. If such a mark is observed, it is good practice to produce and submit an LSP of the mark found.

Early LSP forms did not have fields for coordinates, so the initial coordinates would be scaled off topographic maps. Due to scaling errors, some marks were mis-plotted, sometimes by hundreds of metres. If one of these marks is discovered, the revised spatial position can be supplied to the SCIMS team either via a mark status notification or submission of an updated LSP. The team will then use EDMARK to update the mark's coordinates and load the updated LSP.

## Conclusion

PSMs are an integral piece of infrastructure for NSW, providing the connection to a common datum for the work undertaken by a multitude of industries. What appears like a simple piece of brass on the street corner is actually

highly complicated. This paper has outlined the journey of everyday survey marks, from manufacture and assigning of numbers, via distribution to surveyors, preparation of a locality sketch plan and metadata stored on public record, through to their initial digital occurrence in SCIMS. The form and style of PSMs is continuously evolving, and DCS Spatial Services welcomes any feedback on potential improvements or alternatives to consider.

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## ISRO and JAXA gear up for joint Chandrayaan-5

During May 13-14, 2025, ISRO, India and JAXA, the space agency of Japan, jointly conducted the third face-to-face Technical Interface Meeting (TIM-3), towards the Chandrayaan-5/LUPEX mission, in ISRO Headquarters, Bengaluru. The meeting was attended by senior officials, project executives, and technical team members from ISRO, JAXA, and the Mitsubishi Heavy Industries (MHI), Japan.

Following the legacy of Chandrayaan-1, Chandrayaan-2 (orbiter-based lunar exploration), Chandrayaan-3 (lander-rover based in-situ exploration) and the forthcoming Chandrayaan-4 (India's first lunar sample return mission), the Chandrayaan-5 / LUPEX (LUNar Polar EXploration) mission will be the fifth mission in the Chandrayaan series of lunar missions, in collaboration with JAXA, to study the lunar volatile materials, including lunar water, in the vicinity of a Permanently Shadowed Region (PSR) in the lunar South pole. The mission will be launched by JAXA onboard its H3-24L launch vehicle, carrying the ISRO-made lunar lander, which will carry the MHI, Japan-made lunar rover. ISRO, apart from developing the lunar lander, is also responsible for developing a few scientific instruments for the mission. The scientific instruments for this mission would be contributed by ISRO, JAXA, ESA and NASA, all thematically connected with the exploration and in-situ analysis of the volatiles reserved in the lunar polar region. [www.isro.gov.in](http://www.isro.gov.in)

## Australia to launch first zero-gravity scientific flight team

Australia will fly its first zero-gravity scientific research team on a large crewed parabolic flight in October this year, following a landmark agreement between the French Space Agency CNES and The University of Western Australia. The partnership will see sovereign Australian experiments conducted aboard Novespace's Airbus A310 Zero-G, the world's largest civilian microgravity research platform. The

team, drawn from UWA's International Space Centre, will carry an experiment designed to advance the extraction of fuel and fertiliser from off-Earth resources, a capability central to the long-term viability of human space exploration.

The campaign comprises three zero-gravity flights, offering a total of 93 parabolic manoeuvres, each delivering up to half a minute of weightlessness, allowing the team to observe and adjust its experiment in a near zero-gravity environment. [www.uwa.edu.au](http://www.uwa.edu.au)

## China launches PRSC-EO3 for Pakistan

China took its total launches this year to 26 over the weekend, with a trio of flights of legacy and newer Long March rocket models. The activity saw the launch of a remote sensing satellite for Pakistan, the lofting of four new satellite internet technology test satellites, and a further launch carrying an environment monitoring satellite. A Long March 6 rocket lifted off at 8:15 a.m. Eastern (1215 UTC) April 25 from Taiyuan Satellite Launch Center, northern China. Aboard was the PRSC-EO3 satellite equipped with a high-resolution optical payload, developed by the Pakistan Space and Upper Atmosphere Research Commission. [spaceneews.com](http://spaceneews.com)

