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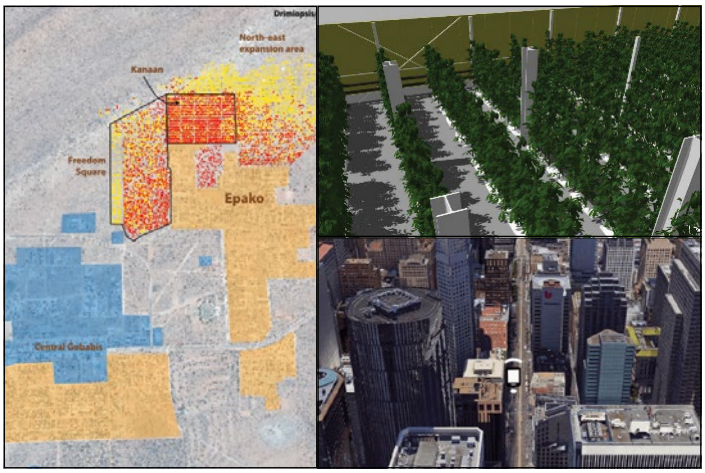

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2020: The year that was...

This was the year, in which most of us have a story to tell,

This was also a year, which was a story in itself.

This was the year when many lost lives and millions livelihoods,

This was also the year when grits get glitters and valor.

This was the year that showed that the mankind is not as kind as claimed.

This was also the year that shone the best of some.

This was the year when fakes and quacks flourished,

This was also the year when science and rationale offered the way forward.

This was the year when the mightiest was maimed and tamed by the tiniest,

This was also the year when hope triumphed the tragedies.

The year 2020 will be over,

But the turmoil it has triggered will continue in 2021 and its resonance even after.

Coordinates wishes a happy and a healthy new year
to our readers, authors and advertisers.

Bal Krishna, Editor
bal@mycoordinates.org

GREENPATROL: A Galileo enhanced solution for pest detection and control in greenhouses with autonomous service robots

One of the key differentiators for the GREENPATROL solution is its ability to autonomously navigate between - and within – greenhouses so that it can execute its planned tasks in different locations. This makes the solution very flexible, but is a challenging undertaking in the greenhouse environment

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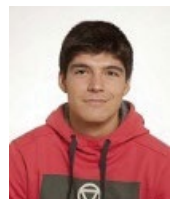

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Introduction

The Horizon 2020 (H2020) GREENPATROL project has developed an autonomous robotic solution that has the ability to navigate inside greenhouses while performing early pest detection and control tasks. This paper describes the main developments within the project, including precise positioning and navigation within the light indoor environment of a greenhouse, perception with visual sensing for on-line pest detection, and strategies for manipulation and motion planning based on pest monitoring feedback.

Motivation for GREENPATROL

With issues such as population growth, climate change, resource shortages and increased competition, a key challenge today for agriculture is to produce more with less. Greenhouses can protect crops from adverse weather conditions, allowing year-round production and consistency of environment in order to increase yields, whilst modern crop management approaches can significantly reduce water usage. However, in a closed environment such as a greenhouse, any infection can spread rapidly without timely pest detection and treatment, which will negatively affect production.

To prevent this, crop inspection to identify pests needs to be executed in a rigorous manner so that the necessary treatment can be applied as early as possible in order to minimise damage. Manual inspection methods were traditionally used, but these are very labour intensive and inefficient, and hence less practical as the area covered by greenhouses increases. As an alternative, automatic inspection using computer vision has become more common. This approach is well suited to carrying out repetitive tasks and can also improve the accuracy of the detection, therefore improving productivity and reducing the use of pesticides.

The main objective of the GREENPATROL project was to design and develop an innovative robotic solution for Integrated Pest Management (IPM) in greenhouse crops, with the ability to navigate inside greenhouses whilst performing pest detection, treatment and control tasks in an autonomous way. It is noted that there are already several automatic Integrated Pest Management (IPM) tools and techniques available ([1], [2], [3]), although none of them use robotic platforms as part of the detection system. The main advantage of using a mobile robotic platform is the fact that it can cover a large greenhouse (or multiple greenhouses) with just a few cameras, because the robot will move around between locations and inspect plants in different sections of the greenhouse. Also, unlike systems that might use fixed guide rails, the robot platform does not require specific fixed infrastructure, and can even cope with changes to the greenhouse layout, making it far more flexible and easier to deploy.

Overview of solution

The GREENPATROL solution consists of the following main elements:

- A robot platform to carry the equipment required for inspection and treatment, and with the ability to travel throughout the greenhouse, including performing precise manoeuvres in tight spaces,
- A localization and navigation system to localize the robot platform within the greenhouse and navigate to the required destination for performing a task, whilst avoiding obstacles,
- A pest detection system, to automatically identify pests (at egg, larva and/or adult stage) that are infecting plants in the greenhouse,
- A control and management function for planning the inspection and treatment regimes, and to interface with the farmer to report on findings and action taken and to take on board updated instructions and plans.

Figure 2. Segway platform used for GREENPATROL system

For the GREENPATROL prototype, the robot platform used is a Segway® Flex OMNI. This platform is chosen because it has true holonomic motion, with the ability to manoeuvre in tight spaces. The platform also includes wheel encoders and an Inertial Measurement Unit (IMU), the data from which are combined to get an improved odometry estimation.

Nevertheless, it is noted that for commercial deployment in different types of greenhouse a different platform, smaller and lighter than the prototype version, will be used.

Positioning and navigation

One of the key differentiators for the GREENPATROL solution is its ability to autonomously navigate between - and within – greenhouses so that it can execute its planned tasks in different locations. This makes the solution very flexible, but is a challenging undertaking in the greenhouse environment.

Figure 1. Commercial greenhouse and crops

The main objective of the GREENPATROL project was to design and develop an innovative robotic solution for Integrated Pest Management (IPM) in greenhouse crops, with the ability to navigate inside greenhouses whilst performing pest detection, treatment and control tasks in an autonomous way

