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# Coordinates

Volume XX, Issue 2, February 2024

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

## A GPS/GNSS

*utilisation risk model facilitates*

## GNSS *applications*

*development and operation*

**New age technologies for cities and infrastructure planning**

# In Coordinates



mycoordinates.org/vol-X-issue-2-February-2014

10 years before...

## Solar cycle 24 and SBAS impacts

**Norbert Suard**

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Division, CNES, Toulouse, France

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Navigation expert,  
Eurocontrol, Brussels, Belgium

**Philippe Yaya**

Project Manager, CLS,  
Toulouse, France

This paper presents briefly the recent (From Q1 2011 to Q1 2013) evolution of the solar and ionosphere/magnetosphere activities, the data collection network set for Eurocontrol and the CNES Navigation and Time Monitoring Facility, the different observations done on EGNOS and WAAS and some analyses performed to characterize these observations

## Vision-based sensor for relative navigation

**Alexandre Pollini**

Project Manager, Swiss Centre for Electronics and Microtechnology

For space faring nations or group of nations, maintaining their autonomy in the engineering of technologies allowing the success of exploration missions is mandatory. This article focuses on one of these technologies - the flash imaging Light Detection and Ranging (LiDAR). This technology has unique features that will allow the success of future complex space exploration missions.

## GIS & GPS in micro-spatial location analysis of solid waste disposal sites

**Dr Anand Gopagani, Dr Deepthi Guntuka and Prof Vijaya Bhole**  
Department of Geography, Osmania University, Hyderabad, India

It is observed that the location of the dumpers has not been properly distributed. Ward wise analysis revealed that the number of dumper bins to a great extent has been influenced by quantum of garbage generation and areal extent of the ward. The ratio of houses to bin is related to the density of population. The inter distance matrix of dumper bins revealed that there is a wide variation.

## Space-based precipitation radar for spatio-temporal hydrology analysis

**M Rizaludin Mahmud**

PhD Candidate, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, Japan

**Asst Prof DrShinya Numata**

Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, Japan

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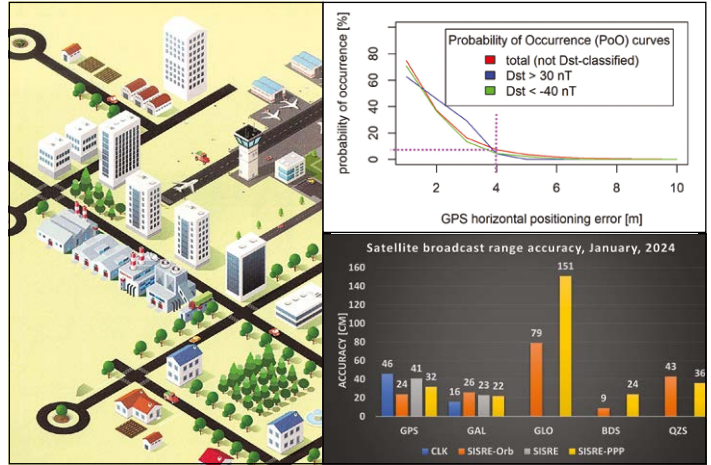
**Dr Tetsuro Hosaka**

Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, Japan

**Prof Dr Mazlan Hashim**

Director Institute of Geospatial Technology, Universiti Teknologi Malaysia

The current status of rain gauge distribution spatial analysis in major hilly watershed in Peninsular Malaysia, and the potential of space-based precipitation radar have been presented in this study. The spatial analysis revealed that the rain gauge distribution had sparse coverage on hilly watershed and possessed inadequate efficiency for effective spatial based monitoring.



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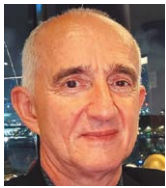
Galileo now meets international standards,  
To guide civil aviation from take-off to landing,  
Can complement EGNOS for the most critical operations.  
Though initially not designed to comply  
The rigorous standards of the International Civil Aviation Organization (ICAO)  
Needed for so-called Safety of Life operations,  
As Europe already had EGNOS for this purpose,  
Galileo has been modified and retuned,  
With technical meticulousness,  
For the Safety of Life Operations.  
An exemplary technological accomplishment,  
And a safer sky.

Bal Krishna, Editor  
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# A GPS/GNSS utilisation risk model facilitates GNSS applications development and operation

GNSS operators extend the PNT performance standards. GNSS-based applications have their own standard requirements for PNT performance. Can the currently existing issue in matching the two standards be overcome?



## Renato Filjar

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navigation nature [2, 8, 9, 10, 13, 14]. The importance of Global Positioning System and Global Navigation Satellite System (GPS/GNSS) for modern civilisation requires maintaining robustness and resilience to natural and artificial adversarial effects which may degrade quality of the GPS/GNSS Positioning, Navigation, and Timing (PNT) service performance, as the PNT performance quality directly impacts the Quality of Service (QoS) of a GPS/GNSS application [2, 10, 13, 14], as depicted in Figure 1

The projection of GPS/GNSS PNT performance specification, as given by GNSS operators, into GPS/GNSS-based application QoS requirements remains a daunting challenge [2, 14, 18, 24]

anticipated by numerous experts as the major roadblock in further adoption of GPS/GNSS as the essential enabler of new technology, and socio-economic systems and services.

GNSS operators address the PNT specifications from their natural perspective of the provision of the best available PNT performance in technology and business environment/conditions under their control [10, 14]. Those involve



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Satellite navigation has been established as a mature technology, a public good, an indispensable critical part of every national infrastructure, and the important enabling technologies that empower the raising number of technology, and socio-economic applications (systems and services), both of navigation and non-

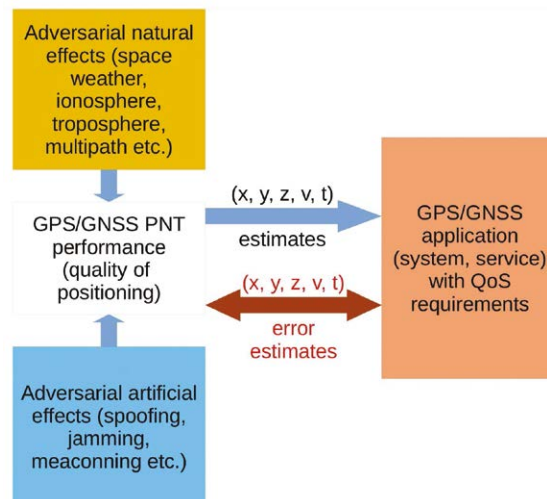


Figure 1 A framework for analysis of effects of the GPS/GNSS PNT performance degradation on QoS of the GPS/GNSS-based application

the equipment, spectrum and signal protection and improvements. External adversarial effects, such as those created by positioning environment, or ambient, are mitigated by the additional, usually costly, infrastructure, and the provision of global error correction models [2, 8, 9, 10, 13, 14], such as Klobuchar and NeQuick for mitigation of the GPS/GNSS ionospheric effects [1, 4, 6, 10, 11, 12] and Saastamoinen for overcoming tropospheric effects [7, 26], on GPS/GNSS PNT performance. Targeted research activities related to GPS/GNSS PNT performance examine temporal degradation of GPS/GNSS PNT resulting from ionospheric [1, 4, 5, 6, 10, 11, 12, 20, 21, 23, 25, 28], tropospheric [7, 26], multipath [22, 27], or spoofing [3] effects, which fail to address the long-term impact on QoS of GPS/GNSS-based applications. As the result, GPS/GNSS applications developers, operators, and users may consider the GPS/GNSS PNT performance specifications defined as overly generalised for ideal ambient conditions, which fail to address the particularities of targeted applications [2, 10, 13, 14].

On the other side, a number of GPS/GNSS-based applications has their PNT performance needs defined either poorly and insufficiently, or not at all [14]. Discipline-specific classes of GPS/GNSS applications have recently considered efforts in assembling the standard requirements for PNT performance in their fields, such as aviation [2], maritime [2, 16], ITS [15, 17], and E112/E911 [15]. Additionally, productive and systematic research performed by European Agency for Space Programme (EUSPA) has resulted in meticulous, systematic, detailed, and transparent catalogue descriptions of a massive list of GPS/GNSS applications, categorised per wide range of disciplines [2]. Furthermore, recent researches utilised new developments in mathematics, statistics, computer science, machine learning/artificial intelligence, and electronics to establish a Software-Defined Radio (SDR)-based framework for provision of Ambient-Aware Application-Aligned (AA2) Space-Based PNT,

featuring satellite-based Positioning-as-a-Service [10]. Introduction of the AA2 PNT has allowed a red-arrow feedback between the GPS/GNSS application and the GPS/GNSS PNT (position estimation) process in Figure 1.

GPS/GNSS applications developers, operators, and users frequently emphasise their need for quantification of the risk of GPS/GNSS PNT to fail in meeting the application's QoS requirements in long term. The quest has inspired the research conducted by our team of experts assembled in Laboratory for Spatial Intelligence, Krapina University of Applied Sciences in Krapina, Croatia. We establish methodology for risk assessment/estimation of the GPS/GNSS PNT failure to meet specific GPS/GNSS application QoS requirements, given targeted PNT performance (mass-market single-frequency GPS/GNSS, or any other scenario), geographical region, and the cause of adversarial effects [10, 11]. The proposed methodology for the GPS/GNSS utilisation risk assessment delivers a risk assessment model, based on statistical analysis of long-term position estimates errors, affected by various levels of ambient conditions in proportions resembling the real environment [10, 11]. Using the outlined approach and considering the statistical aspect, the set of positioning estimate errors has become the appropriate sample of a general population of errors, thus allowing for estimation of risk that GPS/GNSS PNT performance may not meet targeted GPS/GNSS positioning requirements of an application [11, 13, 25, 19, 29].

As the result, the methodology yields a GPS/GNSS utilisation risk model in a form of the Probability of Occurrence (PoO) Model, which states the probability that GPS/GNSS PNT positioning error exceeds the level required by QoS of the particular GPS/GNSS application [10, 13, 25].

In statistical terms, the proposed PoO Model is defined as the tail distribution, or Complementary Cumulative Distribution Function (CCDF) [19, 29],  $\bar{F}_x(x)$  of the set of long-term positioning estimation errors analysed, defined using the Cumulative Distribution Function (CDF)  $F_x(x)$  [19, 29], as outlined in (1) and explained in [25].

$$\bar{F}_x(x) = 1 - F_x(x) \quad (1)$$

The PoO model is derived from the set of GPS/GNSS positioning estimation errors  $x$  in the set by counting occurrences of errors exceeding the set level  $r_0$ , as defined with (2).

$$\bar{F}_x(x=r_0) = \sum_i |x_i| \geq r_0 \quad (2)$$

The procedure is to be repeated for various values of  $r_0$ , preferably equally separated and with the suitable coverage of the error range, thus allowing for the precision and resolution of the PoO Model. The PoO Model may be expressed in an analytical form of mathematical expression, or as a diagram [10], as depicted in Figure 2.

The proposed PoO Model development methodology and interpretation has been demonstrated in several cases of the single-frequency commercial-grade unaided GPS/GNSS PNT utilisation affected by ionospheric effects in polar, sub-equatorial, and mid-latitudes [5, 11, 13, 25]. Experimental raw GPS pseudorange measurements taken throughout a year with 30 s sampling rate at various stationary International GNSS Service

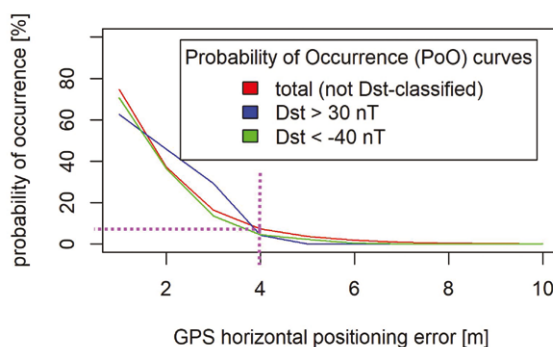


Figure 2 Graphical determination of risk of horizontal GPS positioning accuracy failing to meet the requested PNT performance level, based on PoO Model [13]

(IGS) reference stations were utilised for calculation of position estimates, using a freely available GNSS SDR framework RTKLIB/RTKPOST (available at: <https://www.rtklib.com>). The RTKLIB/RTKPOST has been configured as a single-frequency commercial-grade unaided GPS SDR receiver, which provided position estimates. Positioning error estimates per position components were derived from the error positioning vector, resulting from the difference between the estimated and true position of the IGS reference station that generated observations for the set of data.

The required PNT performance has been defined in terms of horizontal positioning error, derived from the northing and easting positioning errors. A GPS/GNSS application with defined PNT requirements may determine the risk of the GPS/GNSS PNT failure to meet the needs by simple interpolation using the PoO Model [13, 25], as depicted in Figure 2. Thus, the utilisation of the proposed PoO Model bridges elegantly the gap between the PNT specifications issued by GNSS operators and the established QoS needs for PNT performance. Developers, operators, and users of GPS/GNSS-based services may utilise the PoO Model to keep the GPS/GNSS as the only provider of the PNT services, or to consider inclusion of additional alternative PNT service providers should the risk of failure to meet the QoS requirements appears to be too high [10, 11, 25].

Proposed PoO development methodology has been demonstrated with deployment through bespoke software purposely developed in the open-source R environment for statistical computing. The R environment is available at: <https://www.r-project.org>

The research presented offers a simple, objective, and transparent methodology for impact assessment of targeted specific cause of the GPS/GNSS PNT performance degradation, which is aligned with the requirements of a specific GPS/GNSS-based application. The PoO is demonstrated in the case

of ionospheric effects and in scenarios of various locations across the world and particular GPS/GNSS applications. Proposed methodology and the PoO model, as its results, successfully facilitate further adoption of GPS/GNSS by the provision of a framework for assessment of the GPS/GNSS PNT risk of failure in provision of required GPS/GNSS PNT performance for a particular GPS/GNSS application. The PoO model benefits GPS/GNSS operators, GPS/GNSS-based application developers, operators, and users, as it allows for a direct derivation of impact of the GPS/GNSS PNT performance degradation on the GPS/GNSS-based application QoS. Presented research does not only enhance the technological aspect of GPS/GNSS utilisation, but provides a contribution to the socio-economic aspect of further adoption of satellite navigation and its PNT service. It contributes to both technology and business environments of GPS/GNSS utilisation, cementing the role of the satellite navigation technology as a pillar of modern society, economy, and civilisation.