## Developing satellite-enabled biodiversity risk solution

CATALYST (PCI Geomatics) and DUAL have successfully completed a pilot project that uses satellite imagery and artificial intelligence to assess biodiversity risk across the United Kingdom. Funded through the UK Space Agency's Unlocking Space for Business programme, the project was delivered over six months by DUAL's climate risk and resilience team. The collaboration produced a scalable biodiversity assessment platform designed to support insurance underwriting, Environmental, Social and Governance (ESG) reporting and regulatory compliance. <https://catalyst.earth/> 

## Restrictions for drones near critical infrastructure sites

The U.S. Federal Aviation Administration (FAA) has issued a proposed rule that would allow specific categories of critical infrastructure sites to apply for restrictions on drone operations around their facilities. Sixteen sectors would be eligible for restrictions including energy production, transportation systems, chemical facilities, water treatment plants, and defense industrial complexes.

The rule would establish two types of restrictions:

1. Standard Unmanned Aircraft Flight Restriction (UAFR): A general restriction that bars unmanned aircraft operations within a specific boundary, except for operators who have previously met rigorous safety and security standards.
2. Special Unmanned Aircraft Flight Restriction (UAF): A much more severe restriction that bars unmanned aircraft operations within a specific boundary for all operators unless they have the express prior approval from both the FAA and the sponsoring agency (for example, the Department of Homeland Security).

The restricted area would have clearly defined horizontal and vertical boundaries. Violators could face civil or criminal penalties. The rule would also allow site operator to contact law enforcement if a drone flew in a restricted area, after which authorities can use Remote ID to locate the control station or operator. Pilots could face license suspensions, revocations, fines and criminal charges for entering these no fly zones. [www.faa.gov](http://www.faa.gov)

## UAV Navigation launches Vector-300

UAV Navigation has launched the Vector 300 - a highperformance autopilot, which is designed to meet the industrial and operational requirements of massproduced, attritable unmanned aerial systems, with a clear focus on loitering munition and Counter-UAS (C-UAS) interceptor applications.

Vector300 has been engineered to combine advanced autonomous guidance, navigation and control (GNC) capabilities with scalability and manufacturability. Its architecture is designed to reduce technical complexity and enable agile, largescale production while ensuring consistent and reliable performance across highvolume deployments. [www.uavnavigation.com](http://www.uavnavigation.com)

## South Korean military eyes AI-powered platform

South Korea's military is moving to build an artificial intelligence-powered platform that integrates and analyzes national geospatial and satellite data, in a bid to enable more data-driven operations across the battlefield. The envisioned system would support the full operational cycle — from intelligence, surveillance and reconnaissance to target identification, situational awareness and battle damage assessment — by applying AI to large volumes of spatial and imagery data.

The initiative comes as the operating environment for geospatial intelligence rapidly evolves, driven by advances in commercial satellite resolution, the expansion of civilian small-satellite constellations and improvements in AI-based image analysis. While the military already has access to a range of spatial and satellite data, officials said the lack of integration for operational use has driven the push for a unified platform.

Through the study, the Army plans to propose a platform structure that automates the collection, processing, analysis and visualization of geospatial and satellite data, while ensuring compatibility with existing military command and control networks. The research will also include developing AI models capable of automatically detecting changes in specific areas, as well as building a web-based prototype service platform. <https://asianews.network>

## NASA's prithvi becomes first AI geospatial foundation model in orbit



Florida as seen from the International Space Station. A NASA geospatial AI foundation model was deployed to a platform aboard the space station for the first time, unlocking new opportunities for Earth observation. NASA

A team of researchers from Adelaide University, ESA (European Space Agency) Φ-lab, Thales Alenia Space, and the SmartSat Cooperative Research Center in South Australia has successfully uploaded and demonstrated NASA and IBM's open-source Prithvi Geospatial artificial intelligence (AI) foundation model aboard two in-orbit platforms, making it the first geospatial foundation model to be deployed in orbit. Trained on 13 years' worth of data, Prithvi can facilitate a wide variety of Earth observation tasks.

By uploading a compressed version of Prithvi to the South Australian government's Kanyini satellite and to the Thales Alenia Space IMAGIN-e (ISS Mounted Accessible Global Imaging Nod-e) payload aboard the International Space Station,



Prithvi's demo prediction of burn scars from the Gifford Fire, which occurred northwest of Los Angeles on August 17, 2025. When deployed aboard an Earth-observing satellite, foundation models can perform advanced analyses before the data even reaches the ground. NASA

the researchers tested the model's flood and cloud detection performance across two different orbiting platforms and computing environments. The team shared their results in a preprint article.