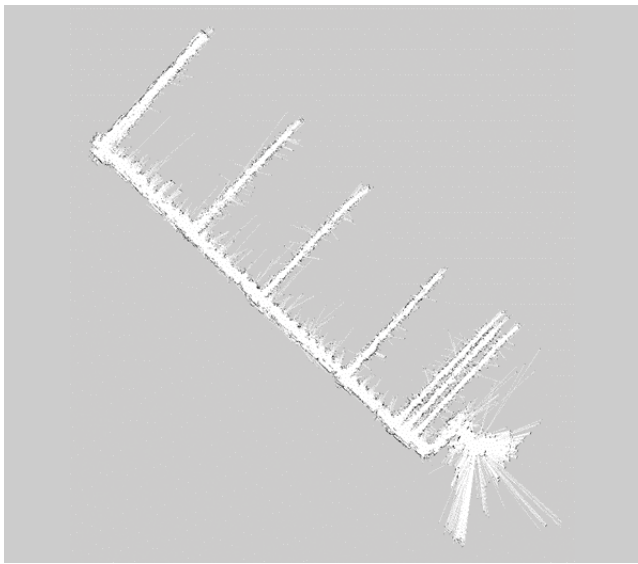

Figure 3. Map of the greenhouse from laser readings

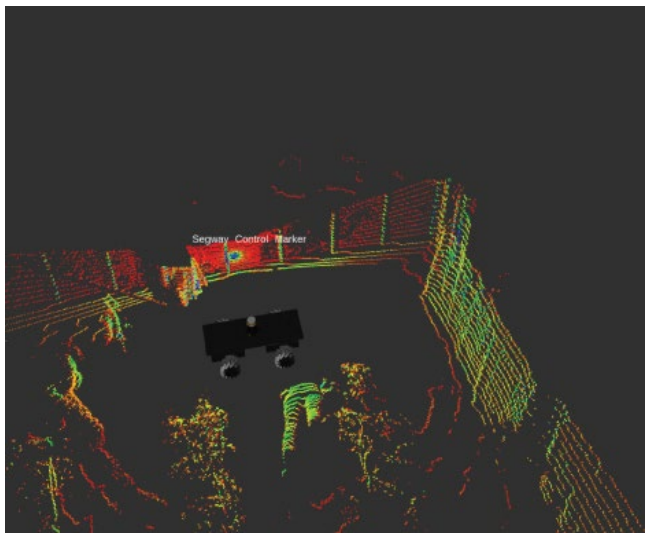

Figure 4. Perception of obstacles from laser readings

As described in [4], the problem of autonomous navigation of mobile robots is divided into three main areas: localization, mapping, and path planning. Localization is the process by which the robot can determine its location and pose with respect to its environment. On the other hand, mapping combines the robot location and pose, and observations of its surroundings, into a consistent model of the local environment. Finally, path planning uses knowledge of the robot location and the map in order to calculate the best route through the environment so it can reach the required location(s) to complete its tasks.

The key to this is the generation of a realistic map of the environment. To build a realistic map, the robot must know its position and orientation (pose) with respect to local surroundings at all locations. However, to localize itself within the environment, the robot needs an accurate map. This apparently circular problem is known as Simultaneous Localization And Mapping (SLAM) [5]. Popular approaches for SLAM implementations use laser range information to directly estimate the 3D locations of the imaged points, and combining this with odometry from the robot, and inertial systems, to localize the platform within the map.

However, the localization from odometry and inertial sensors can be subject to rapid error growth if not constrained, and even with accurate localization it is very difficult to maintain a realistic and up-to-date map that a visual-based system could perform an efficient matching. This is because the greenhouse environment is not static and will change over time as plants grow, the light intensity in the greenhouse changes, and the greenhouse layout is modified. There are even transient obstacles (such as people and other equipment) that need to be avoided.

For these reasons, the GREENPATROL solution has an absolute localization function in order to provide real-time absolute position and heading information in a global reference frame. Having the absolute position and orientation means that the robot platform can always know where it is in relation to the greenhouse (inside or outside, whereabouts in the greenhouse). The navigation part can then plan a path through the map from the known location to the required destination, and the relative localization (with laser measurements) can be used to avoid obstacles and to take over the positioning part in cases where the absolute locations performance is degraded. The absolute localization information is also logged for geo-referencing to record where actions have taken place (e.g. locations of plants where pests have been detected, locations of plants where treatment has been applied, etc.).

Absolute Localization in the Greenhouse

Greenhouses are challenging environments for precise GNSS positioning and navigation, with their metal-reinforced structures of glass or polycarbonate likely to cause multipath and signal blockages. To overcome this, the GREENPATROL solution

has a number of novel techniques to overcome these issues and allow precise positioning (to 30cm horizontal accuracy) within the greenhouse.

To enable precise positioning without reliance on local infrastructure, the absolute localization utilizes Precise Point Positioning algorithms. A high quality GNSS receiver is used to provide multi-constellation, multi-frequency GNSS observation and navigation data, and these are processed along with real-time precise orbit and clock corrections [7] using bespoke algorithms developed by GMV NSL in order to obtain a precise solution. To allow for the fact that there may be additional noise and multipath in the greenhouse, various data quality checks and employed to identify and remove degraded data. However, the biggest improvement to positioning in this difficult environment comes from the use of the Galileo E5 AltBOC signal.

> the GREENPATROL solution has an absolute localization function in order to provide real-time absolute position and heading information in a global reference frame. Having the absolute position and orientation means that the robot platform can always know where it is in relation to the greenhouse

Table 1: Comparison of position accuracy in greenhouse for different solutions

Solution Type	Constellations	Signals	Horizontal Error Percentile (Units are metres)			
			50%	68%	95%	99%
Single Point Code	GPS	L1	1.63	2.32	6.1	6.76
	GPS+GALILEO	L1	1.82	2.58	5.57	6.29
PPP	GPS	L1/L2	0.69	0.79	1	1.21
	GPS+GAL	L1/L2/E5a	0.31	0.38	0.56	0.56
	GPS+GAL	L1/L2/E5 AltBOC	0.15	0.23	0.3	0.32

Figure 5. Absolute localisation equipment

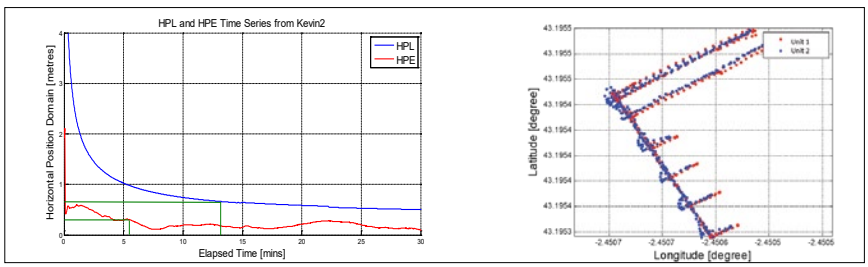

Figure 6. Example test results showing position accuracy (left) and consistency check of two units' solutions (right)

The Galileo E5 signal uses class of offset-carrier modulations known as Constant-Envelope AltBOC. The Galileo E5 signal has a sub-carrier frequency of 15x1.023 MHz and code chipping rate of 10x1.023 MHz represented as AltBOC (15,10). With this, the E5 signal offers improved performance for code tracking jitter less than 5cm even at signal strength of 35 dB-Hz [8]. Due to the code chipping rate and higher signal bandwidth, the AltBOC (15,10) also helps to eliminate the long-range multipath effects on code phase measurements [9].

As an early activity within the project, the performance of PPP at a static location in the greenhouse with different constellations and signals was assessed. The following table shows position accuracy (after convergence) for different solutions.

The results for standard single point code positioning are shown for comparison. It can be seen that the performance is worse than would be expected in open sky conditions, due to the increased level of multipath and signal blockages. Multi-constellation GPS+Galileo L1E1 performance is better than GPS alone due to the increased number of satellites, meaning that geometry is improved and identification and elimination of degraded measurements is more successful.

PPP performance (using GMV NSL software) is also shown. It can be seen

The Relative Localisation, besides performing the transformation of absolute coordinates to a relative reference frame, tries to improve the solution of position and orientation obtained by the Absolute Localisation

that, as expected, the position accuracy is better than standard single point positioning, due to using enhanced orbit and clock messages and the use of carrier phase measurements, which suffer less from multipath. Nevertheless, the high code multipath and frequent cycle slips lead to degraded performance compared to what would be expected in open sky conditions - for GPS only (L1/L2) the 95% horizontal accuracy is 1m. The inclusion of additional satellites with Galileo E1/E5a does help to improve the solution, but by far the best performance is achieved when using E5 AltBOC for Galileo. This seems due to a combination of lower multipath and improved signal tracking (fewer cycle slips).

In addition to the use of E5 AltBOC signal, the GREENPATROL solution also uses additional measurements from other sensors to enhance the GNSS PPP solution. Odometer measurements from the robot platform and IMU data are integrated into the position engine, so allowing better mitigation of faulty measurements and also to allow continuous provision of position and heading information even if GNSS measurements are lost completely.