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# GNSS constellation specific monthly analysis summary: January 2024

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



## Narayan Dhital

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

## Introduction

The broadcast messages of all GNSS have evolved to provide further useful parameters in the last decade. In this article, besides baseline performance summary, an overview is provided to one of such relatively new parameters—the Earth Rotation Parameters (ERPs) that are being sent out by satellites of GPS, BDS, QZSS, and IRNSS. It is now possible to apply the ERPs in real-time applications, thanks to the broadcast messages, for reference frame transformation between earth-fixed and inertial frames. All 4 constellations broadcast decent-quality ERPs with different update frequencies. In this month's performance analysis summary, the broadcast ERPs constituting pole coordinates ( $x_p$  and  $y_p$ ) and the difference between Universal Time 1 (UT1) and Universal Time Coordinated (UTC) are reported in addition to the satellite orbit and clock-related parameters.

The article attempts to also monitor the behavior of satellite attitude in terms of yaw angle. Even though such information is not critical for users applying only broadcast messages in the PVT applications, it is essential for precise applications where errors in satellite antenna phase center offset, carrier-phase wind-up, and solar radiation pressure modelling can not be ignored. In this month's performance analysis, only GPS constellation is considered. In the future analysis, other constellations will be included.

## Analyzed Parameters for 01-31 January, 2024

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

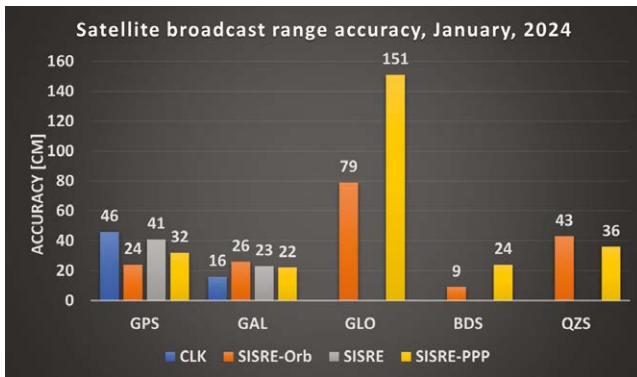
- a. Satellite Broadcast Accuracy, measured in terms of **Signal-In-Space Range Error (SISRE)** (Montenbruck et. al, 2010)
- b. **SISRE-Orbit** ( only orbit impact on the range error), SISRE (both orbit and clock impact), and **SISRE-PPP** (as seen by the users of carrier phase signals, where the ambiguities absorb the unmodelled biases related to satellite clock and orbit estimations. Satellite specific clock bias is removed) (Hauschlid et.al, 2020)
- c. **Clock Discontinuity**: The jump in the satellite clock offset between two consecutive batches of data uploads from the ground mission segment. It is indicative of the quality of the satellite atomic clock and associated clock model.
- d. **URA**: User Range Accuracy as an indicator of the confidence on the accuracy of satellite ephemeris. It is mostly used in the integrity computation of RAIM.
- e. **GNSS-UTC offset**: It shows stability of the timekeeping of each constellation w.r.t the UTC
- f. **ERPs Accuracy ( $x_p$ ,  $y_p$  and UT1)**: It shows the prediction accuracy of the linear model at 1 day interval (or the discontinuity between two batches of data) and the accuracy

w.r.t precise products from IERS (IERS et. al, 2024). Due to the required latency of IERS C04 products, Dec 16, 2023 to January 16, 2024 time frame is selected.

**g. Satellite Yaw Maneuver:** It shows the behavior of satellites that are operating under the low sun angle w.r.t the orbital plane and their yaw rate to quickly align the solar panels towards the sun direction (Liu et. al, 2022)

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

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



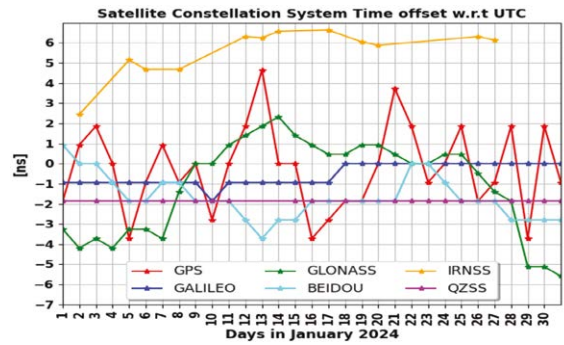
**(c) Satellite Clock Jump per Mission Segment Upload**

Const	Mean [ns]	Max [ns]	95_Percentile [ns]	99_Percentile [ns]	Remark (Best and Worst 95 %)
IRNSS	4.89	617.3	7.09	33.93	Best I03 (3 ns) Worst I09 (14.23 ns)
GPS	0.47	17.61	0.92	3.23	Best G04 (0.4 ns) Worst G08 (6.37 ns)
GAL	0.09	4.85	0.18	0.47	Best E21 (0.15 ns) Worst E10 (0.24 ns) Relatively higher discontinuity on Jan 22 for multiple satellites E30, E15, E3, E11, E12

**(d) User Range Accuracy (Number of Occurances in Broadcast Data)**

IRNSS-SAT	2 [m]	2.8 [m]	4.0 [m]	5.7 [m]	8 [m]	8192 [m]	9999.9 [m]	Remark Other URA values (frequency)
I02	2994	6	-	-	2	1	6	-
I03	430	-	-	-	1	-	-	-
I06	442	3	-	-	1	-	-	-
I09	519	14	3	1	-	-	-	-
I10	434	1	1	1	2	1	-	URAs 11.3 (1), 16 (1), 32 (2), 64 (1) and 128 (1)

**(e) GNSS-UTC Offset**



**(f): Broadcast Earth Rotation Parameters (Discontinuity and Accuracy in RMS)**

Unit: xp, yp in mas. dUT1 in msec

Quality Indicators	GPS			BDS			QZSS			IRNSS		
	xp	yp	dUT1	xp	yp	dUT1	xp	yp	dUT1	xp	yp	dUT1
Discontinuity	0.59	0.49	0.29	0.85	0.75	0.13	0.65	0.54	0.14	0.65	0.54	0.14
Accuracy	2.28	1.51	0.53	2.14	1.53	0.13	0.18	0.33	0.16	0.71	0.51	0.11

Note:- Mission segment upload rates are GPS: 1 day; BDS: up to 20 days; QZSS: 1 hour & 1 day (1 day selected in the analysis); IRNSS-1 day.

**Remark:** The introduction to the ERPs and the broadcast navigation format are available in (Steigenberger et. al, 2022 and IGS et.al, 2021). Regarding the performance obtained by analyzing the 1 month of data, it can be observed that the accuracy of GNSS broadcast ERPs does not have drastic differences among the constellation. A special mention is needed for GPS accuracy due to its reference epoch in broadcast data not matching the IERS C04 (00 h UTC) reference epoch. As the IERS reference epoch is propagated with a simpler linear model, without accounting for semidiurnal tidal effects, and whereas the GPS ICD specifies the consideration of such variations, the direct comparison with GPS data will have a bias. (Steigenberger et. al, 2022) shows such bias could be in the range of 1 mas for polar coordinates and upto 0.5 msec for dUT1. When the bias is subtracted from the accuracy for GPS, the values will be at least similar, if not better, to other constellations (QZSS and IRNSS). The relatively lower accuracy and higher discontinuities of BDS are attributed to the lower update rate of the ERP prediction model from the mission segment. It is observed that the update period ranges up to 7 days or even more in some cases. The overall performance looks similar to the results provided in the literature (Liu M et. al, 2023; Liu W et. al, 2023).

Note:- ERPs are introduced only in RINEX version 4. Galileo and GLONASS do not provide ERPs in the broadcast messages.

**(g): GNSS satellite nominal and non-nominal yaw attitude (GPS Constellation)**

The GNSS satellites orient their satellite body-fixed reference

frame to point navigation payload towards the Earth and the solar panel towards the Sun. This continuous orientation is achieved by the so-called yaw attitude. For a given sun elevation angle  $\beta$  and orbital angle  $\mu$ , the nominal yaw angle can be derived from the following equation (Li et. al, 2022),

$$\varphi = ATAN2(-\tan \beta, \sin \mu)$$

For January 2024, the yaw angles attained by all satellites for all combination of Sun elevation angles and the orbital angles are provided in Fig (g) (i) (here yaw angle and beta angle are shown as positive values only). The relation between the beta angle and the nominal yaw angle is straightforward: the lower the Sun-elevation angle, the higher the required yaw angle to orient the solar panels towards the Sun direction. This means GNSS satellites cannot follow a

nominal yaw-steering whenever the Sun elevation angle relative to the orbital plane gets too low and the yaw rate required to keep the satellite solar panels pointing towards the Sun exceeds the maximum satellite yaw rate. The strategies on how GNSS satellites perform rate-limited yaw-steering are different for each type of spacecraft and only partly documented for public users. The nominal yaw attitude has two singularities when the satellite is nearest to the sun (noon turn) and farthest away in the shadow of the Earth. For such low beta angles, the satellites start yawing with a higher yaw rate than the maximum satellite hardware yaw rate. The approach on how each GNSS satellite executes rate-limited yaw maneuver is different for each satellite.

(g) (i): GPS satellite nominal attitude yaw angle for different Sun elevation angle and orbital angle

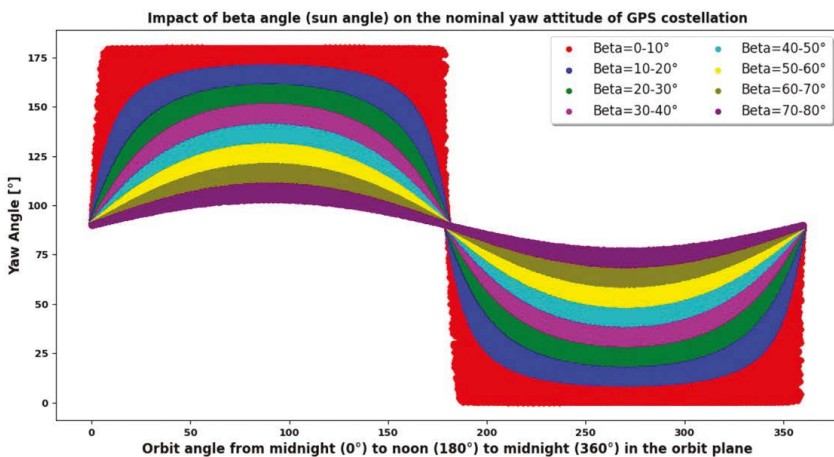


Fig: (g) (i)

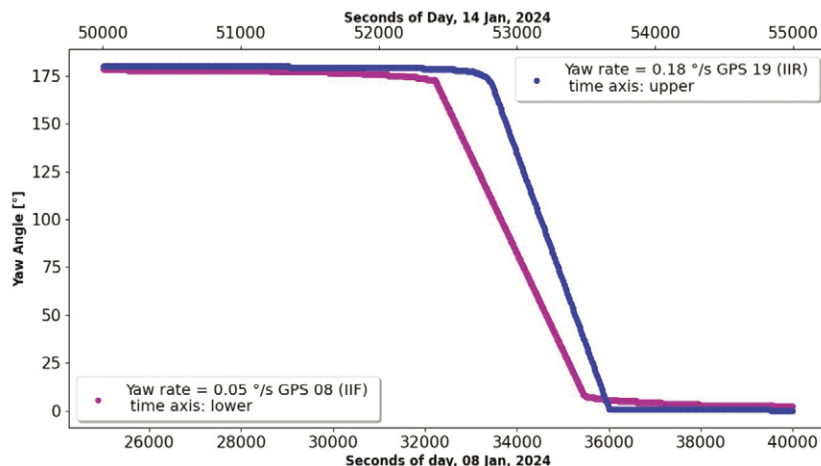


Fig: (g) (ii)

In January, the following satellites were maneuvering under the low beta angle ( $> -1^\circ$  and  $< 1^\circ$ ):

**G08 (IIF): Day 04-07; G15 (IIR-M): Day 27-29; G17 (IIR-M): Day 10-13; G19 (IIR): Day 13-15; G29 (IIRM): Day 11-14**

As presented in different literature (Cao et. al, 2018; Liu et.al, 2022, Sylvain et. al, 2021), the yaw rate of the GPS satellites depends on the satellite type and the beta angle. The nominal yaw rate is close to  $0.01^\circ/\text{sec}$  and during the orbit noon and midnight maneuver, the rate increases to  $0.08^\circ/\text{sec}$  for GPS IIF and IIA satellites and  $0.18^\circ/\text{sec}$  for GPS IIR/RM satellites. To monitor the yaw rate of the identified satellites undergoing the midnight maneuver, satellites from IIF and IIR-M blocks are selected for January 2024 (note: no satellites from block III-A, are in the low beta angle during this month). For the IIF, the only available satellite undergoing mid-night maneuver is G08 and for this satellite, 08 January is selected where the beta angle is above  $1^\circ$  (to have a different beta angle in the analysis). For the IIR block, satellite G19 is selected for 14 Jan where the beta angle is below  $1^\circ$ . The yawing rates for G19 and G08 are computed to be  $0.18^\circ/\text{sec}$  and  $0.05^\circ/\text{sec}$ . The beta angle for GPS 08 on 08 Jan was from  $-2.11^\circ$  to  $-1.21^\circ$ , which is the reason for the slower yaw rate. With an even smaller beta angle below  $1^\circ$ , it is expected to yaw by more than  $0.08^\circ/\text{sec}$ .

(g) (ii): GPS satellite yaw maneuver for midnight turn during low beta angles

Note:- The yaw angle available from the BKG “SSRC00BKG” stream is used for this analysis. For higher precision applications where an accurate model of GNSS yaw attitude is needed, quaternions provided by IGS Analysis Centers can also be used to derive the yaw angle and to execute the reference frame transformations.

### Monthly Performance Remarks:

1. Satellite Clock and Orbit Accuracy

- For GPS, the satellite clock and orbit accuracy shows improved performance in comparison to December 2023 (Dhital et. al, 2024). There were multiple satellites in maneuvers and non-healthy status. GPS satellite PRN 27 was removed from the analysis for a whole month due to bad data. It was declared unused in late December 2023 but came back to nominal status again. However, the orbit and clock data are erroneous. Overall, the SISRE value looked better due to improved satellite clock performance.
- For Galileo, there was a slight improvement in already good satellite clock performances. However, the orbit looked to go down by 7 cm in comparison to December 2023. In contrast to GPS, the SISRE for Galileo is impacted by the fluctuation in the orbit quality. It is noteworthy to point towards January 22, where multiple satellites including E30, E15, E3, E11, and E12 had relatively large discontinuity (> 4 ns).
- For GLONASS, there were numerous days (02, 06, 14-17 January) where the specific portion of the time had large clock offsets and in a few cases large orbit outliers. The reasons for such errors have not been identified in the analysis and will be updated after investigation in future issues. As a first step, a robust strategy to identify the errors in broadcast ephemeris data logging in RINEX is required. For January, the orbit performance after removing above mentioned days looks similar to December 2023 but the SISRE looks slightly degraded (mostly likely due to degraded clocks on some of the days).
- For BDS and QZSS, the performance looks very much the same as in

December 2023. For QZSS, there are days with better orbit quality and some days with degraded performance. This might be due to the nature of IGSO and will be looked into in detail in future analysis.