The team chose Prithvi for their research because of its strong generalization across Earth observation tasks, and because of its availability as an open-source model.

"If Prithvi weren't open source, I would have to train my own foundation model," said Dr. Andrew Du, the project's lead researcher, who is a postdoctoral researcher at Adelaide University and an AI engineer at the SmartSat Cooperative Research Center. "Having that model openly available saved a lot of time and effort."

A foundation model is an AI model trained on an enormous amount of unlabeled data, which allows the model to begin detecting patterns in the data that humans wouldn't notice on their own. The model can then be fine-tuned for specific applications using much smaller amounts of labeled data.



*Flooding around Lake Norman in North Carolina caused by Hurricane Helene on October 7, 2024. The blue areas of the image are the Prithvi foundation model demo's prediction of the extent of the flooding. NASA*

"Prithvi is the first model of its kind to be deployed in orbit, and that demonstrates exactly why we make our AI models open source," said Kevin Murphy, chief science data officer at NASA Headquarters in Washington, whose office led the collaboration that created Prithvi. "By sharing these tools with anyone who wants to use them, we accelerate scientific and technological development into the future."

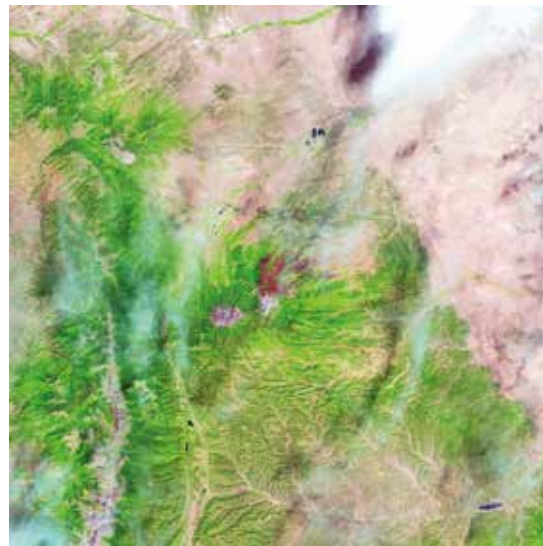
Developed by a team of data scientists from IBM and NASA's IMPACT AI team within the Office of Data Science and Informatics at NASA's Marshall Space Flight Center in Huntsville, Alabama, the Prithvi Geospatial model was trained on the Harmonized Landsat and Sentinel-2 dataset. This dataset compiles over a decade of global geospatial data from NASA's Landsat and ESA (European Space Agency) Sentinel-2 satellites. Prithvi can be adapted for tasks such as mapping flood plains, monitoring disasters, and predicting crop yields.

By sharing these tools with anyone who wants to use them, we accelerate scientific and technological development into the future.

#### **KEVIN MURPHY**

*NASA Chief Science Data Officer and Acting Chief Data Officer/Chief AI Officer*

Earth-observing satellites collect enormous amounts of data about our planet. Processing and analyzing the data in orbit before the satellite sends it back to Earth can help researchers gain insights more quickly. However, active satellites often can't accept large software updates because of bandwidth limits, so the AI



*On June 22, 2013, the Operational Land Imager (OLI) on Landsat 8 captured this false-color image of the East Peak fire burning in southern Colorado near Trinidad. Burned areas appear dark red, while actively burning areas look orange. Dark green areas are forests; light green areas are grasslands. Data from Landsat 8 were used to train the Prithvi foundation model, which can help detect burn scars. NASA Earth Observatory*

models they carry for data analysis tend to be lightweight and highly specialized.

Researchers can use the flexibility of a foundation model to facilitate a wide range of Earth observation tasks in one software architecture. If they want the model to take on a new task once the satellite is in orbit, they only need to upload a small extra decoder package – using far less bandwidth than uploading a whole new model to the satellite.

Sending Prithvi to orbit is an early demonstration of how foundation models could transform Earth observation. In addition to data analysis, foundation models could eventually help scientists interact with the instruments collecting the data.