Many different tests have been performed in open sky and greenhouse conditions to understand and assess the performance of the solution. Overall, it has been seen that the real-time position accuracy of the absolute localization solution can achieve 30cm (95%) and the heading accuracy 5 degrees (95%) in all conditions. This satisfies the system requirements to allow autonomous navigation and for geo-referencing the different actions taken by the robot.

Relative localization and navigation

The generation of maps and their use inside greenhouses poses certain problems that do not occur in other types of environments. On the one hand there is a high symmetry from the structural point of view, but on the other hand it is a very irregular environment due to the presence of the plants. In addition, the environment is very changeable over time as the plants grow, and different stages of growth carry associated big changes related to the density of the leaves. The combination of high symmetry and high irregularity results in great difficulties to detect differentiating elements (or recognizable references), which are key in a relative location system using maps. All this is aggravated by the possible dimensions of the greenhouse that make the map generators tend to warp long straight paths, where the differentiating elements known beforehand are lost sight of.

The fact that Absolute Localization feeds into the position solution of Relative Localization mitigates the problems discussed above, as it can make up for the absence of recognizable references by increasing the reliability of the positions taken as input. That is why both the algorithms used for map generation ad for localization have been configured in such a way that absolute position-related inputs have been given more confidence than those related to the sensors that perceive the environment.

The Relative Localization, besides performing the transformation of absolute coordinates to a relative reference frame, tries to improve the solution of position and orientation obtained by the Absolute Localization. It has been found through tests in the greenhouse that this solution is good enough so that the position cannot be improved, although sometimes the orientation can be improved, up to 30% [10]. In any case, the Relative Location acts as a safeguard in cases of loss of GNSS signal, making changes in its configuration to adapt to the circumstances.

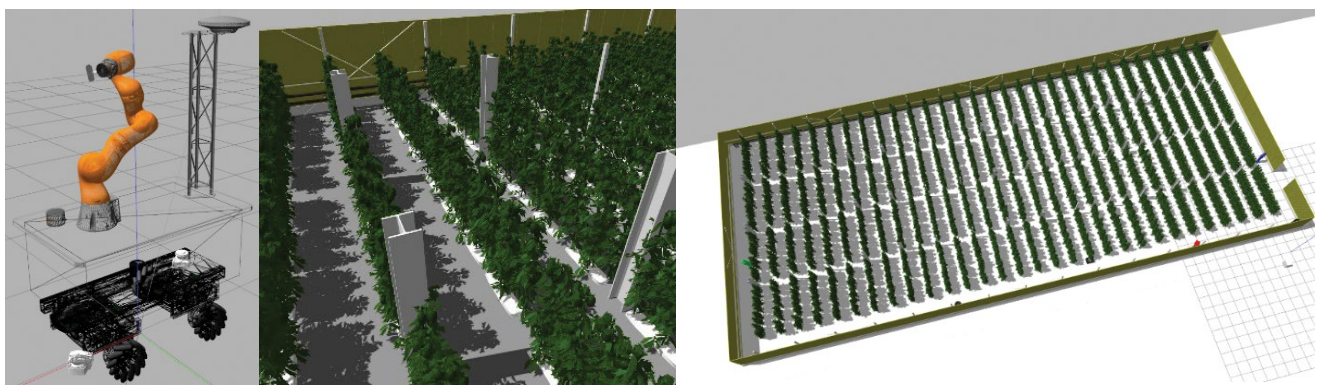

Figure 7: Greenhouse simulated and detail of randomized plants and robot platform

Within GREENPATROL, extensive work has been done on training and testing alternative machine learning and deep learning algorithms in order to determine the best approach to use for real-time detection

Figure 8: Robot arm and camera used in GREENPATROL demonstrator

Figure 9. Cultivation chamber and automatic dataset generation system

Figure 10. Example identification of pests on infected leaves through deep learning algorithms

Navigation is also affected by the previously discussed issue of plant irregularities. The combination of potentially narrow spaces, irregular elements and the need to maintain certain safety distances can lead to situations of blockage in navigation when the same configurations as in wider spaces are applied.

To solve it, an adaptive system of the navigation configuration has been chosen, which adjusts the safety distances, the dynamics of the robot's movement and the behaviour in the face of unforeseen obstacles according to the available space perceived at each moment around the platform. With this, a navigation approach adaptable to a changing environment, fluid in open spaces and viable in narrow spaces has been achieved

Navigation missions are determined by a high-level planner integrated with the IPM system that generates alternate inspection and treatment missions. Each of these missions is composed of multiple navigation objectives that carry an associated task to be performed at the destination.

Before testing in the greenhouse, a great effort has been made to create a representative scenario for verification at simulation level for the navigation algorithms, integrated with the rest of the subsystems. Several simulated greenhouses with realistic dimensions and number of plants have been generated. The largest of them is 1,500m2 and 1,920 plants. In order to reflect the expected differences in each of the plants, an approach has been adopted in which by using the same plant 3D model, different perceptions of them are obtained by applying small randomized variations in their position, orientation and size. In this scenario, and simulating different plant grow stages, 36 different missions have been carried out involving more than 4,000 navigation targets and all have been achieved without incident.

Pest detection

As well as being able to navigate through the greenhouse, another key aspect of the GREENPATROL solution is the ability to autonomously perform the tasks that are assigned to it. The core of this is to automatically perform pest detection within the greenhouse.

There are two aspects to the pest inspection. The first is the automatic, and accurate, identification of pests. The second is the strategy for how to best monitor the greenhouse in order to detect and monitor any infestation that occurs.

For the automatic identification of pests, the GREENPATROL system uses cameras

Figure 11. Robot set-up and trajectory in greenhouse validation

Figure 12. Robot arm and performing detection and treatment

In the localisation and navigation tests, the absolute localisation system (using PPP+DR and Galileo E5 AltBOC) was used in combination with the laser measurements and local map data to navigate through the greenhouse. Various routes were planned to test that the robot could navigate autonomously through the greenhouse, whilst avoiding obstacles and the plants themselves.

to take images of plants and uses machine learning and deep learning techniques to process the images automatically identify pests. As the plants will grow over time, it is important that the system is able to adapt to this change and so the cameras are mounted on a robotic arm that allows the cameras to be raised up and down (to cope with different height plants) and to twist to different orientations to be able to photograph both the top side and underside of leaves on both sides of the robot platform.

Within GREENPATROL, extensive work has been done on training and testing alternative machine learning and deep learning algorithms in order to determine the best approach to use for real-time detection. An extensive database of images of healthy and infected plants was populated through cultivating plants in lab conditions, as well as setting up an automatic system in a commercial greenhouse to record images in the same environmental conditions (including light levels) as would be expected for the final system.

The images are pre-processed to check for image quality, enhance features and add illumination to very dark areas, and then each image is viewed manually and pests (including eggs, larvae and adult pests) are tagged. This large dataset then provides the information to be able to develop and train the models, and to test the performance.

After investigation, a Deep Learning model was chosen for full implementation. This is because the Deep learning models were more robust than computer vision or machine learning with respect to lighting conditions, which is important for real scenarios where the light quality in the greenhouse will vary. In final testing of this model, almost 7,000 images were used for validation and it was shown that the pests were detected with 91% success rate and were correctly identified (i.e. type of pest) with 89% success rate, which fulfils the requirements set for the system. A more detailed description of the learning strategies for pest detection and identification can be found in [6].