- For IRNSS, the overall constellation clock discontinuity is slightly degraded in comparison to December 2023. The URA statistics also suggest more broadcast data with degraded accuracies.:

## 2. UTC Prediction (GNSS-UTC):

Among the GNSS, only GLONASS showed different results in comparison to December 2023. The UTC prediction accuracy for GLONASS appears to be more stable. In this month's analysis, QZSS is also added, which is not regularly present in the IGS RINEX V3 broadcast. For the available days, the offset remains very much the same..

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<https://cddis.nasa.gov> (Daily BRDC); [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

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

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Among the GNSS, only GLONASS showed different results in comparison to December 2023. The UTC prediction accuracy for GLONASS appears to be more stable. In this month's analysis, QZSS is also added, which is not regularly present in the IGS RINEX V3 broadcast.

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# New age technologies for cities and infrastructure planning

Integration of land use, utilities, transport and building on a common network helps optimize space efficiency and configurations.



**A K Jain**  
Worked as Commissioner (Planning), Delhi Development Authority and as a member of the Committee of

the Ministry of Housing and Urban Affairs on the DDA (2015). He was a member of UN Habitat (2007-12). Author of several books, he is visiting faculty in planning and architecture. He was awarded 2nd Urban Professional Award 2014 at World Urban Forum in Medellin, Colombia and IBC Lifetime Achievement Award (2023), Living Legend (2022) by the Indian Institute of Architects (NC) and the Lifetime Achievement Award by the Smart Habitat Foundation (2022)

**D**uring last decade, new age technology has changed the script of urban planning and management. As demonstrated by Smart Cities Mission, PM Gati Shakti Master Plan, the 21.8 km long Mumbai Trans Harbour Link (MTHL) inaugurated by Prime Minister Narendra Modi on 12<sup>th</sup> January 2024 new technology is vital for delivery with speed, scale and skills.

The breakthrough in digital technology and informatics has multiplied space, energy and time. It is time that new forms of energy, services, construction and recycling are evolved, which are characterized by online exchange of information, interactions, dynamic networks and floating nodes. Integration of land use, utilities, transport and building on a common network helps optimize space efficiency and configurations.

The ICT (Information and Communication Technology), Artificial Intelligence, Big Data Analytics, Machine Learning, Deep Learning, blockchain, GIS, GPS, etc. are disrupting the urban planning

processes, infrastructure projects, transport systems, land management and enforcement. In this light, it is urgent to review the drafts of NCR Plan 2041 and Delhi Master Plan 2041.

At the United Nations Conference of the Parties (COP 26, Glasgow, 2021) PM Narendra Modi committed to achieve by 2030, 50% of the power requirement from renewables and reduce the carbon intensity of the economy to 45%. India must achieve net zero emissions by 2070 by clean technologies, like smart grid, electric transport, ethanol blending in gasoline, solar photovoltaic and batteries (Fig. 1).

At the COP 27 (2022, Sharm-el-Sheikh, Egypt), India launched its long-term Low Emission Development Strategy (LT-LEDS) by expanding renewable energy, power grid, and energy conservation, rational use of fossil fuels, nuclear energy, green hydrogen, fuel-cells, and biofuels.

The 28<sup>th</sup> Conference of the Parties (COP 28, 2023, Dubai) agreed to accelerate climate actions and operationalization

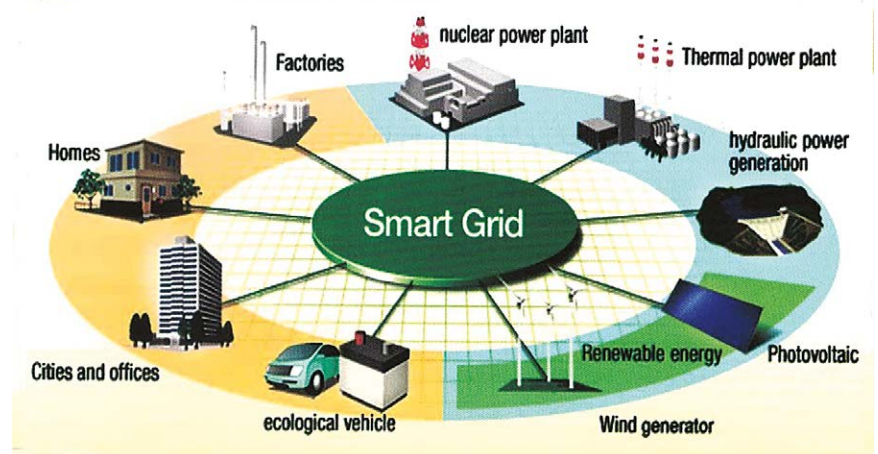


Fig. 1: Smart Grid for Integration of various Sources of Energy and its Uses

of the Loss and Damage Fund and adoption of a framework for the Global Goal on Adoption (GGA) to strengthen action on climate resilience. It focused on climate action and sustainability challenges in the urban sector, building and construction industry. This needs radical changes and use of new technologies in the urban sector.

The PM Gati Shakti Master Plan provides an example of sustainable infrastructure for seamless movement of people, goods and services. It leverages new technologies, breaking the silos of departmentalisation to achieve ease of doing business. It is based on the six core principles-incorporating infrastructure such as laying utilities during the planning phase, enhancing connectivity to help seamless movement, ensuring ecological focus on conservation of forests, biodiversity, rivers, etc., and expeditious clearances.

Prioritisation, synchronisation and coordination are made possible by focussing on each aspect of a project in granularity on one platform with visibility across stakeholders. This also helps drive faster prioritisation and easier synchronisation to avoid delays. The detailed analysis from the data layer ensures better optimisation of project and quick interventions for closure. The Gati Shakti Master Plan has coordinated with the Indian Space Research organisation (ISRO) for spatial planning, engaging BiSAG (Bhaskar Acharya National Institute for Space Applications) and Geo-Informatics. This GIS platform builds over 1200 data layers of Central Government and 755 of the States/Union Territories. Multi-modal integration, last mile connectivity and e-governance are the pillars of PM Gati Shakti Master Plan. All the modes of goods and passenger transport are digitised and pooled and adopt Intelligent Transport Systems and transit-oriented development. This envisages road design with dedicated tracks for cycles, pedestrians and public transport. The highways, roads and railways provide for safe crossing of pedestrians, prams, wheelchairs and animals.

The Whole of Government platform enables easier collaborations across departments, dramatically simplifying the planning process while ensuring the design that is mindful of all economic and social aspects. Area Development Approach has been conceptualised to create convergence of adequate infrastructure catalysing socio-economic and sustainable development within a geographical location. Major areas of planning include Integrated Command and Control Centre (ICCC), physical infrastructure, i.e. energy, water supply, sewerage/sanitation, drainage, waste recycling, roads, parking, workspaces and social amenities, such as education, hospitals, parks, art and cultural spaces, tourism, etc (Fig. 2).

According to NASSCOM- McKinsey Report 'Sustainability Opportunity for

Tech Services and Solutions' (2022) digital technologies such as Cloud, IOT, Blockchain and AI (Artificial Intelligence) can be critical in evolving sustainability solutions, for urban management infrastructure, energy management, property, real estate and buildings which end up benefitting bottom lines and accelerating deliveries (Fig. 3). It is estimated that during next 25 years, the number of buildings in India will be multiplied six times. These have to be net zero and energy efficient. This involves upgrading the power monitoring system, unlocking renewables, smart waste management/recycling with easy to digest dashboards, which provide Real Time measurement of power loads.

The Ministry of Housing and Urban Affairs (MOHUA) in 2021 launched the



Fig. 2: The Whole of Government Platform of PM Gati Shakti Master Plan by using ITC, Optimise Area Planning, GIS and Digital Surveys  
Source: DPIIT, Ministry of Commerce and Industry, 2023

National Urban Digital Mission (NUDM). It aims to push for the digitalization of urban planning and governance by the ULBs. Global positioning systems and satellite-guided GPS devices are being increasingly used for urban surveys, planning and laying of services. By data analytics the plans can be implemented with precision and accuracy.

Under the Geospatial Policy 2022, Digital Twins provides a technology

platform for 3D modelling and virtual representation of an object or a system that uses sensors, drones, 5G Internet of Things (IoT) and industrial IoT (IIoT) data. It applies advanced analytics, machine learning and artificial intelligence (AI) to derive real time insight into the performance, operation and sustainability of a project, a city, buildings, energy storage, energy distribution network and renewable energy.

The MOHUA and NIUA, along with the Bureau of Indian Standards (BIS) have developed The Unified Digital Infrastructure – ICT Reference Architecture Standards (IS 18000:2020) for digitalization of urban practice. The “Unified Digital Infrastructure” comprises the sensors, data systems, IoT systems and platforms. Smart Cities – GIS (IS 18008: 2020) standards define key formats for GIS platforms; and Unified Data Exchange Standards lay out the architecture for instituting data exchanges or marketplaces.

The “smart nodes on a smart grid” concept enables high-speed communication and data management, carbon-emission accounting and performance to optimise their performance, monitoring and maintenance. The Inter Agency and Inter Sectoral collaboration can be achieved efficiently by Digital Infrastructure (Fig. 4).

The National Urban Innovation Stack (NUIS) is part of the agenda of digitalization and datafication by creating certain design principles, defining digital components, platforms and standardization. The creation of a “shared digital infrastructure” aims at systematically organizing India’s urban data and employing it for a variety of purposes. It is a collection of cloud-based services, which provide a single capability across multiple urban services, accessible through simple, open APIs compatible with global standards and specifications. Together, these services and standards create a powerful framework to drive convergence and a faster implementation cycle.

The MOHUA has established several assessment frameworks to measure the progress of digitalization and datafication in cities over time. The Data Maturity Assessment Framework (DMAF) and the Integrated Command and Control Centre Assessment Framework (IMAF) have been developed for the centralized monitoring and evaluation of datafication in cities.

The Centre for Digital Governance (CDG) has been established in the NIUA in 2020

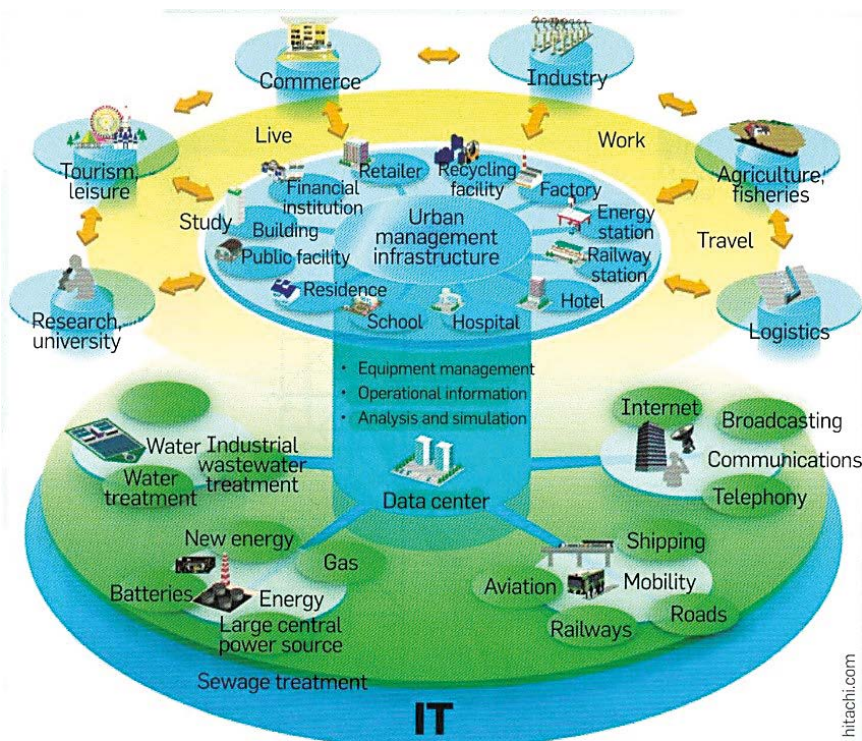
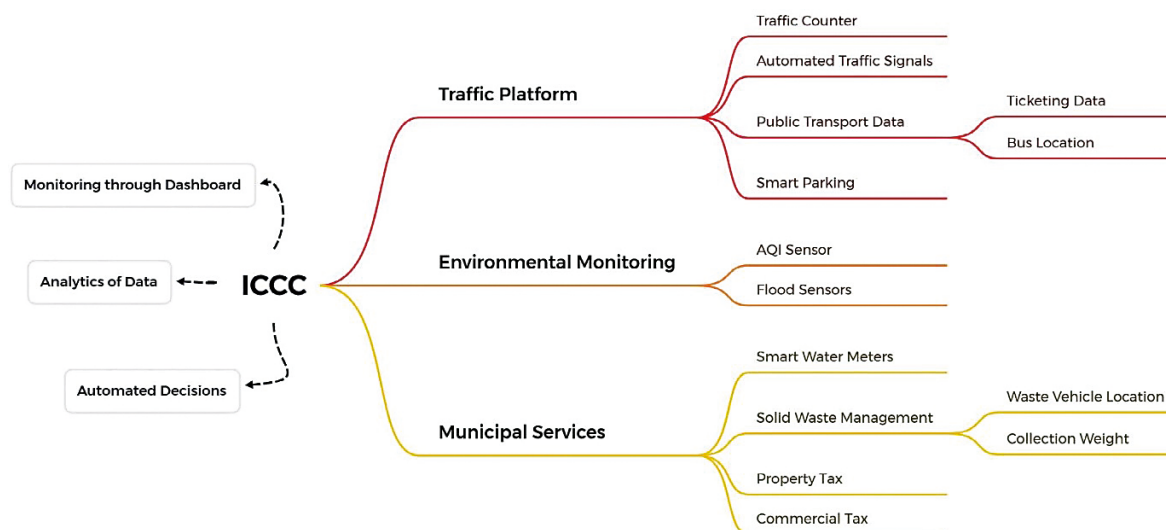


Fig. 3: ICT for Urban Infrastructure  
Source: Hitachi.com



Fig. 4: Inter Agency and Inter Sectoral Collaboration by Digital Infrastructure



**Fig. 5: Model of the Integrated Control and Command Centre (ICCC)**

Source: Parkar, Khaliq and Uttara Purandare (2023) Decoding Ditzitization of Urban Governance in India, Centre for Policy Research, New Delhi

to create policies through research, digital infrastructure, platforms, partnerships, and act as an advisory body for the cities. The CDG is guided by two committees, the City Data Alliance (CDA) and the Smart Cities Advisory Forum (SCAF), which are composed of citizens, academia, industry, and municipal agencies.