"A large language model is also a type of foundation model," Du said. "In the future, this could allow operators to interact with satellites in natural language, asking questions about onboard data or system status and receiving responses in a conversational way."

The NASA team behind Prithvi continues to work on open-source foundation models trained on NASA data. A heliophysics model, Surya, was released in 2025, and the team intends to create foundation models for planetary science, astrophysics, and biological and physical sciences as well.

The Prithvi Geospatial foundation model is funded by the Office of the Chief Science Data Officer within NASA's Science Mission Directorate at NASA Headquarters in Washington. The Office of the Chief Science Data Officer advances scientific discovery through innovative applications and partnerships in data science, advanced analytics, and artificial intelligence. To learn more about NASA's AI foundation models and other AI tools for science, visit:

**By Lauren Leese**

*Web Content Strategist for the Office of the Chief Science Data Officer*

<https://science.nasa.gov> 

## Measuring water levels with cm-level accuracy using GNSS-IR

Researchers at the Institute of Geodesy and Geoinformation at the University of Bonn, led by Dr. Makan Karegar, have transferred water-level monitoring technology from the Rhine to Africa, Australia, and the Philippines as part of ESA projects. Originally developed in the DFG Collaborative Research Center SFB 1502 (DETECT), the technology enables continuous, freely accessible monitoring of inland and coastal waters in data-poor regions worldwide.

The technological centerpiece is the Raspberry Pi Reflector (RPR), a compact, solar-powered sensor developed at



**Image Credit:** Makan Karegar/University of Bonn

the University of Bonn. Using Global Navigation Satellite System Interferometric Reflectometry (GNSS-IR), it measures water levels with centimeter-level accuracy (<https://www.uni-bonn.de/en/news/272-2022>).

Only a portion of the signals emitted by the GNSS satellites is directly captured by the antenna. The rest is reflected by the water surface and reaches the receiver via this detour. When superimposed with the directly received signal, it forms specific patterns known as interference patterns. These can be used to calculate the distance from the antenna to the water surface.

The CAMEO-WAGST project (“Cameroon Advanced Measurements for Enhanced Observations of Water levels using Affordable GNSS-IR and Sentinel-3 & 6 Technology”) has established the first dedicated GNSS-IR network for monitoring water levels along coasts and rivers in

Cameroon and was funded by the European Space Agency (ESA). Between May and June 2025, researchers, in collaboration with Dr. Loudi Yap, director of the Research Laboratory in Geodesy at the National Institute of Cartography, installed eight RPR sensors in Cameroon—two on the Sanaga River and six along the coast. “A lack of infrastructure for reliable hydrological and coastal monitoring in Cameroon has so far hindered effective flood risk management and early warning systems,” said Yap.

This collaboration, under the umbrella of the EO Africa Research and Development Facility, is already bearing fruit, says

Dr. Roelof Rietbroek, research coordinator at ESA’s EO Africa R&D Facility. “We hope this paves the way for more reliable monitoring of flood-prone regions in Africa.”

Building on this success, the follow-up project St3TART-FO was launched in collaboration with the European Space Agency. A total of 17 RPR sensors will be installed in seven countries, including West Africa, Australia, and the Philippines. “The goal is to create a freely accessible reference measurement network for calibrating satellite data,” says Karegar. For the first time, the network will provide continuous water-level data at previously unmonitored locations.

The collaboration is based on years of scientific exchange between Africa and Europe. Partners include the International Institute for Water and Environmental Engineering (2iE) in Burkina Faso, the National Institute of Cartography in Cameroon, Ghana’s Environmental Protection Authority (EPA), the Nigeria Hydrological Services Agency (NiHSA) and the University of Maiduguri in Nigeria, Assane Seck University of Ziguinchor

in Senegal, the University of Southern Queensland in Australia, and the University of the Philippines Diliman. [www.uni-bonn.de](http://www.uni-bonn.de)

## Protect civil aircraft in conflict zones say UN aviation chief

The International Civil Aviation Organization (ICAO) is calling for stronger measures to protect civilian aircraft from military threats, revealing that the risk of weapons targeting civilian planes grows worldwide.