In terms of the strategy for crop inspection to best detect and monitor infestation, there are several approaches that can be used. On the one hand it can be considered that every plant could be checked every day for signs of pests. However, this would be very time consuming and very inefficient – even for an automated solution. Alternatives include regular inspection of samples throughout the whole greenhouse, or focused inspection of particular areas that are particularly susceptible to infestation. The approach also needs to be adaptable to respond to events, for example inspection may be stepped up in areas adjacent to a section where pests have been detected to identify any spread, or there may be a return to areas where treatment has been applied to assess the effectiveness. In any case, the best strategy for a particular greenhouse will depend on things such as the size of the greenhouse, type of crop, etc. and so the GREENPATROL solution is configurable by the operator to choose the most appropriate strategy to use.

System testing

To complete the project, the GREENPATROL system has been demonstrated in the greenhouse. Unfortunately, restrictions imposed during the COVID pandemic have affected the test campaign, but nevertheless two sets of tests were performed in the greenhouse in August 2020. One set of tests has considered the localization and navigation capability, and a second set of tests checked the pest detection and treatment capability.

In the localization and navigation tests, the absolute localization system (using PPP+DR and Galileo E5 AltBOC) was used in combination with the laser measurements and local map data to navigate through the greenhouse. Various routes were planned to test that the robot could navigate autonomously through the greenhouse, whilst avoiding obstacles and the plants themselves.

From these tests it was determined that the localization and navigation function was successful. The robot platform autonomously performed basic navigation manoeuvres – travelling along the main corridor and turning into side corridors – and there were no collisions with infrastructure, or plants. Additional unexpected static obstacles were detected and avoided.

Other validation tests have considered the manipulation capabilities of the robot arm, the leaf detection capabilities, the pest detection and identification capabilities, and the spraying capabilities. Various tests for inspecting and treating plants were performed using plants on both the right and left sides of the robot. The onboard cameras were used to acquire pictures of the leaves on the plants and the Deep Learning pest detection and identification model were tested.

During the tests, the robot successfully executed of simple pest inspection and treatment plans. Although there were challenges with the illumination conditions and occlusion by leaves close to the camera, and most of the obtained pictures were healthy, nevertheless some *Tuta absoluta* and Whitefly insects were correctly identified.

Summary and conclusions

Overall, the GREENPATROL project has demonstrated the viability of a robotic solution for autonomous detection and treatment of pests within greenhouses.

- The project has developed and demonstrated a Galileo based GNSS positioning solution with the required accuracy in the greenhouse environment
- The solution has demonstrated autonomous navigation in the greenhouse, enabled by the absolute localization solution
- The pest detection and classification ability has been developed and validated
- A new IPM strategy for scouting in the greenhouse has been developed.

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Bibliography

[1] UEKA, Y. & ARIMA, S., 2015. Development of Multi-Operation Robot for Productivity Enhancement of Intelligent Greenhouses: For Construction of Integrated Pest Management Technology for Intelligent Greenhouses. Environmental Control in Biology, pp. 63-70.

[2] Ebrahimi, M. A. K. M. H. M. S. &. J. B., 2017. Vision-based pest detection based on SVM classification method. Computers and Electronics in Agriculture, pp. 52-58

[3] Xia, C. C. T. S. R. Z. &. L. J. M., 2015. Automatic identification and counting of small size pests in greenhouse conditions with low computational cost. Ecological informatics, pp. 139-146.

[4] Pattinson, Tiwari, Zheng, Fryganiotis, Campo-Cossio, Arnau, Obregon, Ansuategi, Tubio, Lluvia, Rey, Verschoore, Lenza, Reyes, 2018. GNSS Precise Point Positioning for Autonomous Robot Navigation in Greenhouse Environment for Integrated Pest Monitoring. 12th Annual Baska GNSS Conference, May 2018.

[5] Berns K., v. P. E., 2009. Simultaneous localization and mapping (SLAM). In: Autonomous Land Vehicles. s.l.:Vieweg+Teubner.

[6] Gutierrez, A., Ansuategi, A., Susperregi, L., Tubío, C., Rankić, I., & Lenža, L., 2019. A Benchmarking of Learning Strategies for Pest Detection and Identification on Tomato Plants for Autonomous Scouting Robots Using Internal Databases. Journal of Sensors, 2019.

[7] Weber G., Dettmering D., Gebhard H.: Networked Transport of RTCM via Internet Protocol (NTRIP). In: Sanso F. (Ed.): A Window on the Future, Proceedings of the IAG General Assembly, Sapporo, Japan, 2003, Springer Verlag, Symposia Series, Vol. 128, p. 60-64, 2005

[8] Sleewaegen J-M, De Wilde W, Hollreiser M (2004) Galileo AltBOC receiver. In: Proceedings of ENC GNSS 2004, Rotterdam, 16–19 May 2004

[9] Shivaramaiah, N.C., "Code Phase Multipath Mitigation by Exploiting the Frequency Diversity in Galileo E5 AltBOC," Proceedings of the 22nd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2009), Savannah, GA, September 2009, pp. 3219-3233.

[10] D. Obregon, R. Arnau et al., Precise positioning and heading for autonomous scouting robots in a harsh environment, International Work-Conference on the Interplay Between Natural and Artificial Computation. Springer, Cham, 2019. pp. 82-96.

UAV technology for formulation of GIS based master plans for small and medium towns

The Ministry of Housing and Urban Affairs (MoHUA), Government of India in October 2020, launched the 'Design and Standards for Application of Drone/ UAV Technology for Formulation of GIS based Master Plans for Small and Medium Towns' (TCPO and SoI, 2020)

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Government of India

The Government of India, in the year 1979-80, initiated a scheme for Integrated Development of Small & Medium Towns (IDSMT). The main objectives of the Scheme were Improving infrastructural facilities and helping in the creation of durable public assets in small and medium towns; Decentralizing economic growth and employment opportunities and promoting dispersed urbanization; Increasing the availability of serviced sites for housing, commercial and industrial uses; Integrating spatial and socio-economic planning; and Promoting resource generating schemes for the urban local bodies to improve their overall financial position. The Guidelines were revised in the year 1995 (MoUAE, 1995). The Scheme was continued with timely amendments and modifications up to the year 2004-2005. Later, in December 2005, the Scheme was subsumed in Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) Scheme. It was envisaged that the investment in the development of small and medium urban centres would help in reducing migration to large cities and support the growth of surrounding rural areas, as well.

The focus, in the subsequent years shifted towards the large and metropolitan cities. The Smart Cities Mission and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) saw the attention diversified to a variety of size class of towns and cities. These missions also saw a clear shift on providing the technical support to the process of Master Planning, with the Geo-Spatial technologies, i.e., the Remote Sensing and GIS. Continuing in the same spirit, the Ministry of Housing and Urban Affairs (MoHUA), in October 2020, launched the 'Design and Standards for Application of Drone/ UAV Technology for Formulation of GIS based Master Plans for Small and Medium Towns' (TCPO and SoI, 2020).

Earlier, under the National Urban Information System (NUIS) Scheme, the first of its kind in the country, a national level High Resolution Geospatial data base was created by obtaining data from Cartosat-1 + LISS-IV imagery and aerial photography, for preparation of 1:10,000 and 1:2,000 scale maps for Master Plan formulation. The NUIS Standards (TCPO, 2006) were subsequently modified to meet the needs of mapping at 1:4,000 scale for the Formulation of GIS-based Master/ Development Plans for 500 AMRUT Cities (TCPO, 2016). These Schemes were supported with dedicated Design & Standards documents.