The Data Analytics and Management Unit (DAMU) coordinates with the cities on datafication, advises cities on data analytics and legal frameworks, creates case studies, and reviews progress of use of data in governance. The SPV hires Project Management Consultants (PMCs) for Area Based Development (ABD), Pan City Projects (PCP), civil infrastructure and digital projects. Data registries enable the planners to have access to common sets of data as a shared resource to improve collaboration and decision making. The strength of the microservice-based stack approach is that each new program creates reusable services, increasing the speed of delivery.

The Integrated Command and Control Centre (ICCC) is one of the key projects under the Smart Cities Mission. The ICCC coordinates multiple municipal functions and operations, and monitors services, transportation, weather, and disasters (Fig.5).

India has been playing a leading role in the field of disaster risk reduction for G 20 countries and has significantly contributed for its mitigation, preparedness, response and recovery, viz. early warning for all, resilient infrastructure, improving finances and capacities for response and eco-system-based approaches invoking geospatial data and new technologies.

Blockchain is emerging as a new age technology for urban development, land management, real estate, title transfer, etc. Non-fungible tokens (NFTs) are unique digital assets with distinct properties on a blockchain ledger. These represent unique assets in digital or physical form. The new technology has potential of drastically change the way to manage land management, land

pooling, planning and land transactions. Digital distributed ledger technology can simplify the complex and open to manipulation paperwork used for property records. As blockchain is immutable and not easily vulnerable to hacking, title records become verifiable and simple to establish a chain of legal ownership.

The Land Administration Domain Model (LADM) defines the Spatial Units and different forms of property ownership (commonly held, public or private). The differentiation is valid for converting private lands for public use (roads, infra services, facilities, parks, etc.), taking over contiguous parcels of lands, and readjustment of ownerships of remaining private lands. It assigns the class and contains the Rights, Restrictions and

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The breakthrough in digital technology and informatics has multiplied space, energy and time. It is time that new forms of energy, services, construction and recycling are evolved, which are characterized by online exchange of information, interactions, dynamic networks and floating nodes. Integration of land use, utilities, transport and building on a common network helps optimize space efficiency and configurations.

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**ACL Digital partners PhoenixAI.tech for AI drone solutions**

ACL Digital has forged a partnership with PhoenixAI.tech to propel the future of AI-powered drones. The partnership will leverage PhoenixAI.tech's and ACL Digital's pioneering work in developing advanced AI/ML algorithms for uncrewed vehicles, IoT, and C-V2X. Together, the companies will address critical challenges in the drone industry, including autonomous navigation, adaptability, task execution, and data processing. [www.acldigital.com](http://www.acldigital.com)

**Antwerp-Bruges gets UTM upgrade**

Unify in collaboration with SkeyDrone, has announced a significant upgrade to the Port of Antwerp-Bruges' (PoAB) UTM system, DronePortal. This enhancement aims to bolster the efficiency of drone operations within the complex airspace of the Port of Antwerp, while also extending support to the Port of Bruges. The development signifies a crucial advancement towards U-space readiness. The PoAB DronePortal has processed over 5,000 flight authorizations, playing a pivotal role in navigating the evolving U-space landscape. The Port of Antwerp-Bruges is poised to become the first official U-space airspace in Europe, marking a significant milestone in uncrewed aerial operations. [www.unify.aero](http://www.unify.aero)

**DJI launches 3D model editing software**

DJI has introduced DJI Modify, the company's first intelligent 3D model editing software. It pairs seamlessly with DJI's enterprise drones and 3D modeling and mapping software, DJI Terra, forming a comprehensive solution for aerial surveying, modeling, and model editing. [www.dji.com](http://www.dji.com)

**Wingtra launches lidar UAV solution**

Wingtra has introduced a lidar UAV mapping solution that combines the WingtraOne GEN II UAV with a newly developed lidar sensor. This integration aims to advance UAV lidar efficiency, increase accuracy and simplify integration. [wingtra.com](http://wingtra.com)

Responsibilities, which are the basis of land adjustment, registration and land pooling.

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# The contributions of space geodesy to the construction of sustainable cities in Africa and around the world

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Space geodesy is the basis for the acquisition of data by orbiting satellites or other spacecraft in the fight against climate change that are crucial in the construction of sustainable cities in Africa.

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## Abstract

The accelerate urbanisation African cities caused by the massive rural exodus contributed to the demographic boom of these cities. Our cities barely breathe. The swamps of yesterday have become the habitats of today, the marine areas become a refuge by excellence for families newly arrived in the city. This is the birth of precarious neighborhoods with growing land insecurity. The disappearance of marine and coastal biodiversity, the increase in pollution in all its forms; this is where space geodesy comes in. Recognized as one of the great revolutions of Navigation. Space geodesy has made available to territories and continents including the oceans a set of techniques that in their applications participate in the construction and management of sustainable cities in Africa and in the world; it participates through its fields of application in atmospheric monitoring, marine environment monitoring, territorial, climatological to ensure a better life on land, underground, in water and under water. These techniques and application are an urban decision support for the construction and management of sustainable cities; precise geodetic measurements make it possible to assess topography, identify flood zones, with facilitates the installation of resilient infrastructure.

## 1 Introduction

In Africa and specifically in Benin, the management of cities continues to be a very complex process. With nearly a quarter of a century of application, decentralization in our countries has still not been enough to have a better management of our cities, municipalities and city districts. The climate shocks of the moment coupled with the environmental challenges of the decade have pushed all decision-makers at national and international level to reinvent our cities, municipalities and city districts to put an end to the inadequacies of the management system in place while taking into account the challenges of the 21st century in the new definition and management of the city. This is how we have moved from cities to sustainable cities. There is definitely no sustainable city without good coastal management and effective land security.

In West Africa, several economic, social and legal factors are favourable to land tenure insecurity. More specifically, it can be an increase in the value of land, the cost of access to a land title; an explosion ddemographics, land disputes, ignorance of the texts and laws governing land ownership, lack of coordination between judicial bodies, slow completion of land disputes at the level of the competent courts. It is in this context where land insecurity is still

relevant and where indigenous peoples continue to be dispossessed of their lands for lack of a reliable and secure management system, that our cities are bathed. Access to land ownership and securing land rights, for poor and rural populations in general and for women in particular, is essential for food and land security and therefore for the security of our cities; land tenure security is therefore a major challenge to ensure the construction of sustainable cities in Africa.

With its 26,000 kilometers of coastline and the density of its hydrographic network, Africa is the second largest continent after Asia. Here in Africa, all it takes is an overflow of waters, a rise in sea level for us to go from a city to a pond. Africa, when it is a victim of rising sea levels, finds itself faced with an avalanche of crisis whose consequences are disastrous. Here, when surface water invades us, groundwater splashes us. They transport on their way the contents of gutters, sewers, septic tanks and deposit them in breeding ponds of microbes to promote the proliferation of waterborne diseases; accelerates the erosion of coasts, roads and buildings. Thus, every year, according to the seasons, African cities face what can be described as a humanitarian crisis. Space geodesy in its earth observation missions has made available techniques to not only manage and secure land and then the coastline but also provide the data and information necessary for the construction and management of its two natural resources for a sustainable city. Carried out in sub-Saharan Africa more precisely in the West African context, this study began in March 2021 during the defense of my thesis on "the impact of modern topography devices on man and his environment. Our document consists of three main parts. The objectives that represent the goal of the research methodology that traces the way in which the research was conducted and then the results that will initially show the roles of space geodesy applications and techniques in the fight against the effects of climate change; and then show how spatial geodesy techniques are used in land tenure security and coastal management.

## 1.1 Research objectives

Our goal is to analyse the contributions of spatial geodesy to the construction of sustainable cities.

Specifically, it is a question of:

- Present the opportunities offered by some applications of spatial geodesy in the realization and management of sustainable cities;
- Determine techniques from space geodesy;
- Show the importance of their uses in securing land.

## 1.2 State of the art

It is a question of shedding light on all the studies, reports and briefs that are available to us and that go almost in the same direction as our study. Thus, the first thesis to have caught our attention is that of Raphaël GRANDIN of the Institute of Physics and the globe of Paris in the specialty "Earth, universe, environment" and whose title is "From the source of earthquakes to risk seismic: contribution of space geodesy" With the general objective of responding to the contribution of space geodesy in the quantification of seismic risks and the source of earthquakes.

In his 206-page dissertation written in order to receive an accreditation to Supervise Research, Raphaël GRANDIN speaking of space geodesy states that "recent advances in space geodesy allow access to the finite slip distribution on fault systems during and between major earthquakes. In particular, wide-swath radar interferometry (InSAR) notably thanks to the Sentinel-1 constellation, now provides means of observation with high revisit frequency, capable of measuring tectonic deformations at high>> [1]. Scale, with increased precision and temporal resolution; The current HDR Lecturer, Institut de Physique du Globe de Paris (IPGP) at University of Paris (UP) in the specialty "Space geodesy and remote sensing applied to active tectonics and volcanism" Raphaël GRANDIN since it is about him affirms in his writings that "the development of methods joint inversion of space geodesy

data (InSAR, optical correlation, GNSS) and seismological therefore makes it possible to build a precise representation of rupture processes, and thus to test and push the limits of the various existing seismic cycle models" [1]. The author who, joins our theme by addressing here, the contribution of space geodesy to the quantification of natural disasters such as earthquakes, earthquakes has already done part of the work [1]. Before Raphaël GRANDIN, Xing Xing Li looked at a problem that is close to that of GRANDIN in his article entitled "Real-time high-rate GNSS techniques for earthquake monitoring and early warning". [2]

L. Awange in his book Environmental Monitoring using GNSS, from page 57 to page 90 states that, the observed parameters necessary for environmental monitoring vary, depending upon the indicators being assessed. Some are physical variables such as changes in soil patterns, vegetation, rainfall, water levels, temperature, deforestation, solar and UV radiation. Others are chemical variables , e.g., pH, salinity, nutrients, metals, pesticides, while others are biological variables , e.g., species types, ecosystem health, and indicator species [3].

In order to understand the expression "sustainable cities", we have gone through more than one document including this one by Vincent Beal entitled "Sustainable city and social justice. What sustainable development tells us about urban production". For the author, sustainability is often presented as a new urban utopia. A "feasible utopia" that could be built by all the individuals populating urban spaces. This utopia according to V. Beal would make" it possible to reconcile economic development, harmonious relations between man and nature and social justice. However, if the sustainable city model does propose an ideal of social justice, it must be understood in the sense in which David Harvey defined this notion. In his book Social Justice and the City, he showed that social justice was by no means universal, that it depended on the spatial and temporal contexts in which it was enunciated"[4].

Above all, it showed that the debates around urban development in the city of Baltimore brought together different arguments put forward by different social groups and all hiding behind a different conception of social justice. This is probably how we should understand the ideal of the sustainable city. The author defines the sustainable city as a utopia of social justice created by and for certain social groups – the creative, the bobos, the yuppies, etc. – whose demographic weight within urban societies and, above all, the influence on the content of urban policies are constantly increasing; as a vision of social justice stripped of its classist dimension and its conflictual dimension [4]. Nevertheless, the author asserts that sustainable development policies can be a means of attracting certain social groups, this is what he clearly states when he says "However, if the discursive use of References to an "urban nature" is much less present, sustainable development policies being reused as an urban marketing tool, particularly in the case of rehabilitation of waterfronts or rivers, recreation of urban green spaces, uses of the prefix "eco", can also be seen as a way to attract certain social groups and to overcome the desire for life in the countryside that derived in many cases from research. an "existential security" linked to proximity to nature."

The vast majority of authors who deal with security or land management use Geographic Information Systems (GIS) as land security tools. If we are not against this truth, we nevertheless remain cautious about the way in which space geodesy is invisible and about the lack of literature dedicated to this discipline which is actually the science allowing the determination of the shape and dimensions of the Earth. The land being here considered as a portion of a territory, the primary basis for securing it remains the determination of its shape and dimensions; this is the role of geodesy and it is spatial when this shape and its dimensions are determined thanks to sources outside the Earth. Our work therefore comes at the right time and will serve to make space geodesy and its advantages for sustainable development in general and urban development in particular more visible.

## 2 Methodology

Global Navigation Satellite Systems (GNSS) are revolutionizing the world in a way their original developers never envisaged. From being military "war" tools, GNSS satellites are rapidly becoming "peace" tools that play a potentially critical role in GNSS satellites are rapidly becoming tools for "peace" that play a potentially critical role in building sustainable cities [3].

The methods used for the collection of information range from documentary research on spatial applications to urban planning and geospatial science techniques and scope. Field operations were also taken into account in the collection and analysis of results. This study was carried out in two phases: an exploratory phase with topographers, surveyors, urban planners, community development agents, and planning professionals. The second phase of this study was based on existing work, projects and programmes on sustainable cities and spatial geodesy, geospatial data at BENIN, in Africa and worldwide.

The purpose of the exploratory phase required, at first glance, a simple interview of land specialists, planning specialists, urban planners and community development officer. The second phase made it possible to identify the major works carried out in cities, city districts, villages, communes, regions of Benin, Africa and the world using space geodesy techniques and applications. In view of these two phases, two priority issues for the construction of sustainable cities thanks to the contributions of spatial geodesy have been defined: land tenure security including urban planning and the management of rivers and bodies of water including the risks of natural disasters. Surveyors-topographers have been identified as key players in land tenure security.

They are upstream and downstream of all work affecting land, watercourse; So to the city and the first civilian users of GNSS receivers, we have therefore constituted two groups of samples for the survey each consisting of:

- a topographic operator, a surveyor-topographer engineer and a doctor in spatial planning and a GIS specialist.
- a senior technician Surveyor-topographer, a Surveyor-Topographer Engineer, a community agent, an Urban Planner.
- a senior technician Surveyor-topographer, a Surveyor-Topographer Engineer, a community agent, an Urban Planner

Twenty-four individual semi-structured interviews were conducted by a single person. The interviews took place from March to May 2021. This type of interview allowed us to receive a lot of important information on the problem. The twenty-four interviews were reformulated and integrated into the results. We have therefore proceeded to the exploitation of the data collected by the method of content analysis and more specifically to the thematic analysis which allows the highlighting of the social representations or judgments of the interlocutors from an examination of certain constituent elements of the discourse: knowledge of the theme, restitution, memorization and appreciation of information tools, frequency of handling GNSS receivers.

The collection of data on major work carried out or underway in Africa and the rest of the world using spatial data or other techniques and applications of space geodesy made it possible to integrate the literature review into our research. Thus, twenty different research works related to the theme were consulted, fourteen works were exploited for effective treatment and reliable, verifiable and accurate results.