ICAO Secretary General Juan Carlos Salazar informed delegates at the 2026 World Overflight Risk Conference in Vallarta, Malta, that emerging military technologies—including long-range weapons systems, unmanned aircraft systems (UAS), global navigation satellite system radio frequency interference, and advanced air defence systems—pose risks to civilian aviation. While praising the aviation industry’s ability to reroute flights and maintain operations during the recent Middle East crisis, Salazar stressed that operational flexibility alone cannot address the fundamental security threat posed by weapons systems.

Salazar commended States and airspace users for the measures implemented to mitigate the safety and security risks posed due to the escalated situation in the Middle East. He noted that more than 10 States had partially or fully closed their airspace, which also significantly impacted international air transport. He pointed to ICAO Assembly Resolution A42-4 and Article 3 bis of the Chicago Convention, which explicitly prohibits the use of weapons against civilian aircraft, as the legal foundation for demanding better protection. However, he acknowledged that international law alone has proven insufficient as regional conflicts intensify.

ICAO is finalizing a Global Crisis Management Framework to coordinate responses when civilian aviation faces threats, but Salazar emphasized that this reactive framework must be paired with proactive measures to prevent attacks on civilian aircraft. [www.icao.int](http://www.icao.int)

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### Trimble Technology enables first centimeter-accurate 3D model

Trimble has announced its continued support of Project Pressure by providing advanced GNSS positioning technology and research funding for the nonprofit organization's latest expedition to map the disappearing tropical glaciers of Puncak Jaya in Papua, Indonesia.

Project Pressure has released a centimeter-accurate, 3D model of the receding ice, created using Trimble positioning technology and drone-based photogrammetry. The model establishes a scientific baseline for calculating the rate of glacier recession and projecting the timeline of disappearance. Local communities also use the data to make informed choices about crop selection and prepare for expected water shortages caused by the loss of these vital reservoirs. This expedition marks the third successful outing in Project Pressure's Melting Topics series, which focuses on mapping equatorial glaciers. [www.trimble.com](http://www.trimble.com)

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### Savvy Navvy expands global chart coverage

Savvy Navvy has developed an in-house approach to processing and reconciling fragmented hydrographic data — combining official hydrographic data with expert geospatial data analysis to scale chart coverage faster and with greater accuracy.

The latest rollout adds more than 2,200 U.S. lakes and extends coverage into Estonia, Lithuania and Latvia in Europe, opening more waterways for boaters across the globe to explore. This comes not long after Danish charts from hydrographic offices were also added to the navigation app. [www.savvy-navvy.com](http://www.savvy-navvy.com)

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### ArkEdge Space delivers JAXA study on LEO PNT system

ArkEdge Space Inc., a Tokyo-based space start-up delivering end-to-end micro-satellite constellation solutions from design to operations has completed a study commissioned by JAXA on

“Elemental Technologies and Systems for a Dedicated, GNSS-Independent LEO-PNT Satellite System.”

Positioning, Navigation and Timing (PNT) - a critical infrastructure is increasingly subject to interruption and interference, both through environmental and security challenges. This project addressed such challenges by examining and categorizing the necessary elemental technologies, including signal design, receiver technology, ground infrastructure, satellite sensors, and the overall system architecture required to realize a LEO-PNT system capable of providing PNT without reliance on traditional GNSS.

The study's focus included achieving satellite orbit determination and time synchronization (ODTS) without GNSS, one of the key challenges facing alternative PNT providers. To address this, the study explored a new architecture for onboard time determination that avoids the need for large atomic clocks. [arkedgespace.com](http://arkedgespace.com)

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### Telit Cinterion integrates Swift's Skylark into IoT positioning solution

Telit Cinterion will offer Swift Navigation's Skylark Precise Positioning Service as part of an integrated IoT positioning solution. This service is available with Telit Cinterion's dual-frequency GNSS modules and NExT cellular connectivity. IoT customers gain one source for the hardware, connectivity and Skylark Dx correction data needed for sub-meter positioning. [www.telit.com](http://www.telit.com)

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### NPL and Vodafone collaborate on terrestrial timing

The National Physical Laboratory (NPL) and Vodafone have successfully completed a set of trials using the NPLTime service as an alternative to GPS-timing signals.