However, due to technological constraints in both the NUIS and AMRUT schemes, different standards were adopted to generate spatial data for local, zonal and regional level plans. This resulted in data inconsistencies at various levels of plan preparation. Technological advancements

The current SDMS of the Survey of India caters to 2D data only. It does not cater to the requirements of 3D textured models that are also produced via UAS survey. Due to paucity of time and resources, the requisite 3D SDMS could not be developed. It is recommended that development of 3D SDMS and its City GML implementation, for depicting city infrastructure and vertical space (floor/ unit) in the city landscape, should be taken up

like Unmanned Aircraft System (UAS) and the Unmanned Aerial Vehicles (UAVs) have now made it possible to obtain quality Geospatial data of high accuracy and better spatial, spectral and temporal resolution at low cost. Thus, the same data acquired by UAS/ UAV, can be used in a vertically seamless manner for preparing master plans at local, zonal as well as regional scales. Hence, the need for revising standards and to further improve the Geospatial data base with help of UAS/ UAVs.

Historically, the country has not been able to keep pace with the planned development of its towns and cities. Out of some 8,000 towns and cities in 2011 (including about 4,000 Census Towns), only 2,631 urban settlements have approved master plans in force and 402 master plans are in the process of being formulated. When completed, the total of only 37 per cent of towns and cities would have master plans/development plans. Besides the procedural delays in obtaining public opinions and objections, and the necessary approvals and notification process, the lack of quality spatial data is one of the biggest culprit to the delays and hence a very low number of Master Plans prepared.

The small and medium towns suffer additionally, due to low fiscal and techno-managerial capacities. These 7,428 small and medium towns, with population less than 1,00,000 each (categorised as Class II to Class VI, as per the Census of India), constitute approximately 40 per cent of the total urban population and 93 per cent of the total number of towns and cities in India (2011). Growing at a rate ranging between 48 to 185 per cent, these small and medium towns have generally grown out of large villages, without much planning and developmental efforts. Viewed as future centres of urban growth, they demand and deserve attention for their planned development.

Urban planning, development and

Table 1: Building Footprint – Geospatial Data Content

S.No	Code	Class	Sub-Class	Geometry
1	06-04	Residential	*House*	Polygon
	06-05		*Group of Houses*	Polygon
	06-06		*Apartment*	Polygon
2	07-01	Commercial	*Retail*	Polygon
	07-02		*Wholesale*	Polygon
	07-03		*General Business*	Polygon
	07-04		*Hotel/Lodge/Restaurant*	Polygon
	07-05		*Shopping Centre/Mall*	Polygon
	07-06		*Multiplex/Cinema*	Polygon
	07-07		*Function Hall/ Marriage Garden*	Polygon
	07-08		*Warehouse*	Polygon
	07-09		*Storage Godown*	Polygon
	07-10		*Resort*	Polygon
	07-11		*Petrol Pump/LPG filling station*	Polygon
	07-12		*Informal Shop*	Polygon
	07-13		*Hostel*	Polygon
	07-14		*Market (Daily & Weekly) / Mandi*	Polygon
	07-15		*Garage*	Polygon
3	08-01	Industrial	*Manufacturing*	Polygon
	08-02		*Service*	Polygon
	08-03		*Chemical*	Polygon
	08-04		*Pharmaceutical*	Polygon
	08-05		*Textile*	Polygon
	08-06		*IT Parks*	Polygon
	08-07		*Industrial Estate/SEZ*	Polygon
	08-08		*Agro based & Food Processing*	Polygon
	08-09		*Obnoxious*	Polygon
	08-10		*Cottage &Household*	Polygon
	08-11		*Other Industries*	Polygon
	08-12		*Dairy Unit*	Polygon
	08-13		*LPG bottling Plants*	Polygon
4	09-01	Mixed	*Residential & Commercial*	Polygon
	09-02		*Residential &Household Industry*	Polygon
	09-03		*Residential & Educational*	Polygon
	09-04		*Residential & Health Services*	Polygon
	09-05		*Commercial & Industrial*	Polygon
	09-06		*Commercial &Health*	Polygon

Table 2: Buildings GIS Data Structure

Attribute Name	Attribute Field Name	Attribute Field Type	Attribute Field Width	Description/Value
Code	**Code**	Alphanumeric	10	Code as given in Table 11
Class	**Class**	Text	25	Class as given in Table 11
Sub-Class	**Sub_Class**	Text	50	Sub Class as given in Table 11
Ward Number	**Ward_No**	Alphanumeric	10	Ward Number
Road ID	**Rd_ID**	Alphanumeric	15	Road ID same as in Road_CLine
Road Name	**Rd_Name**	Text	30	Road Name same as in Road_CLine
Locality Name	**Locality**	Text	50	Locality Name
Colony Name	**Colony**	Text	50	Colony Name
Number of floors	**No_floors**	Numeric	5	Number of floors in a building
Construction Type	**Cons_type**	Text	15	Pucca/Semi Pucca/Kutcha
Area in sq. mt.	**Area**	Double	10 Up to 4 decimals	Area of corresponding building footprint
Description	**Descr**	Text	50	Name of building and Details, if any
Survey Date	**SVY_Date**	Date		Date of Surveying
Metadata ID	**Meta_ID**	Text	50	ID of Metadata
Additional Information	**Add_Info**	Text	200	Any other information
Photograph	**Photo**	Text	254	Hyperlink of photograph of Feature

Table 3: Sewerage Network – Geospatial Data Content

S.No	Code	Class	Sub-Class	Geometry	Symbol
1	18-03-01	Sewerage Network	*Sewage Treatment Plant*	Point	
	18-03-02		*Sewage Pumping Station*	Point	
	18-03-03		*Pumping Line*	Line	
	18-03-04		*Main Sewer Line*	Line	
	18-03-05		*Branch Sewer Line*	Line	
	18-03-06		*Service Sewer Line*	Line	
	18-03-07		*Manhole*	Point	
	18-03-08		*Vent Valve*	Point	

Table 4 Gas Distribution Network Line GIS Data Structure

Attribute Name	Attribute Field Name	Attribute Field Type	Attribute Field Width	Description/Value
Gas Distribution ID	**GD_Line_ID**	Alphanumeric	15	Unique Id
Code	**Code**	Alphanumeric	10	Code as given in Table 16
Sub-Class	**Sub_Class**	Text	50	Sub Class as given in Table 16
Ward Number	**Ward_No**	Alphanumeric	10	Ward Number
Road ID	**Rd_ID**	Alphanumeric	15	Road ID same as in Road_CLine
Road Name	**Rd_Name**	Text	30	Road Name same as in Road_CLine
Locality Name	**Locality**	Text	50	Locality Name
Survey Date	**SVY_Date**	Date		Date of Surveying
Metadata ID	**Meta_ID**	Text	50	ID of Metadata
Additional Information	**Add_Info**	Text	200	Any other information
Photograph	**Photo**	Text	254	Hyperlink of photograph of Feature

management require intense surveys, accurate measurements, change detection and timely implementation and monitoring. Traditional survey techniques for huge areas for planning require use of large sensors, satellites, extensive manual work, manned aircraft, etc. This is where city planners/ managers/ administrators/ tax collectors can benefit from the potential of UAV technology to transform planning and management; where the low-cost Drones/ UAVs, on as and when required, could provide very detailed, up-to-date geographic information for small areas within limited resources and time frame. The Geospatial technologies like Drone/ UAVs, along with Geographic Information System (GIS) can provide input for the preparation of base maps, which are pre-requisite for formulation of Master/ Zonal/ Local Area Plans, especially for small and medium towns. Thus, UAV/ drones provide a much cheaper alternative to manned flight, and enable applications that were near impossible earlier.