## 3 Results

### 3.1 Space geodesy in the face of the climate emergency

Known for its applications on earth, physical geodesy understood that it was necessary to leave the earth to be able to observe and characterize it. It has therefore acquired a space dimension for better observations from space thanks

to spacecraft, both natural and artificial satellites. More, precisely, it is a set of several applications which, in their implementation, use or involve various techniques of geodetic sciences.

Among its applications, we have remote sensing which is in turn used in several fields of application such as: meteorology, climatology, oceanography, cartography, remote sensing of the atmosphere, terrestrial and meteorological [5].

## 3.2 The monitoring systems

### 3.2.1 Weather and climate monitoring systems

Meteorological, climatological and atmospheric monitoring systems allow us to observe and track the behaviour of cloud masses, their distributions and properties as a function of time. It is through these systems that we have weather information on earth [5].

### 3.2.2 Terrestrial surveillance systems

Terrestrial monitoring systems are systems that provide geographic information about the earth and the changes it undergoes. The Copernicus Earth Monitoring Service (CLMS) provides geographic information on land cover and its changes, land use, vegetation condition, water cycle and energy variables at the Earth's surface [6]. It supports applications in a variety of fields ranging from spatial and urban planning to forest and water management, agriculture and food security, nature conservation and restoration to rural development, all of which contribute to climate change mitigation and environmental management.[6]

### 3.2.3 Marine Environment Monitoring System

The observations and forecasts generated by the Copernicus Marine Environment Monitoring Service (CMEMS) offer multiple applications in the maritime domain like Maritime safety; Marine resources Coastal and marine environment [6]. The availability

of Copernicus Maritime Service data on the African coasts to protect during oceanchallenge4africa 2022 competition allowed our team to choose a suitable site to host a coastal wetland. The service also contributes to the protection and sustainable management of living marine resources in particular for sustainable fisheries management or the decision-making process of regional fisheries organisations. Physical and marine biogeochemical components are useful for water quality monitoring and pollution control. Sea level rise is a key indicator that helps assess coastal erosion.

Satellite data can be used to measure ocean height, melting glaciers and ice sheets, the distribution of water masses on Earth, and tectonic plate movements. This information is essential for understanding the impacts of climate change on the Earth and for developing effective strategies to combat climate change.

## 3.3 Land tenure security and coastal management for Sustainable African cities.

### 3.3.1 The urgency of land tenure security

For the majority of people in developing countries, land tenure insecurity is a very concrete reality; Land rights are a luxury, given that only 30% of the world's inhabitants hold formal title deeds. Securing land rights is an important issue for poverty reduction and shared prosperity at the country level [7]. Recognition of land rights is key to boosting investment and growth, particularly in agriculture and infrastructure; It also makes it possible to combat expropriations and forced migration and thus contributes to the resilience of countries and their populations to shocks [7].

"Building sustainable societies requires solving land issues: countries, regions, cities, and villages need well-established property rights, clear borders, and accessible land services to grow economically," said Ede Ijjasz-Vasquez, Senior Director of the World Bank's

Social, Urban, and Rural Development Practice. "Authorities need accurate geographic information to plan for road construction, the development of public services and infrastructure, and in doing so, create jobs" [7]. But securing property rights is not only useful from a country's growth and investment climate perspective. It is also a crucial aspect of social inclusion, especially for historically marginalized social groups, including indigenous peoples, including women and youth. Finally, securing property rights is important for families and individuals. Thus, it is essential that women are not excluded from this process, as the consequences are far-reaching in terms of household income, food security and equity. Securing land rights is above all a key to women's empowerment and urban development [7].

In a classic way, a city is a geographical and social environment formed by an important meeting of buildings housing inhabitants who work, for the most part, within the agglomeration. The sustainable city of the 21st century can therefore be defined as a geographical and social environment formed by a mix between constructions made of innovative materials and green spaces and which integrates indigenous peoples in its operation while promoting the sustainable conservation of their lands and where the risks of natural disasters are can be estimated over time. GPS relative kinematic positioning is usually adopted to estimate seismic displacements as double-differenced ambiguities can be fixed to integers for guaranteeing high accuracy [8]. There can be no sustainable cities without securing the territory. Before securing a thing, an object, a land, it is necessary to know precisely its location in time and space. This is where space geodesy comes in through satellite positioning systems including GNSS (Global Navigation Satellite Systems).

### 3.3.2 The satellite positioning system.

The satellite positioning system also known as GNSS (global navigation satellite systems) is a set of components

based on a constellation of artificial satellites to provide a user via a small portable receiver with its 3D position, 3D speed and time. This category of geopositioning system is characterized by metric accuracy, its worldwide coverage and the compactness of the terminals, but also by its sensitivity to obstacles present between the receiving terminal and the satellites. Some augmentation and reliability systems of regional or global scope, free or paid, make it possible to make the system reliable and improve performance (DGPS, EGNOS, A-GNSS, etc.)

### 3.3.3 Usefulness of satellite positioning systems

The surveys carried out during our research work allowed us to understand the usefulness of geodesy in urban planning. Indeed, we have detected several uses of space geodesy in favor of the construction of sustainable cities in Africa that we have grouped into five different categories. From the detection of illegal occupations to the monitoring and evaluation of land, urban planning and management policies, to mapping and management of land information, not to mention the collection of accurate data. Thus, for the detection of illegal occupations, Satellite imagery and radar data can identify land use and unauthorized, encroaching construction, allowing authorities to take appropriate action to enforce land rights. This information is particularly valuable in areas where access to land is difficult or where illegal activities are hidden. Concerning Cartography and Land Information Management, Land mapping, which uses remote sensing techniques, provides a visual and understandable representation of land information. High-resolution satellite imagery, with the advent of LiDAR data, provides details on physical terrain characteristics and land use. This information, combined with geodetic data, facilitates effective land management and planning, ensuring effective protection of land rights and prevention of land-use conflicts. For the urban planning and management policies In an urban context marked by

the phenomena of metropolisation and globalisation, new issues are emerging and generating new forms of governance. Radar images provide information on building density, land use patterns, urban infrastructure growth and development trends. This accurate mapping is essential for urban planning, land management and sustainable development decision-making.

By allowing the detection of infrastructures, they offer a synoptic and detailed view of urban infrastructures, which makes it possible to assess their condition, identify maintenance needs and prepare the city to welcome new construction. To monitor and evaluate land policies, satellite positioning systems using in situ observations provide valuable data for assessing the effectiveness of land policies and development programmes. By monitoring changes in land use over time, geospatial data can be used to assess the impact of land policies on sustainable development natural resource conservation and poverty reduction. This information enables policy makers to make informed decisions and adjust land policies according to local needs and realities. Satellites orbiting the earth also allow us to collect data. Here, we are talking about data collected directly in the field using GNSS receivers. GNSS receivers make it possible to accurately measure the coordinates of plots of land. Using satellite positioning techniques (GNSS), we can accurately determine property boundaries and create reliable geodetic references. This data plays an essential role in establishing clear and indisputable title deeds that ensure legal certainty of land transactions. GNSS receivers make it possible to accurately measure the coordinates of field plots.

### 3.4. Coastal management

The littoral zone is defined as the part of a territory where a course or body of water is in contact with the land. The need to house the growing populations on the one hand and the presence of a vulnerable coast on the other jeopardize the fragility of the coastline. Particularly significant challenges arise in coastal,

riparian and island communities, affected by flooding and submersion, as well as accelerating coastal erosion. These impacts are exacerbated by rising sea levels, changes in winter conditions and an intensification of extreme weather events.

To overcome this state of affairs, space geodesy and remote sensing altimeter satellites measure the height of the sea surface several times to detect seasonal variations. These measurements make it possible to monitor changes in sea level in real time and identify long-term trends to make navigation at sea safer, determine favorable conditions for sports and cultural activities on the coast and install a safety cordon.

By using space techniques to measure changes in sea level height, scientists can better understand the effects of global warming and melting glaciers on sea level rise. They can also study the impacts of sea level change on coastal ecosystems, human populations and coastal infrastructure. Better coastal management makes it possible to control the behaviour of surface waters and to enable sustainable management of cities in Africa and around the world.

### 3.4.1 Flooding and overflowing waters

The ocean covers more than 70% of the planet. It is our source of life, Looking at the horizon, the ocean seems limitless and out of reach. The skyline marks the boundary between the terrestrial world and the maritime world; Yet, it only takes one unusual rain for it to invade us [9].

In this context where the world is becoming more and more uncertain, especially because of the climate change, it is therefore becoming necessary to develop new strategies for flood risk management to anticipate flood scenarios that models probabilists judge as extreme or rare, Water overflow scénarios.

Thus, thanks to space science and technology, we can already protect and monitor coasts, control activities along the oceans and all waterways.

### 3.4.2 Usefulness of satellite positioning systems

The use of space geodesy is not only terrestrial, it is also marine, coastal etc. Satellites in orbit around the earth also carry out observations at coastal level and allow us to have information on different aspects of the coastline and rivers. These are: Management of sensitive coastal areas, coastal monitoring and mapping, coastal risk forecasting, coastal Development Planning.

Thus, for coastal monitoring and cathography, Space geodesy provides accurate measurements of coastal morphological changes, including the evolution of beaches, dunes, and estuaries. Airborne LiDAR surveys provide detailed topographic and elevation data to map changes in coastline and quantify coastal erosion. Remote sensing, using satellite imagery and radar sensors, can also monitor sediment movements, coastal currents and changes in coastal wetlands.. For the coastal risk forecasting, the combination of geodetic data and remote sensing makes it possible to model coastal risks such as erosion, storms and marine submersion. Using accurate numerical terrain models (DTMs) and hydrodynamic simulations, it is possible to estimate high-risk areas and plan appropriate adaptation measures. Continuous remote sensing coastal monitoring also provides real-time data on extreme weather events, allowing for a quick and effective response in the event of an emergency. The littoralization of socio-economic development is manifesting itself in an accelerated manner. It has thus generated strong competition over space and coastal resources, causing conflictual relations between sectors, particularly in terms of spatialization of activities. By mapping these ecosystems and monitoring their health, priority conservation areas can be identified and appropriate protection measures put in place.

In addition, remote sensing provides tools to assess water quality, marine biodiversity and anthropogenic pressures on coastal ecosystems, thus facilitating the integrated and sustainable management

of these fragile area. Space geodesy and remote sensing are valuable tools for sustainable coastal zone planning and management. By providing accurate data on topography, sea level, the combination of geodetic and remote sensing data provides a better understanding of the physical characteristics of the coastline, such as topography, altitude and slopes. This information is valuable for coastal development planning, identification of risk areas, demarcation of building zones, prevention of illegal land use and preservation of sensitive natural areas. They also contribute to the development of integrated coastal management plans, taking into account environmental, social and economic aspects.

## 4 Conclusion


Space geodesy is the basis for the acquisition of data by orbiting satellites or other spacecraft in the fight against climate change that are crucial in the construction of sustainable cities in Africa. From controlling the hydrographic network to mastering the exact dimensions of the earth, it gives us data that we use to prepare a strategic response to the environmental challenges of the 21st century; The sciences of space geodesy are fundamental tools for the well-being of man and his environment. Today, everyone receives a signal whether through a mobile phone, a connected geodetic GNSS receiver, everyone enjoys the benefits of science and the work of these brave astronauts, engineers and geodesists. But is there an environmental and social impact study on all permanent stations installed on earth? [10] Thus, to enable Africa to take full advantage of these disciplines and one day have its satellite positioning system such as the American GPS, the Chinese Beidou, the European Galileo or the Russian Glonass, it is important to strengthen the capacities of land and urban planning actors in geo-spatialization and remote sensing techniques in developing countries, to promote international collaboration for the effective and ethical use of data from space geodesy techniques and sciences with respect for man and his environment

in order to guarantee data security and the preservation of man and his environment.

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# Constraints of surveying and mapping awareness in Nigeria: A comprehensive review

This paper sheds light on the key obstacles that prevent the widespread recognition and appreciation of surveying and mapping in Nigeria



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## Abstract

This accounts for the various forms of complexity that contribute to the lack of awareness surrounding surveying and mapping in Nigeria. Despite the crucial importance of accurate geospatial information in shaping the development of the nation, there exists a substantial gap in awareness among the general public. By meticulously analyzing and synthesizing a wide range of existing literature, this paper sheds light on the key obstacles that prevent the widespread recognition and appreciation of surveying and mapping in Nigeria. From outdated perceptions to insufficient educational initiatives, this study uncovers the underlying factors that hinder progress in this critical field. Ultimately, by bringing these constraints to the forefront, this paper aims to spark a much-needed conversation and pave the way for greater understanding and support for surveying and mapping in Nigeria.

## Introduction

The field of surveying is an essential aspect of urban planning, resource management, and economic development in Nigeria. It involves a diverse range of disciplines, including geodesy, geometry, trigonometry, physics, and law, to accurately determine terrestrial positions. Surveying plays a crucial role in preventing boundary disputes, ensuring informed land valuation, and guiding construction decisions, all of which are vital for the progress and development of

the country. Despite its importance, there is a significant lack of awareness about the pivotal role that surveying plays among the general public, policymakers, and certain professionals in Nigeria. This lack of awareness can lead to misunderstandings and misconceptions about the profession, hindering its effectiveness and impact on the development of the country. Furthermore, the surveying profession in Nigeria faces numerous challenges, ranging from technological advancements that continuously reshape employment practices to legislative changes that impact the way surveys are conducted. As highlighted in previous studies (Adeoye, 2007; Kabir et. al., 2022), these challenges must be addressed to ensure that the surveying profession in Nigeria can continue to effectively contribute to the country's development and progress.

This paper aims to:

- a. Identify the key constraints affecting the awareness of surveying and mapping in Nigeria.
- b. Analyze the impact of these constraints on national development and
- c. Propose strategies for overcoming these constraints and enhancing awareness.

## Constraints to surveying and mapping awareness

The field of surveying is an essential aspect of urban planning, resource management, and economic development



in Nigeria. It involves a diverse range of disciplines, including geodesy, geometry, trigonometry, physics, and law, to accurately determine terrestrial positions. Surveying plays a crucial role in preventing boundary disputes, ensuring informed land valuation, and guiding construction decisions, all of which are vital for the progress and development of the country. Despite its importance, there is a significant lack of awareness about the pivotal role that surveying plays among the general public, policymakers, and certain professionals in Nigeria. This lack of awareness can lead to misunderstandings and misconceptions about the profession, hindering its effectiveness and impact on the development of the country. Furthermore, the surveying profession in Nigeria faces numerous challenges, ranging from technological advancements that continuously reshape employment practices to legislative changes that impact the way surveys are conducted. As highlighted in previous studies (Adeoye, 2007; Kabir et al., 2022), these challenges must be addressed to ensure that the surveying profession in Nigeria can continue to effectively contribute to the country's development and progress.