Requirements for precise time delivery have driven the telecoms sector toward the increased use of GNSS for accurate timing. There are various alternatives to GNSS, each with their own capabilities, but

GNSS has become the default mechanism for most sectors to access timing signals.

As the telecommunications industry rolls out 5G networks and prepares for 6G, it's important there is a range of diversified timing signal sources that are resilient and secure. All major telecommunications providers in the UK and Europe share this requirement. [www.npl.co.uk](http://www.npl.co.uk)

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### NAL Technologies unveils ALTM-T for precision timing

NAL Technologies (Naltec has added to its Alternative Location and Timing Module (ALTM) family with ALTM-T. It is engineered for applications and infrastructure demanding precise location, timing and synchronization redundancy with other APNT sources.

ALTM-T is an ultra-low size, weight and power (SWaP) receiver optimized for precision timing at <50ns RMS. It also conforms to the M.2 3042 B-key standard form factor and uses less than 600MW consumption, making it suitable for SWaP-constrained systems. [naltec.com](http://naltec.com)

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### TrustPoint secures U.S. Space Force TACFI contract

TrustPoint has been awarded a \$4 million Tactical Funding Increase (TACFI) contract to demonstrate a first-of-its-kind GPS-independent PNT system. The award, issued by SpaceWERX, the innovation arm of the United States Space Force, and jointly funded by the Small Business Innovation Research (SBIR) program and the Commercial Space Office (COMSO), supports a full end-to-end demonstration of TrustPoint's resilient navigation architecture designed for defense and commercial applications.

Under the contract, TrustPoint will design, deploy, and operate a fully integrated PNT system comprising four satellites and four ground stations, delivering a complete operational architecture. The program will execute an end-to-end system demonstration, including live trilateration across multiple space and

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## MARK YOUR CALENDAR

### June 2026

#### ICCGIS 2026

14 - 19 June

Nessebar, Bulgaria

<https://iccgis.cartography-gis.com>

#### 4<sup>th</sup> Geospatial & Space Technology MENA Forum

24 - 25 June 2026

Dubai, United Arab Emirates

<https://menageospatialforum.com>

### July 2026

#### XXV ISPRS Congress

4 - 11 July 2026

Toronto, Canada

[www.isprs2026toronto.com](http://www.isprs2026toronto.com)

### August 2026

#### 13<sup>th</sup> IGRSM Conference 2026

05 - 06 August

Kuala Lumpur, Malaysia

<https://conferences.igrsm.org>

### September 2026

#### ION GNSS+ 2026

14 - 18 September

Orlando, Florida, USA

[www.ion.org](http://www.ion.org)

#### Intergeo 2026

15 - 17, September

Munich, Germany

<https://dvw.de/intergeo/en>

#### 21st International 3D Geoinfo Conference

28-29 September

Sofia, Bulgaria

<https://gdmc.nl/3DCadastres/workshop2026>

### October 2026

#### 14th International FIG Workshop on the Land Administration Domain Model & 3D Land Administration

1-2 October

Sofia, Bulgaria

<https://gdmc.nl/3DCadastres/workshop2026>

#### 3rd Annual International Geotechnical Innovation Conference

12 - 13 October

Jeddah, Saudi Arabia

<https://geotechnicalinnovationconference.com>

### November 2026

#### United Nations World Geospatial Information Congress (3rd UNWVIC)

16-19 November

Jeddah, Saudi Arabia

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

#### Geoworld

23 - 26 November

Dubai, UAE

<https://www.geoworldevent.com>

ground assets, operational services, and advanced receivers. [trustpointgps.com](http://trustpointgps.com)