The Design, provided in the document, covers Flying Parameters from Technical Considerations; Flying Pattern & Overlaps; Flying Parameters from Statutory Considerations; Density and Distribution of Ground Control Points (GCPs) for Control and Check Point.

The Standards, provided in the document, cover Statistical Assessment of Horizontal and Vertical Accuracies; Assumptions regarding Systematic Errors and Acceptable Mean Error; Horizontal Accuracy Standards for Geospatial Data; Vertical Accuracy Standards for Geospatial Data; Accuracy Requirements for Ground Control used for UAS Survey; Reporting; Spatial Reference Frame; and Numbering System for Hard Copy.

Standards for both vertical and horizontal accuracy for geospatial data have been provided. The document provides for detailed geospatial data content and data structure for the various feature layers in the point, line and polygon formats, as the case may be. The various features covered are Roads, Railways, Bridges and Flyovers, Water bodies, Land use and Land cover, Educational and Health facilities, Community toilets, Fire stations, Garbage collection and dumping points, Landfill sites and dumping yards for the solid waste, Mobile phone towers, hotspots; Slums, Bus stops, trees, Building foot prints, Water supply networks, Storm water Drainage network, Sewerage network; networks for Power supply and Gas distribution; DEM layer, Contours, Cadastral layer; Administrative, planning, and Municipal boundaries; Hazard prone areas, etc. Some

Since the Drone technology is capable of providing very detailed and accurate information at large scales, there exists tremendous potential to take the technology further at the levels of Local Area Planning (LAP), neighbourhood planning and for site planning

Table 5 Urban Land Use – Land Cover – Geospatial Data Content (part)

S. No	Code	Class	Sub-Class	Geometry	Symbol
	24-20		*Mobility Hub*	Polygon	
	24-21		*Inland water transport terminal*	Polygon	
	24-22		*Boat yard*	Polygon	
	24-23		*E-Vehicle charging point*	Point	
	24-24		*2 Wheeler Taxi Stand*	Polygon	
20	25-01	**Traffic related**	*Traffic Island*	Polygon	
	25-02		*Median / Divider*	Polygon	
	25-03		*Parking Space / Area*	Polygon	
21	26-01	**Rural**	*Village / Abadi Area*	Polygon	
22	27-01	**Green Areas**	*Reserved Forest*	Polygon	
	27-02		*Protected Forest / Notified Forest*	Polygon	
	27-03		*Social*	Polygon	
			Green belt	Polygon	
	27-04		*Tree Clad Area*	Polygon	
	27-05		*Tree*	Point	
	27-06		*Vested Forest*	Polygon	
23	28-01	**Agricultural Land**	*Cropland*	Polygon	
	28-02		*Fallow land*	Polygon	
	28-03		*Plantations*	Polygon	
	28-04		*Orchard*	Polygon	
	28-05		*Horticulture*	Polygon	
	28-06		*Plant nursery*	Polygon	
24	29-01	**Wetlands**	*Waterlogged*	Polygon	
	29-02		*Low lying area*	Polygon	
	29-03		*Marshy*	Polygon	
	29-04		*Swampy*	Polygon	
	29-05		*Mudflat*	Polygon	
	29-06		*Creek*	Polygon	
25	30-01	**Wastelands**	*Scrubland*	Polygon	
	30-02		*Barren*	Polygon	
	30-03		*Rocky*	Polygon	
	30-04		*Sandy area*	Polygon	
	30-05		*Salt affected*	Polygon	
	30-06		*Gullied*	Polygon	
26	31-01	**Specific Land Use**	*Hill / Mountain*	Polygon	
	31-02		*Snow covered area*	Polygon	
	31-03		*Mining Area*	Polygon	
	31-04		*Grazing land*	Polygon	
	31-05		*Pastures*	Polygon	

of these spatial information is often neglected but extremely important in preparation of Master Plans. Spatially insignificant but functionally important features like location of ATMs, Meteorological Stations, Dairy Booths and Light House, etc. have also been provided for.

The tables included in the Design and Standards document provide detailed specifications for the Feature Class and Sub-class, three level coding, expected geometry (i.e., the point, line and polygon) as well as symbols. This will prove to be extremely useful in maintaining uniformity across various Master Plans for the small and medium towns located under jurisdiction of the different State Town and Country Planning Departments in the country. Uniformity will further ensure that no data has been omitted. It will further help in horizontal and vertical integration of data and for ease of inter-town comparisons for academic analysis.

A few samples of these tables, showing the feature class, sub-class, coding, geometry and symbols have been provided as tables 1-5. Another sample table, showing Ground Control Points GIS Data Structure, has been provided as Table 6.

Spatial Data Model Structure (SDMS)

Geospatial Data Content and GIS Data Structure Standards for mapping at very large scale (1:1,000)

The standard Spatial Data Model Structure (SDMS) for large scale for 2D feature extraction using UAV have been formulated to maintain consistency with the SDMS of the Survey of India as well as DMS of AMRUT. The feature layers are classified into classes and sub-classes for ease of operation.

Feature geometry

The Design and Standard document recommends that all features, which are represented by double line on large scale,

shall also be represented by its centre line. It is also recommended that all features which are represented as polygon features on large scale, shall also be represented by its centroid. Attributes of such features which are attached to corresponding lines/ points on small scale should be attached to centre line/ centre point on large scale. SDMS has been modified accordingly to maintain compatibility at various scales.

Coding scheme

Each GIS feature is assigned with a unique numeric code. The code is unique with respect to the feature, irrespective of its geometry and layer.

Layer wise Data Content, Classification and GIS Data Structure

The layers are broadly classified into 8 categories, viz. Base Layers, Urban Land use/ Land cover, Building Footprints, Utilities, Hypsography, Cadastral Layer, Boundaries and Hazard Prone Areas. These categories are further subdivided into 69 major classes and 533 sub-classes for 1:1,000 scale urban Geospatial data for GIS based Master Plan Formulation using Drone Technology.

Regulations for operational procedures

Directorate General of Civil Aviation (DGCA) of India announced 'Civil Aviation Requirements (CAR) Section 3 – Air Transport, Series X Part I, Issue I', in 2018, for regulation and requirements for operating of civil UAS/ RPAS in India. These statutory provisions not only have strong implementations on the UAS design but also on the operation of UAS. This CAR, issued under the provision of Rule 15A & Rule 133A of Aircraft Rules, 1937, lays down operational requirements for civil RPAS, licensing process, security/ safety, remote pilot training, RPAS maintenance, equipment, operating restrictions, general requirements, minimum standards for manufacturing of RPAS (both Indian & foreign), legal obligations, insurance & enforcement action for violation/ breach of compliance.

An understanding of provisions contained in above notification is very important because they directly or indirectly affect the standards & design of geo-spatial data acquisition. The document provides further details of these requirements and statutory obligations, and the various procedures that need to be followed for compliance.