## Constraints on national development

Several strategic measures are proposed for consideration in analyzing the impact of these constraints on national development surveying practices in Nigeria. The voice and tone of the response text should maintain a professional demeanor.

## Educational Gaps

In Nigeria, there is a significant gap in the integration of geospatial education at various academic levels, which poses a challenge to the educational system. Currently, only twenty (20) Universities and thirty-six (36) Monotechnic/ Polytechnics/ Colleges of Technology in Nigeria offer Surveying and Geoinformatics at different levels, as

recognized by SURCON (2019) and Kabir et al. (2022). However, these institutions often lack the necessary resources to provide quality training in this field. Moreover, the national curriculum does not adequately emphasize the importance of surveying as a discipline, resulting in a lack of foundational understanding among students and professionals. The absence of a strong educational foundation in surveying perpetuates a cycle of unawareness. As a consequence, graduates enter the workforce with limited knowledge of the field's significance, which hampers their ability to contribute meaningfully to national development.

## Limited Public Outreach

Despite its crucial role in infrastructure development and disaster preparedness, the communication of surveying to the general public in Nigeria is insufficient. There is a noticeable absence of targeted public outreach programs aimed at increasing awareness about the valuable contributions of surveying. As a result, the general population remains uninformed about the significant impact surveying has on shaping their everyday lives. This lack of awareness undermines public support for surveying activities and diminishes the perceived importance of this field.

## Technological Barriers

The world is undergoing continuous change, driven by constant technological advancements. However, Nigeria is facing a technological divide in the field of surveying practices. While new surveying instruments and advanced methods are being introduced regularly, there is a lack of uniform adoption, resulting in disparities between those who embrace modern tools and those who lack access or resist innovative approaches. The surveying industry in Nigeria has evolved significantly over the past decade, and even more so in the past five years. We are currently experiencing a period of constant movement, with rapid technological advances, legislative

changes, and evolving demands on the skills of surveyors (Adeoye, 2007). This technological gap hinders the effectiveness of surveying practices in Nigeria. Professionals who are not up-to-date with modern technologies may struggle to compete globally, impeding the country's progress in geospatial data collection and analysis.

## Limited Government Initiatives

The absence of comprehensive government initiatives in Nigeria has hindered the promotion of surveying as an important profession. The lack of supportive policies has resulted in a lack of recognition and integration of surveying into national development strategies. Without government advocacy, surveying faces difficulties in gaining the necessary attention and support for its inclusion in critical decision-making processes. This lack of recognition limits the potential contribution of the field to the nation's socio-economic growth.

## Perceived Lack of Relevance

Surveying in Nigeria faces the challenge of being perceived as irrelevant or disconnected from everyday life. The general populace may not recognize its crucial role in shaping infrastructure, land use, and disaster preparedness. This perception diminishes interest in surveying as a career, resulting in a shortage of professionals. The lack of skilled individuals in the field further reinforces the notion that surveying is not a vital aspect of national development, perpetuating a cycle of Under-recognition. An exploration of existing studies and initiatives within Nigeria related to surveying and mapping awareness to establish a baseline for this research.

## Insecurity and Safety Concerns

The current state of insecurity in Nigeria has significantly impacted the safety of both lives and properties, which

has consequently affected the Surveying profession. Insecurity and safety concerns within the field of surveying manifest in various ways, such as posing threats to the physical safety of surveyors, particularly in areas characterized by civil unrest, political instability, and high crime rates. These challenges often hinder fieldwork and jeopardize the well-being of survey teams. Additionally, surveyors in certain regions face risks from wildlife, challenging terrains, and criminal activities. Moreover, geopolitical issues contribute to the risks associated with land disputes or border conflicts, further escalating tensions and posing threats to surveyors, especially when conducting surveys near disputed or sensitive areas.

### Insufficient Collaboration

Effective surveying and mapping rely heavily on collaboration, as it facilitates the sharing of knowledge, best practices, and resources. Unfortunately, Nigeria is facing a major hurdle due to the lack of collaboration among survey professionals, government agencies, and stakeholders. This constraint is impeding the progress and effectiveness of surveying and mapping initiatives in the country. Insufficient collaboration has resulted in challenges such as data fragmentation, duplicated efforts, limited information exchange, and inconsistent standards. The absence of standardized practices across surveying entities has further exacerbated the issue, leading to inconsistencies in data collection, processing, and reporting. As a consequence, the reliability and comparability of survey results are compromised.

### Discussion on strategies for improvement

Several strategic measures are proposed for consideration to address the challenges faced by surveying practices in Nigeria.

### Curriculum Enhancement

The integration of geospatial education into formal academic curricula is not only

a response to current challenges, but also a proactive strategy to equip future surveying professionals with the necessary skills to navigate the complexities of the modern world. This initiative serves as an investment in the future of the surveying sector in Nigeria, ensuring its resilience, relevance, and ability to make meaningful contributions to the country's development and sustainable land management. By closing the existing educational gap, this approach aims to produce graduates who possess a comprehensive understanding of the impact of surveying on the landscape, thus fostering informed citizens. The adoption of curriculum enhancement is crucial for the advancement of the surveying profession in Nigeria.

### Public Awareness Campaigns

The implementation of focused public awareness campaigns is regarded as a strategy to change the perception of surveying from just a profession to a fundamental element for the advancement of sustainable development. This endeavor seeks to foster a shared understanding of the importance of accurate surveys and mapping by educating communities about their significance, advocating for best practices, and actively involving the public through different communication channels. Consequently, this will assist in establishing trust, minimizing conflicts, and cultivating a cooperative and knowledgeable society that acknowledges and encourages the crucial role of surveying in shaping the future of the nation.

### Technological Training

Technological training is a powerful solution for addressing the challenges faced in the field of surveying in Nigeria. This training program aims to equip professionals with the essential skills needed to effectively utilize modern surveying technologies, thereby improving the efficiency, accuracy, and global competitiveness of the surveying profession. The implementation strategies, such as integrating the

curriculum, providing practical training, and collaborating with technology providers, are designed to create a workforce that can not only adapt to technological advancements but also drive innovation. As Nigeria progresses in terms of technology, it is crucial for the surveying profession to keep up, and investing in technological training is an investment in the overall development of the country.

### Collaboration with Security Agencies

It is essential to establish collaboration with local law enforcement and security agencies in order to enhance project operations. This partnership may include sharing project plans, obtaining security briefings, and receiving support in high-risk areas. Moreover, providing trainings to the survey teams on safety protocols and situational awareness will greatly enhance their ability to navigate challenging situations. This will ultimately contribute to the overall improvement of the team's performance. The tone of the response text should maintain a professional demeanor.

### Establishment of a Collaborative Platform


The objective is to establish a centralized platform or network that facilitates efficient collaboration among survey professionals, government agencies, and stakeholders. This platform will function as a central hub for sharing information, coordinating projects, and initiating joint initiatives. By promoting a cooperative environment, it will support professionals nationwide in leveraging their collective expertise and resources to progress in the field of surveying. Effective collaboration is not just a solution; it serves as a driving force for innovation, efficiency, and sustainable development.

### Conclusion

The aforementioned strategies are positioned as practical measures aimed at addressing

current challenges. They are intended to contribute to a Nigeria where surveying is not only seen as a profession but as a vital force that shapes our collective destiny. The emphasis lies in the belief that an educated, aware, and technologically adept approach to surveying can drive the nation towards unprecedented growth and prosperity. These strategies are presented with a focus on practical implementation and tangible outcomes. This paper emphasizes the urgent need for increased awareness of surveying and mapping in Nigeria and proposes actionable strategies to overcome the identified constraints. By fostering a culture of understanding and appreciation, Nigeria can fully utilize the potential of geospatial information for sustainable development.

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## ESB Networks and Neara partner to reduce risk of climate-related power cuts

Ireland’s Asset Owner and Distribution System Operator, ESB Networks, has partnered with Neara, the leading AI infrastructure modelling platform, to mitigate the impact of extreme weather events on energy supply and speed up the clean energy transition.

With the frequency and intensity of storms increasing across Ireland in recent years, ESB Networks is taking an innovative approach to climate-proof its network and protect its 2.4 million customers from the growing risk of weather-related power outages. Through this new partnership, ESB Networks is deploying Neara’s AI and digital modelling technology to transform the way they identify, evaluate, and address risks across their Transmission network spanning over 7,500km.

ESB is leveraging Neara’s technology to create a ‘digital twin’ model that maps all their infrastructure using high accuracy LiDAR down to the level of individual structures (poles, towers) and the conductors strung between them. For this reason, LiDAR data is essential in building the ‘digital twin’. The model is used to analyse and stress-test key parts of the network in granular detail within a simulated digital environment. [www.esbnetworks.ie](http://www.esbnetworks.ie)

## A collaborative smart city research project

As part of the Smart DCU (Dublin City University) program, which is utilizing the university campus as a test site to explore and evaluate the latest advancements in smart city solutions, Dublin City University (DCU) is collaborating with Insight SFI Research Center for Data Analytics (Insight) and Bentley Systems. This collaborative initiative aims to investigate the power of artificial intelligence (AI) and immersive digital twin technology using DCU as a city microcosm for developing intelligent and sustainable urban spaces.

It strives to push the boundaries of digital twins by leveraging Insight’s AI expertise and Bentley’s advanced technology applications in a secure and controlled campus environment, helping guide cities in the strategic deployment of smart city innovations.

The project involves establishing AI algorithms and digital twins to simulate and visualize scenarios and use predictive analytics to improve mobility and safety on campus, as well as enable real-time monitoring of building performance, occupancy, and air quality. The goal is to gather digital insight to help the university better understand how people, traffic, and buildings interact within the built environment, making more informed decisions. [www.bentley.com](http://www.bentley.com)

## Antarctica mysteries to be mapped by robot plane

A team of scientists and engineers have landed in Antarctica to test a drone that will help experts forecast the impacts of climate change. The autonomous plane will map areas of the continent that have been out of bounds to researchers. It has been put to the test in extreme weather around Wales’ highest peaks.

Its first experiment will survey the mountains under an ice sheet to predict how quickly the ice could melt and feed into global sea-level rise. Scientists want to understand Antarctica better but they are limited by the existing technology. Strong winds, below-freezing temperatures and sudden storms are common. These dangerous conditions, as well as dark winters and the need to transport pilots and large amounts of fuel, put limitations on use of traditional crewed planes.

The British Antarctic Survey developed the new drone with UK company Windracers to be easily repaired if something goes wrong. The drone was tested in Llanbedr, Eryri (also called Snowdonia) in north Wales - a stand-in for the difficult weather and terrain of Antarctica. During a practice run in strong winds with rain lashing the airfield,

engineer Rebecca Toomey explained that the drone can fly to remote areas without concerns for pilots' safety. [www.bbc.com](http://www.bbc.com)

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### SUV ended up on flight of steps

An SUV driver relying on Google Maps for navigation ended up stuck on a flight of steps in Gudalur, a hill town in Tamil Nadu. The incident happened when a man was driving from Gudalur, where he and his friends spent the weekend, and was using Google Maps for directions on their way back to Karnataka.

Gudalur, situated at a tri-junction among Tamil Nadu, Kerala, and Karnataka, is a popular holiday spot, often visited by tourists heading to Ooty. [www.indiatoday.in](http://www.indiatoday.in)

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### TopGis elevates 3D visualization capabilities with the UltraCam Osprey 4.1

Leading Czech geospatial technology firm, TopGis, has reinforced its commitment to delivering cutting-edge 3D interactive city visualizations with the recent acquisition of the UltraCam Osprey 4.1 from Vexcel Imaging. With the UltraCam Osprey 4.1, TopGis aims to obtain higher quality data and the ability to document greater detail. The strategic move to incorporate the UltraCam Osprey 4.1 aligns with the evolving landscape of 3D worlds and digital twins. The shift towards widespread oblique imaging reinforces the significance of using cutting-edge technology, making the UltraCam Osprey 4.1 the ideal choice for TopGis. [vexcel-imaging.com](http://vexcel-imaging.com)

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### BlackSky inks \$50 million deal

BlackSky, an Earth observation and data analytics firm, will provide satellite imagery services and imaging spacecraft to the Republic of Indonesia under a \$50 million deal announced on Feb. 8. BlackSky will work with Thales Alenia Space to establish the building blocks of a sovereign Earth imaging satellite network tailored to Indonesia's national security needs. <https://spacenews.com>

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### Call for Proposals operationally ready CPNT Services

The Volpe National Transportation Systems Center of the U.S. Department of Transportation (DOT) has issued a solicitation to obtain proposals from vendors with operationally ready complementary positioning, navigation and timing (CPNT) services to be used for testing and evaluation in the Rapid Phase of the DOT's CPNT Action Plan. The Volpe Center is seeking proposals from industry professionals to deploy PNT services with a technical readiness level (TRL) of eight or higher.

The evaluation conditions will include situations where GPS/GNSS service is disrupted or manipulated, and CPNT-specific threat vectors are introduced. Proposals are encouraged to be tailored to critical infrastructure PNT user requirements with the expectation that Rapid Phase evaluation results will be shared with sector risk management agencies (SRMAs) through the Federal interagency process to drive CPNT adoption.

According to the Volpe Center, it is prepared to make multiple awards if multiple proposals meet the solicitation requirements. [www.transportation.gov](http://www.transportation.gov)

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### GPS Rapid Prototype Demonstration Tranche 0

The U.S. Space Systems Command (SSC), part of the United States Space Force, is actively seeking insights from the GNSS industry through a Request for Information (RFI) regarding the development of a Global Positioning System (GPS) Rapid Prototype Demonstration, Tranche 0.

This initiative is part of a strategic effort to upgrade GPS capabilities to meet modern challenges in space navigation and ensure continued operational superiority. This RFI aims to collect information about the industry's capacity to innovate and deliver solutions that can enhance the GPS infrastructure. The focus is on identifying technologies and approaches that can reduce the size, weight, power and cost (SWaP-C) of future GPS satellites,

streamline their production and launch processes and improve compatibility with a variety of launch vehicles.

According to the SSC, the goal of Tranche 0 is to create a prototype satellite that can emit certain GPS signals that are compatible with existing user equipment. The operation of this prototype in medium-Earth orbit (MEO), approximately 20,000 km above Earth, aims to test and validate these innovations in a real-world setting. The SSC's approach aims to encourage collaboration, inviting both established and emerging players in the industry to showcase their abilities in rapid development, fabrication, and integration of GPS payloads. <https://sam.gov>

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### GMV defines late collision avoidance

GMV, as part of the consortium led by Astroscale UK, has been awarded with a new activity within the ESA's CREAM (Collision Risk and Automated Mitigation) cornerstone, as an extension to the CREAM#2 activity, to advance in an alternative commanding path for late collision avoidance manoeuvres (CAM) making use of the Galileo Return Link Service.