## DNK offers program to protect ships from GNSS interference

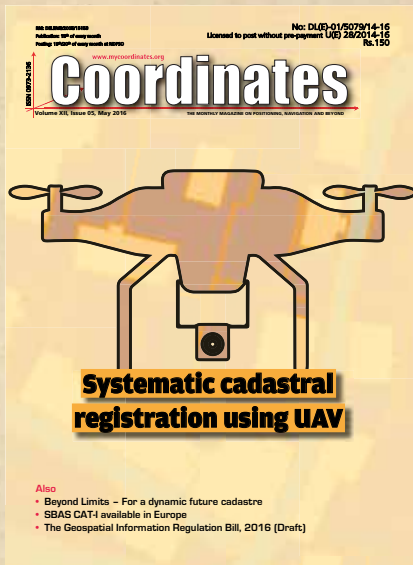
Norwegian insurer DNK will provide members with assured positioning, navigation and timing (A-PNT) services using Iridium Communications' low-Earth orbit satellite network. DNK, Den Norske Krigsforsikring for Skib, specializes in war-risk insurance. The new program allows its clients to select systems from specialized technology vendors to protect against GNSS interference while qualifying for insurance premium rebates. The framework aligns with DNK's aim of using digital technologies to safeguard Norwegian-owned or controlled vessels from war, terror, piracy and cyberattacks. DNK evaluated alternative positioning frameworks based on Iridium's global network of 66 low-Earth orbit (LEO) satellites. The vendors participating in the program offer subscription-based hardware systems with a configuration including an Above Deck Unit that transmits jamming and spoofing telemetry back to DNK, alongside an optional Below Deck Unit that provides real-time situational awareness directly to the vessel crew. [www.warrisk.no](http://www.warrisk.no)

## BeiDou spatiotemporal industry reaches \$195 billion in 2025

China's BeiDou spatiotemporal industry achieved a total output value of 1.33 trillion yuan (about \$195 billion), marking a milestone in a new stage of high-quality growth, according to a report released on Monday by the Global Navigation Satellite System (GNSS) and Location Based Services (LBS) Association of China. The BeiDou spatiotemporal industry is a comprehensive system centered on the BeiDou Navigation Satellite System (BDS), integrating technologies such as remote sensing and geographic information systems (GIS), mobile communications and indoor positioning. Within this industry, the satellite navigation sector – the core of BeiDou – generated 629 billion yuan (about \$92 billion) in 2025, up 9.24% year on year, demonstrating strong resilience and significant growth potential. [cgtn.com](http://cgtn.com)

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## SBAS CAT-I available in Europe

Pedro Pintor, Teodoro Seoane, Ridha Chaggara and Roberto Roldán  
ESSP-SAS, Spain

In the first semester 2015, the EGNOS service provider, ESSP, deployed EGNOS System Release (ESR) v2.4.1M. This new ESR was the last step before declaration of EGNOS SoL LPV200 service level on the 22nd September 2015. For the first time, an equivalent CAT-I service based on SBAS in Europe is achieved. LPV200 service brings improvement in the existing Air Navigation capacities and infrastructure in Europe enabling the implementation of the PBN concept in Europe within the Single European Sky and the ICAO Global Air Navigation Plan.

## Beyond Limits – For a Dynamic Future Cadastre

Daniel Steudler on behalf of Think Tank "Dimension Cadastre", Switzerland

The virtual world has for many years been used mainly for special effects on big screens and will increasingly be used in the future, whether for activities via webcams or via applications for smart devices. There are three key elements that play a role in this: first, the Internet provides a common platform and simplifies the communication between systems that were previously incompatible; second, the introduction of geo-localisation via global navigation satellite systems means that any location can be viewed and accessed in real time and at any time; and third, visual recognition makes it possible to remotely identify, for example, the names of mountains, sites and monuments. The combination of these key elements makes it possible to bring more or less complex datasets and images onto the screen.

## Systematic cadastral registration using UAV technology

Prof Dr Murat MEHA

CEO, Kosovo Cadastral Agency, a University Professor and Head of the state Border Demarcation Commission, Kosovo

Kathrine Kelm

Senior Land Administration Specialist, World Bank

Muzafer Çaka

Kosovo Cadastral Agency, Republic of Kosovo

Qazim Sinani

Kosovo Cadastral Agency, Republic of Kosovo

Korab Ahmetaj

Kosovo Cadastral Agency, Republic of Kosovo

The advantage of UAV systems is the ability to quickly observe the surface of areas at low flying altitude while still meeting the accuracy requirements and standards of the Cadastre in Kosovo. For example the ortho image with high accuracy was produced for a part of the cadastral zone of Ferizaj within 24 hours. About 293 hectare are surveyed and processed up to the final product. Usually when surveying with the conventional methods using GNSS technology for the same size area, would have taken up to 10 working days, assuming the atmospheric conditions permitted.

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