National Unmanned Aircraft System (UAS) Traffic Management Policy (Draft)

In the meanwhile, the Ministry of Civil Aviation, Government of India has come out with the Discussion Draft of the National Unmanned Aircraft System (UAS) Traffic Management Policy further to the recent developments in the UAS ecosystem and the vision of developing India as a global hub for UAS technology. The primary objective of this policy document is to define how various UA Operational Scenarios will be enabled in the low-level airspace using the UTM Ecosystem and the Regulatory System referred to as the DigitalSky Platform. This document identifies a vision and a roadmap for enabling future UA operational scenarios in all airspaces while addressing aviation security concerns and measures to mitigate them based on threat and risk assessments. Various concepts like the UTM Stakeholders, UTM Architecture, UTM Services, UTM-ATM Integration, Data Security and Data Privacy, which are key to the operationalisation of the UTM Ecosystem in India, are further identified in this document.

When implemented, this will give further boost and direction to the Drone/ UAV Technology for Formulation of GIS based Master Plans.

Indicative format for urabn data collection

Master Plan formulation requires a

Table 6: Ground Control Points GIS data Structure

Attribute Name	Attribute Field Name	Attribute Field Type	Attribute Field Width	Description/Value
Ground Control point ID	**GCP_Id**	Alphanumeric	15	Unique Id
Code	**Code**	Alphanumeric	10	Code as given in Table 19
Sub-Class	**Sub_Class**	Text	25	Sub Class as given in Table 19
X Coordinate	**X**	Double	Up to 8 decimals	X Coordinate
Y Coordinate	**Y**	Double	Up to 8 decimals	Y Coordinate
Z Coordinate	**Z**	Double	Up to 8 decimals	Z Coordinate
Description of the Ground Control point	**Descr**	Text	250	Description
Monument	**Monument**	Text	5	Yes/No
Sketch Map or Image	**Sketch**	Blob		Sketch Map or Image to be attached
GCP Status	**GCP_St**	Text	20	Ok/ Distributed/ Missing
Checked on	**Ckhd_ON**	Date		SoI/GoI's Order No. (with date) for inducted team to chek GCP Status
Survey Date	**SVY_Date**	Date		Date of Surveying
Metadata ID	**Meta_ID**	Text	50	ID of Metadata
Additional Information	**Add_Info**	Text	200	Any other information
Photograph	**Photo**	Blob		Hyperlink of photograph of Feature

variety of data at different stages of the planning. While primary data collection involves time-consuming surveys, most socio-economic data may be obtained from published or un-published secondary sources. In order to streamline the process and minimise delays in the plan preparation process, a standardised data collection format has been provided as an effort to simplify and speed up the plan preparation process.

This format for urban data collection at town/ ward level consists of 25 tables which cover key areas such as demography, physical and locational aspects, physical and social infrastructure, environment, housing and slums, governance, etc., vital for studying existing situation and framing proposals. The guidelines to fill in the format have also been provided.

Future scope and path ahead

The current SDMS of the Survey of India caters to 2D data only. It does not cater to the requirements of 3D textured models that are also produced via UAS survey. Due to paucity of time and resources, the requisite 3D SDMS could not be developed. It is recommended that development of 3D SDMS and its City GML implementation, for depicting city infrastructure and vertical space (floor/ unit) in the city landscape, should be taken up.

As multiple functional units exist in the same building, the classification can be done at Building Unit level. The classification of various classes (commercial/ industrial, etc.) can be further done up to the next more detailed level.

The present document focuses on Design & Standards for data acquisition and spatial data base creation for Master Plan formulation. Task force may be constituted to document the training requirements; changes in existing mechanism, development of applications for integration of GIS based master-plan into the business processes of TCPO and urban authorities. Further, since the Drone technology is capable of providing very detailed and accurate information at large scales, there exists tremendous potential to take the technology further at the levels of Local Area Planning (LAP), neighbourhood planning and for site planning. Possibilities also exist to engage the technology for Urban Design studies, particularly when it comes to studying and analysing building facades of large buildings and monuments. Photogrammetric records of buildings and precincts of heritage value could also be generated for further studies and archiving. UAVs could easily manoeuvre to capture the elevations for the purpose of geo-tagging the pictures on GIS maps. Inspections and documentation relating to violation of building bye-laws can be an additional support to the urban local bodies. The technology driven plan preparation process will also ensure meaningful public participation in various stages of planning. These and other possibilities must be explored as part of the 'Pilots' being planned, as detailed below.

Proposed pilots

The Ministry of Housing and Urban Affairs (MoHUA) is in the process of launching pilot projects for 10 AMRUT towns at different geographic locations (viz., coastal, hilly, plain, riverine and desert), wherein complete drone mapping, at a scale of 1:1,000, will be taken up using the said Design & Standards.

References

[1] Ministry of Civil Aviation, 'National Unmanned Aircraft Systems (UAS) Traffic Management Policy (Discussion Draft Version 1.0)', November 2020, Government of India. https://www.civilaviation.gov.in/sites/default/files/National-UTM-Policy-Dicussion-Draft-30-Nov-2020.pdf

[2] Ministry of Urban Affairs and Employment, 1995, 'Integrated Development of Small and Medium Towns: Revised Guidelines – 1995', Government of India. http://mohua.gov.in/upload/uploadfiles/files/90.pdf

[3] TCPO, 2016, 'Sub-Scheme on Formulation of GIS based master Plans for AMRUT Cities: Design and Standards', Ministry of Urban Development, Government of India http://amrut.gov.in/upload/uploadfiles/files/designandStandards_AMRUT(3).pdf

[4] TCPO, 2006, 'National Urban Information System (NUIS) Scheme - Guidelines for Implementation', Ministry of Urban Development, Government of India. http://tcp.cg.gov.in/nuis/Guidelines.pdf

[5] TCPO and SoI, 2020, 'Design and Standards for Application of Drone/ UAV Technology for Formulation of GIS based Master Plans for Small and Medium Towns', Ministry of Housing and Urban Affairs, Government of India. http://tcpo.gov.in/sites/default/files/newfile/dron-min.pdf

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5. Smt. Maitreyee Banerjee, Research Assistant, TCPO, Government of India

Improving urban GPS accuracy for your app

In addition to 3D mapping aided corrections, we continue to work hard to make location as accurate and useful as possible

Frank van Diggelen
Principal Engineer, Google

Jennifer Wang
Product Manager, Google

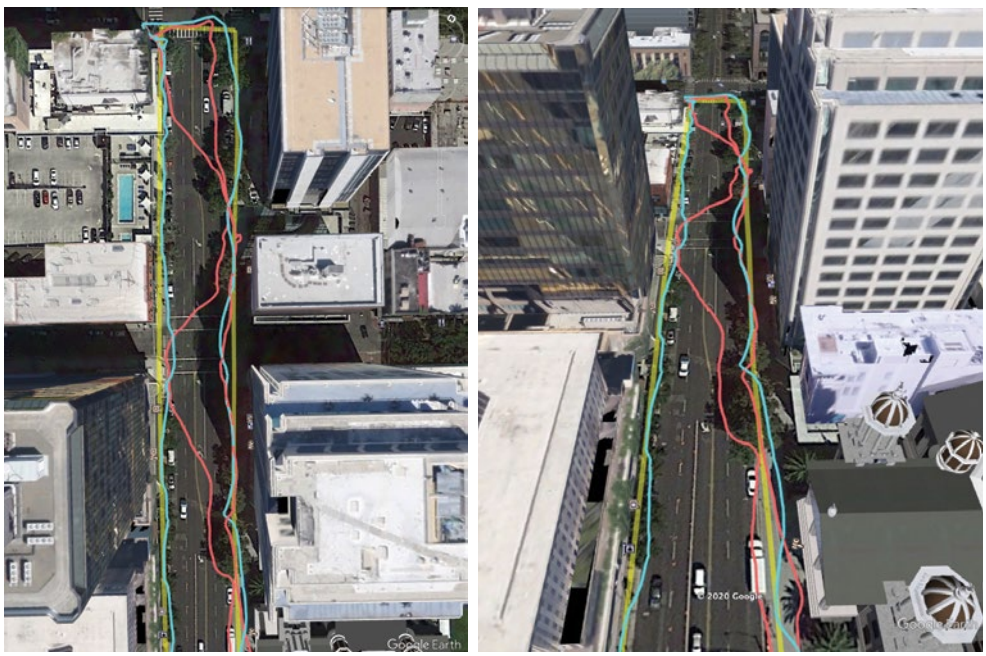
At Android, we want to make it as easy as possible for developers to create the most helpful apps for their users. That's why we aim to provide the best location experience with our APIs like the Fused Location Provider API (FLP). However, we've heard from many of you that the biggest location issue is inaccuracy in dense urban areas, such as wrong-side-of-the-street and even wrong-city-block errors.