The increasing space traffic congestion in low earth orbits has also increased the number of collision avoidance manoeuvres. They represent a very relevant cost in terms of operations effort and propellant, reducing the operational lifetime, and affecting the nominal mission of the satellite. As a result, satellite operators wait as long as possible to command the avoidance manoeuvre in order to reassess the risk and to avoid unnecessary ones. This commanding requires communication with the satellite, which is typically only available few times per day in LEO, when the satellite passes over the ground stations. This represents an important limitation for the satellite operator which can only wait until few hours before the encounter using the last passes available. The new developments proposed target to mitigate this limitation by providing alternative late commanding paths to

trigger the manoeuvre much closer to the conjunction, allowing a net reduction on the number of collision manoeuvres required, and therefore, reducing the propellant consumption and increasing the operational lifetime of the satellites.

This is achieved by using of the Galileo Signal-in-Space (SiS) and its Return Link Service as an alternative continuous communication path to relay collision avoidance manoeuvre decisions to satellites mounting on-board Galileo compatible GNSS receivers. [www.gmv.com](http://www.gmv.com)

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### FAA tells pilots to go analogue as GNSS 'spoofing' incidents increase

The Federal Aviation Administration is advising pilots to prepare to use conventional navigational aids to manage the risks of 'spoofing' attacks on global positioning systems and global navigation satellite systems.

Incidents of aircraft navigation systems disrupted by false data have become more frequent, causing pilots to veer dangerously off course. Though all pose a danger to aircraft, interference, jamming, and spoofing, differ in the extent of risk.

Interference and jamming prevent aircraft navigation systems from obtaining a reliable positioning signal. Spoofing sends false navigational data, sometimes corrupting critical flight systems and making them unusable.

In a recently published Safety Alert for Operators, the FAA advises civilian flight crews to monitor the performance of their equipment onboard, report any GPS/GNSS issues to air traffic controllers, and prepare to fly without digital satellite navigation systems before they take off. [www.forbes.com](http://www.forbes.com)

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### Viasat demonstrates UK SBAS

Viasat, Inc. has demonstrated a UK satellite-based augmentation system (UK SBAS) for the first time, showing how highly accurate GPS data can maximize safety and improve efficiency. The test

flight, flown from Cranfield Airport using the National Flying Laboratory Centre's Saab 340B aircraft, showcased a UK-based SBAS that delivers more precise, reliable navigation data. The UK is no longer part of the EU's similar European Geostationary Navigation Overlay Service (EGNOS), following its exit from the European Union. While EGNOS can still be used for non-safety applications in the UK, the trial aims to provide a first step toward a complementary UK SBAS which can be used for critical safety of life navigation services across air, land, and sea.

UK SBAS works by combining ground monitoring data with satellite connectivity to provide more reliable navigational data. Across a range of applications, it can offer positioning down to a few centimeters of accuracy, rather than the few metres provided by standard GPS. For aviation, the system gives pilots greater trust in their onboard instruments, which has major implications when pilots may not be able to physically see a runway or other obstacles due to bad weather. [www.viasat.com](http://www.viasat.com)

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### Galileo, now fit for aviation

Galileo, satellite navigation system, now meets international standards to guide civil aviation from take-off to landing, complementing Europe's EGNOS for the most critical operations. Galileo was not designed to comply with these strict safety requirements, so how did engineers at ESA achieve this feat? This is a tale of engineering excellence.

In civil aviation, especially for critical stages such as final approaches, navigation systems need to be extremely reliable. The International Civil Aviation Organization (ICAO) defines the strict requirements that systems need to fulfil to be used in these so-called Safety-of-Life operations, where a malfunction of the system would lead to major human or environmental catastrophes. Galileo was never designed to comply with these rigorous integrity standards as Europe already had EGNOS, a dedicated Safety-of-Life system for

navigation. EGNOS 'augments' GPS signals for critical operations in aviation, maritime navigation, agriculture and more. But in 2016, ESA joined forces with the European Commission (EC) and the EU Agency for the Space Programme (EUSPA) to elevate Galileo's reliability and make it fit for civil aviation, as a standalone support system during en route and augmented by EGNOS at take-off and landing. [www.esa.int](http://www.esa.int)

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### BAE Systems completes design review for M-Code GPS receiver

BAE Systems' program to design and manufacture an advanced military GPS receiver and next-generation semiconductor has completed Critical Design Review (CDR).

The Military GPS User Equipment (MGUE) Increment 2 Miniature Serial Interface (MSI) program is part of a \$247 million contract received in 2020 from the U.S. Space Force. The MSI includes a Next-Generation Application Specific Integrated Circuit (NG ASIC) which will provide enhanced security and performance of M-Code technology. It can also be easily transitioned into future BAE Systems M-Code GPS receivers. [www.baesystems.com](http://www.baesystems.com)

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### Korea's KASS now certified and operational

The Korea Augmentation Satellite System (KASS), designed and implemented by Thales Alenia Space, has been officially certified by Korean national authorities and has entered operational service. The system was developed in partnership with the Korea Aerospace Research Institute (KARI) on behalf of the Korean Ministry of Land, Infrastructure and Transport (MOLIT).

The project has received support from various international and European entities, including the European Commission, the European Union Agency for the Space Programme (EUSPA), the European Space Agency (ESA), the European Aviation Safety Agency (EASA) and the French Space Agency (CNES).

KASS, operational via the MEASAT-3d geostationary satellite launched in 2022, will soon be enhanced by the addition of KOREASAT 6A. It is currently under development by Thales Alenia Space for KT SAT Corporation, South Korea's leading satellite communications operator.

The addition of KOREASAT 6A — equipped with a satellite-based augmentation system (SBAS) payload — aims to improve the system's service continuity and operational availability.

Designed to meet international standards set by the International Civil Aviation Organization (ICAO), KASS will initially prioritize aircraft applications and focus on Safety of Life services critical during flight phases, including landing.

This focus is intended to enhance flight safety and efficiency while minimizing the environmental impact of aviation. Additionally, KASS is designed to be interoperable with other SBAS satellite navigation systems worldwide to offer seamless flight safety across different zones. [www.thalesaleniaspace.com](http://www.thalesaleniaspace.com)

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### Google Maps introduces enhanced navigation feature for tunnels

Google Maps has recently introduced a new feature designed to address the challenges users face while traversing tunnels. Android version of Google Maps can now utilise Bluetooth beacons to precisely track the user's location in areas where conventional GPS signals often encounter limitations. This feature aligns with a capability already present in Waze, a navigation app also owned by Google, which employs Bluetooth signals from beacons to transmit location data to mobile devices. Google Maps then utilises this information, coupled with the device's mobile connectivity, to offer real-time traffic data in scenarios where conventional GPS connections might falter. ▽

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### Funds for space preservation efforts by UK Space Agency

The UK Space Agency recently allocated a £2m investment for research into the refuelling of a mission designated for the removal of space debris. Currently, numerous inactive space objects orbit Earth. Statistics indicate almost 37,000 objects larger than 10cm, and approximately 130 million smaller than 1cm, ranging from decommissioned satellites to tools lost by astronauts, even including specks of paint. Their high-speed orbits pose a significant hazard to active satellites.

In a bid to foster the long-term sustainability of space, the UK Space Agency is spearheading initiatives to bolster UK capabilities in space environment management, thereby affirming its commitment to more sustainable space operations. [www.gov.uk/government/publications/sbri-active-debris-refuelling-mission-feasibility-study-phase-1](http://www.gov.uk/government/publications/sbri-active-debris-refuelling-mission-feasibility-study-phase-1)

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### LeoLabs, Secure World Foundation lead joint statement on space debris

LeoLabs released a joint statement on debris remediation signed by representatives of commercial entities in collaboration with the Secure World Foundation (SWF).

LeoLabs and SWF led this effort in response to the continual accumulation of massive derelict objects (e.g. spent rocket bodies, etc.) in low Earth orbit (LEO).

As of January 2024, around 29% of the total mass in LEO consists of these massive objects, 43% of which were left in orbit since the turn of the century. These objects pose the greatest debris-generating potential in LEO, putting the satellites the global economy relies on at risk. [www.leolabs.space](http://www.leolabs.space)

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### Tracking methane leaks with space tech

Google and the Environmental Defence Fund (EDF) recently announced a new partnership to track

methane emissions from oil and gas operations. This collaboration leverages space technology to detect and expose leaks, holding companies accountable and ultimately aiding in climate change mitigation efforts.

The centrepiece is the launch of MethaneSAT, a new satellite specifically designed to detect methane emissions with high precision. Scheduled for launch in March 2024, this satellite will provide unprecedented global coverage and sensitivity for identifying leaks. Google provides its cloud computing resources and data analysis and visualization expertise to process and analyze MethaneSAT's data. This includes creating a dynamic methane map accessible to the public later this year. The collected data will be available to various stakeholders, including researchers, regulators, and the public.

By overlaying MethaneSAT data with Google's oil and gas infrastructure map, the project aims to identify specific equipment types most prone to leaks, aiding in targeted mitigation efforts. <https://blog.google/outreach-initiatives/sustainability/how-satellites-algorithms-and-ai-can-help-map-and-trace-methane-sources/>

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### Synspective signs MOU with Vietnam

Synspective, a Synthetic Aperture Radar (SAR) satellite data and analytics solution provider, entered into an agreement with the National Remote Sensing Department of the Ministry of Natural Resources and Environment of Vietnam and Fujitsu Vietnam. This collaboration aims to advance the application of satellite remote sensing technology in monitoring natural resources and the environment, preventing natural disasters, and fostering economic development in Vietnam. [synspective.com](http://synspective.com)

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### TCarta, Capella Space partnership

Capella Space Corp announced a partnership with TCarta to add high-resolution SAR satellite imagery to

TCarta's coastal monitoring and shoreline feature extraction solutions. It will enable more consistent and reliable identification of coastline changes so coastal managers have accurate and up-to-date information for mitigating the impacts of climate change.

Rising oceans and melting glaciers are quickly changing the geography of the world's coastlines, reshaping ecosystems, and threatening the livelihoods of coastal communities. [www.capellaspace.com](http://www.capellaspace.com)

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### ISRO launches INSAT-3DS meteorological satellite

INSAT-3D meteorological satellite was successfully launched from the Satish Dhawan Space Centre in Sriharikota on the GSLV-F14. It deployed the INSAT-3DS into the intended geosynchronous transfer orbit.

The INSAT-3DS satellite is an exclusive mission designed for enhanced meteorological observations, monitoring of land and ocean surfaces for weather forecasting, and disaster warning.

The primary objectives of the mission are to monitor Earth's surface, carry out oceanic observations and its environment in various spectral channels of meteorological importance, provide the vertical profile of various meteorological parameters of the atmosphere, provide data collection and dissemination capabilities from data collection platforms, and provide satellite-aided search and rescue services. [www.isro.gov.in](http://www.isro.gov.in)

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### AWS launches first space tech accelerator program in India

Amazon Web Services (AWS) India Private Limited has announced the AWS Space Accelerator: India, a technical, business, and mentorship opportunity designed to foster startups focused on space technology, and accelerate their development, with support from, T-Hub, and Minfy. This is AWS's first accelerator program in India focused on startups in the space sector, and follows

the MoU it signed with ISRO and IN-SPACe in September last year, which envisions to nurture startups in space-tech, and support innovation in the sector.

The 14-week accelerator program will provide India-based startups dedicated business resources, expertise, and guidance around technology and business capabilities, and help them leverage AWS to build, grow, and scale their missions. The program is open to both early-stage and mature startups based in India whose missions support the space sector, who need a technology platform for their ideas, and are looking to accelerate their growth and investment opportunities.

Space tech startups operate in a high-risk environment that requires significant capital investment and access to a skilled workforce, and need to undertake significant technology development and testing. The accelerator program seeks to address these challenges by providing space tech startups an opportunity to build and test their solutions using simulation technologies on AWS before making capital investments, allowing them to rapidly experiment at a low-cost, and enhance their solutions, before launching and scaling them. <https://press.aboutamazon.in>

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### Greece announces €60m EO microsatellite constellation

The Greek Ministry of Digital Governance has announced the development of a €60-million Earth observation microsatellite constellation. It will provide the country with optical, multispectral, and hyperspectral Earth observation data.

An initial call for information for what was then referred to as the National Programme for the Construction of Small Satellites was published in September 2021. The programme was announced as an element of the country's national space strategy, with funding coming from Greece 2.0, which is the country's national recovery and resilience plan. The call was developed in collaboration with the European Commission and the European Space

Agency, with the agency also handling the publishing and management of the call.

On 24 January 2024, the Ministry of Digital Governance announced that this initial phase had been completed and that the project was ready to begin accepting proposals. According to this announcement, the constellation will have a total budget of €60 million. This project is, however, only one element of the country's larger Microsatellite Programme, which has a total budget of €130 million. [europeanspaceflight.com](http://europeanspaceflight.com)

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### Digital Public Infrastructure for Earth observation

Space startups such as GalaxEye Space, Dhruva Space and Pixxel in India have called on the government to implement a digital public infrastructure (DPI) for earth observation-based geospatial analytics. The Indian Space Association (ISPA) has sent a representation to the government making a similar pitch, saying it will open new horizons for India's booming space sector.

The government must commit towards procuring and integrating these solutions, according to the space companies, since space technologies find widespread applications across areas such as agriculture, disaster management, infrastructure planning and urban development. [economictimes.indiatimes.com](http://economictimes.indiatimes.com)

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### ESA launches Maritime Sustainability Task Force

The European Space Agency (ESA) recently launched its Maritime Sustainability Task Force. Initiated by ESA's Business Applications and Space Solutions (BASS) programme, the new Task Force will see ESA working together with a number of major players in the sector, including shipping companies, maritime authorities, classification societies, and industry associations. Together they will work to leverage on space solutions to reduce the environmental impact of the maritime sector. [business.esa.int](http://business.esa.int) 

# Maya city discovered in the jungle using Laser mapping

Three four-hour flights high above the jungles of Campeche on Mexico's Yucatan Peninsula exposed a hidden gem on the ground below: a lost city that was likely abandoned more than 1,000 years ago.

It was all in a day's work for Juan Carlos Fernandez-Diaz, an assistant

professor in civil engineering at the University of Houston, who spotted the city in March 2023 during an airborne archaeological survey of the area.

For the past decade, he's been a trailblazer in the archaeological application of LiDAR, airborne light detection and ranging equipment that can find structures

obscured by dense tree canopies and other vegetation — relics that in some cases reveal traces left by a lost civilization.

Archaeologists subsequently surveyed the site, which they've named Ocomtun, for six weeks in May and June 2023 and found 50-foot-tall (15.2-meter-tall) structures resembling pyramids, pottery and engravings that they believe date back to between 600 and 900 AD — known as the Late Classic Period in the Maya Civilization.

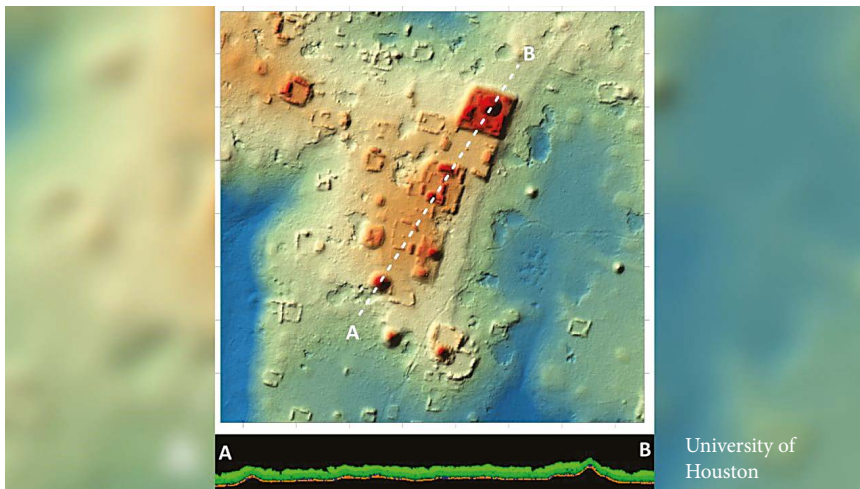
"When we see the (LiDAR) images, we can see that there's something amazing [but] the real discovery happens after a lot of investigation and exploration," said Fernandez-Diaz, who is also the co-Investigator at the National Center for Airborne Laser Mapping.

While LiDAR revealed the location of structures, archaeologist Ivan Šprajc — a researcher at the Slovenian Academy of Sciences and Arts (ZRC SAZU) — still faced an enormous hurdle when he and his team went to survey the area.



Jonathan Burke/University of Houston

Juan Fernandez-Diaz examines maps on his computer.



Shown here is a LiDAR image of Ocomtun.

## Ocomtun's 'peculiar features'

Maya civilization is best known for its pyramid temples and impressive stone structures that have been found across southern Mexico, Guatemala, Belize, Honduras and El Salvador.

Šprajc and his team found three plazas complete with large buildings and a ball game field. He said that the city resembles other Maya cities from the same period, but there are "certain peculiar features."

During the six-week survey, Šprajc and his colleagues conducted archaeological





Pictured here are the remains of a building with a staircase in the city of Ocuntun.

reconnaissance and dug a 2-meter by 2-meter test pit and the pottery fragments they found helped them understand the age of the site. They plan to return next year for further investigation.

### Transformative technique

Remote sensing technology, first used in archaeology at the turn of the century, has revolutionized the field, particularly for researchers working in densely forested areas that are difficult to explore on foot, such as those in central America, Šprajc said.

From an airplane or in some cases a drone, a LiDAR sensor tracks the amount of time each laser pulse takes to return and uses that information to create a three-dimensional map of the environment below.

“The simplest analogy is like playing tennis, you know, you basically throw a ball to the wall and see the ball come back and basically measure the time it (takes to go) to the wall and come back. And because it’s a laser, it’s traveling at the speed of light,” Fernandez-Diaz explained.

He’s mapped more than 20,000 square kilometers (7,722 square miles) of Central American jungle and

been involved in 45 archaeological projects, including the discovery of the largest and oldest Maya temple near Tabasco, Mexico, and tens of thousands of Maya structures and settlements in the Guatemalan jungle.

Understanding sites like these can shed light on the origins of cities and community life and whether large construction projects in the past required the support of powerful elites and centralized authority of some kind. In the case of the newly discovered city, though, many questions remain unanswered.

While LiDAR saves time in the research process — in some cases one day in the air can replace a lifetime’s work of an archaeologist on the ground — Šprajc says the work he pursues is still costly. He raised funds from seven different institutions and companies to fund the field work, including four Slovenian businesses — publisher Založba Rokus Klett, transport company Adria kombi, lender Kreditna družba Ljubljana and travel agency AL Ars Longa — and two US-based organizations, Ken & Julie Jones Charitable Foundation and Milwaukee Audubon Society as well as his own institution ZRC SAZU. <https://edition.cnn.com/2023/07/26/americas/laser-mapping-reveals-a-forgotten-maya-city-scen>

### Trimble introduces MX90 Mobile Mapping System

Trimble released the Trimble MX90 mobile mapping system. It provides a complete field-to-finish mobile mapping solution that enables powerful workflows for data capture, processing and analysis. The vehicle- or train-mounted MX90 rapidly captures highly detailed laser scans and imagery—both panoramic and multi-angle. High-resolution immersive imagery, high-density colorized point clouds with accurate color projections and scene inspection capabilities enable new workflows, such as automatic crack detection. [www.trimble.com](http://www.trimble.com)

### Septentrio’s new smart antenna for machine automation

Septentrio has launched a new smart antenna AntaRx. Enclosed in a ruggedized housing, it can handle high levels of shocks and vibrations and is ready for operation in harsh industrial environments. Built on Septentrio’s long standing GNSS experience, this multi-frequency receiver delivers high-accuracy RTK positioning down to the centimeter level. [www.septentrio.com](http://www.septentrio.com)

### OxTS introduces GNSS/IMU

OxTS has introduced the RT3000 v4 GNSS inertial measurement unit (IMU). It offers uninterrupted position, orientation and dynamics in challenging environments. The IMU will reach the desired specification within three minutes of low dynamic movements, which reduces the time and space required for high dynamic maneuvers before each data collection. [www.oxts.com](http://www.oxts.com)

### Polaris Location Services in South Korea

Point One Navigation has expanded its Polaris real-time kinematic (RTK) location network to South Korea. The network is set to provide comprehensive coverage throughout the country. It offers centimeter-level accurate GNSS positioning with accuracy ranging from

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## MARK YOUR CALENDAR

### March 2024

#### Geo Connect Asia

06 - 07 March 2024

Singapore

<https://www.geoconnectasia.com>

#### DGI 2024

11 - 13 March

London, UK

<https://dgi.wbresearch.com>

#### Munich Satellite Navigation Summit 2024

20 - 22 March

Munich, Germany

[www.munich-satellite-navigation-summit.org](http://www.munich-satellite-navigation-summit.org)

### April 2024

#### GISTAM 2024

02 - 04 May

Angers, France

<https://gistam.scitevents.org>

#### IGRSM Conference 2024

29 - 30 April

Kuala Lumpur, Malaysia

<https://conference.igrsm.org>

### May 2024

#### Geolignite 2024

14-15 May 2024

Ottawa, Canada

<https://geolignite.ca>

#### FIG Working Week 2024

19 - 24 May

Accra, Ghana

[www.fig.net/fig2024/Welcome.htm](http://www.fig.net/fig2024/Welcome.htm)

#### National Surveyors' Conference

21 - 24 May 2024

Cardigan, PE Canada

<https://www.acls-aatc.ca/nsc-2024>

### June 2024

#### GEO Business 2024

05 - 06 June

London, UK

<https://www.geobusinessshow.com>

### July 2024

#### Esri User Conference

15 - 19 July 2024

San Diego, CA, USA

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

### August 2024

#### International Geographical Congress 2024

24 - 30 August

Dublin, Ireland

<https://igc2024dublin.org>

### September 2024

#### ION GNSS +

16-20 September

Baltimore, USA

<https://www.ion.org/gnss/index.cfm>

1 cm to 10 cm, which makes it ideal for challenging environments, such as urban areas with limited sky view. Unlike standard GNSS systems — which face position uncertainty due to atmospheric signal delay, satellite orbit variation, clock drift and signal multipath — the Polaris network counters these issues using additional information from compact base stations. [pointonnav.com](http://pointonnav.com)

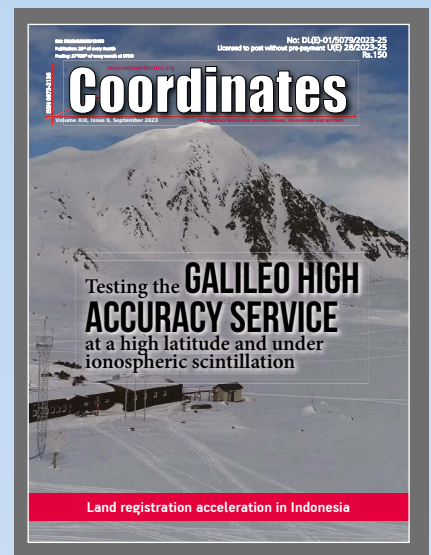
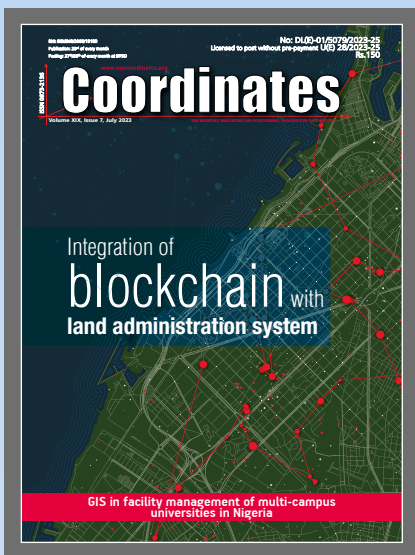
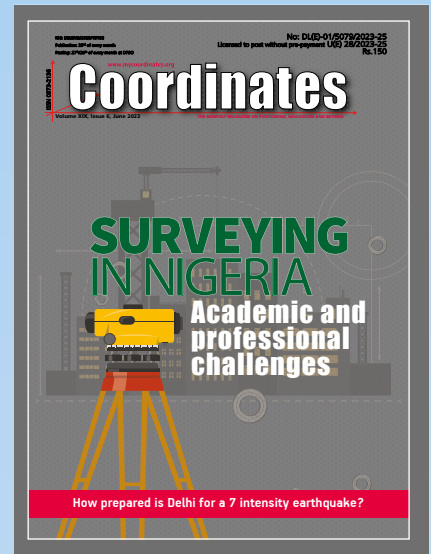
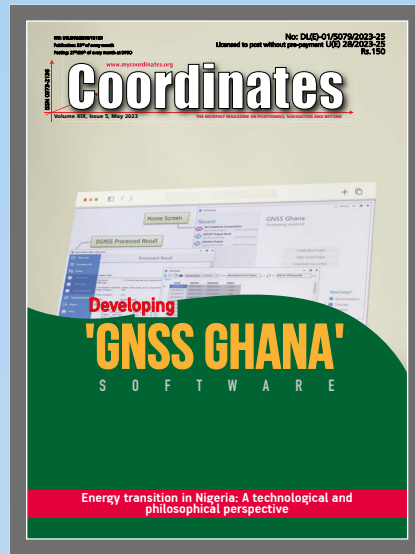
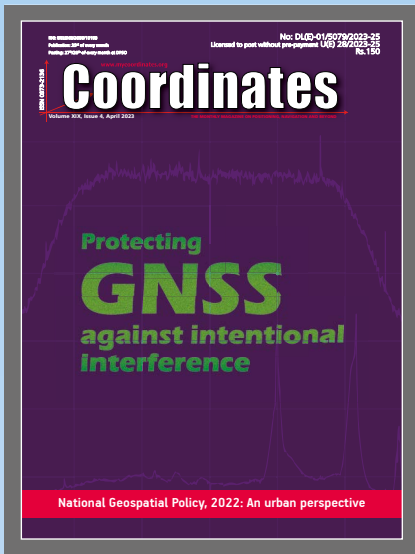
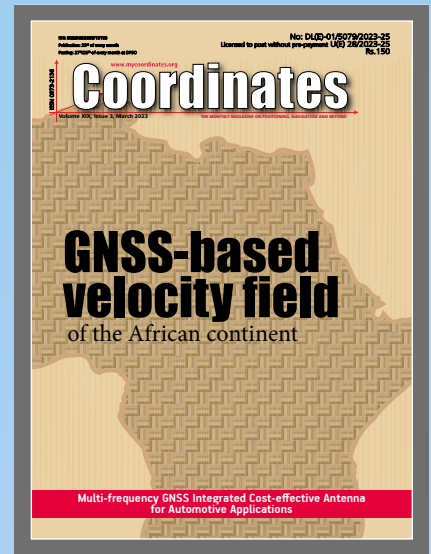
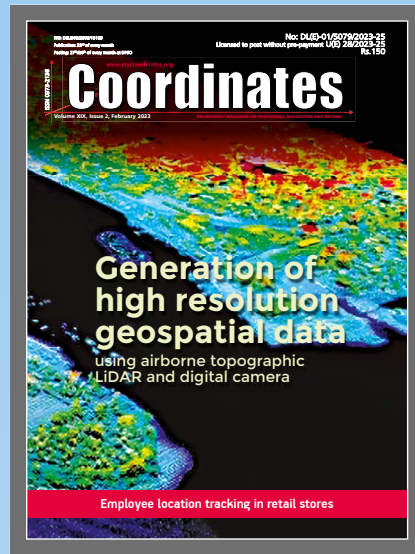
## Intecs combines GNSS and sensor data for train localization

Intecs is creating a multi-sensor, GNSS-based platform for obtaining absolute position of trains on rail lines. The system incorporates cameras that read QR codes installed in the area adjacent to the track. The system includes a robust, software-based, data fusion engine that combines GNSS and visual data to determine train position.

A number of field tests of the new system have been undertaken. A crucial set of trials, carried out at an auto racing track, involved a ground vehicle with GNSS antennas on the roof and with cameras pointing to one side, where QR code panels were set up at 10-meter intervals. The vehicle completed 30 laps around the course under different conditions.

## AG3335MA GNSS chip series

Airoha Technology launched its AG3335MA satellite positioning chip series at the end of December 2023. This new chip series has successfully passed the AEC-Q100 Grade 2 reliability qualification tests for automotive applications. The AG3335MA series chips have been certified by a third-party quality management system equipped with an automotive specification laboratory. [www.airoha.com](http://www.airoha.com)



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**0.05°**  
ATTITUDE

**0.02°**  
HEADING

**1 cm**  
POSITION

## NEW ELLIPSE-D

### The Smallest Dual Frequency & Dual Antenna INS/GNSS

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- » Quad Constellations
- » Post-processing Software



**Ellipse-D**  
RTK Dual Antenna



**Ellipse-N**  
RTK Single Antenna



**OEM**  
RTK Best-in-class SWaP-C