This is particularly critical for the most used location apps, such as rideshare and navigation. For instance, when users request a rideshare vehicle in a city, apps cannot easily locate them because of the GPS errors.

The last great unsolved GPS problem

This wrong-side-of-the-street position error is caused by reflected GPS signals in cities, and we embarked on an ambitious project to help solve this great problem in GPS. Our solution uses 3D mapping aided corrections, and is only feasible to be done at scale by Google because it comprises 3D building models, raw GPS measurements, and machine learning.

The December Pixel Feature Drop adds 3D mapping aided GPS corrections to Pixel 5 and Pixel 4a (5G). With a system API that provides feedback to the Qualcomm® Snapdragon™ 5G Mobile Platform that powers Pixel, the accuracy in cities (or "urban canyons") improves spectacularly.



Picture of a pedestrian test, with Pixel 5 phone, walking along one side of the street, then the other. Yellow = Path followed, Red = without 3D mapping aided corrections, Blue = with 3D mapping aided corrections.

Why hasn't this been solved before?

The problem is that GPS constructively locates you in the wrong place when you are in a city. This is because all GPS systems are based on line-of-sight operation from satellites. But in big cities, most or all signals reach you through non line-of-sight reflections, because the direct signals are blocked by the buildings.

The GPS chip assumes that the signal is line-of-sight and therefore introduces error when it calculates the excess path length that the signals traveled.

The most common side effect is that your position appears on the wrong side of the street, although your position can also appear on the wrong city block, especially in very large cities with many skyscrapers.

There have been attempts to address this problem for more than a decade. But no solution existed at scale, until 3D mapping aided corrections were launched on Android.

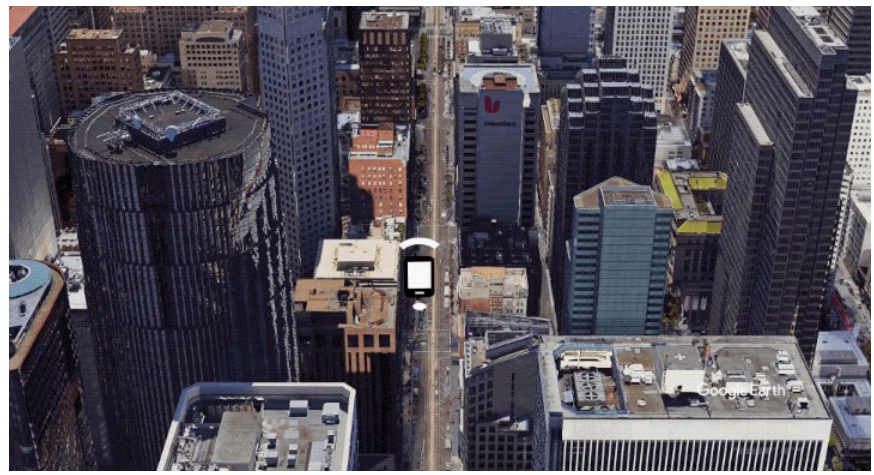
How 3D mapping aided corrections work

The 3D mapping aided corrections module, in Google Play services, includes tiles of 3D building models that Google has for more than 3850 cities around the world. Google Play services 3D mapping aided corrections currently supports pedestrian use-cases only. When you use your device's GPS while walking, Android's Activity Recognition API will recognize that you are a pedestrian, and if you are in one of the 3850+ cities, tiles with 3D models will be downloaded and cached on the phone for that city. Cache size is approximately 20MB, which is about the same size as 6 photographs.

Inside the module, the 3D mapping aided corrections algorithms solve the chicken-and-egg problem, which is: if the GPS position is not in the right place, then how do you know which buildings are blocking or reflecting the signals? Having solved this problem, 3D mapping aided corrections provide a set of corrected positions to the FLP. A system API then provides this information to the GPS chip to help the chip improve the accuracy of the next GPS fix.

With this December Pixel feature drop, we are releasing version 2 of 3D mapping aided corrections on Pixel 5 and Pixel 4a (5G). This reduces wrong-side-of-street occurrences by approximately 75%. Other Android phones, using Android 8 or later, have version 1 implemented in the FLP, which reduces wrong-side-of-street occurrences by approximately 50%. Version 2 will be available to the entire Android ecosystem (Android 8 or later) in early 2021.

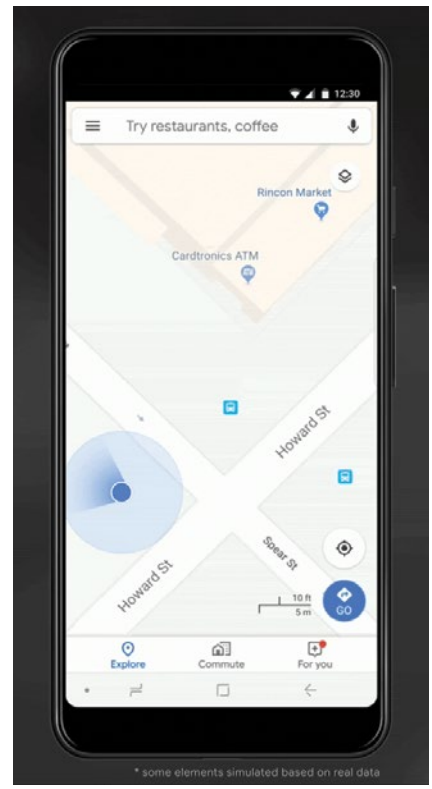
Android's 3D mapping aided corrections work with signals from the USA's Global Positioning System (GPS) as well as other Global Navigation Satellite Systems (GNSSs): GLONASS, Galileo, BeiDou, and QZSS.



Our GPS chip partners shared the importance of this work for their technologies:

"Consumers rely on the accuracy of the positioning and navigation capabilities of their mobile phones. Location technology is at the heart of ensuring you find your favorite restaurant and you get your rideshare service in a timely manner. Qualcomm Technologies is leading the charge to improve consumer experiences with its newest Qualcomm® Location Suite technology featuring integration with Google's 3D mapping aided corrections. This collaboration with Google is an important milestone toward sidewalk-level location accuracy," said Francesco Grilli, vice president of product management at Qualcomm Technologies, Inc.

"Broadcom has integrated Google's 3D mapping aided corrections into the navigation engine of the BCM47765 dual-frequency GNSS chip. The combination of dual frequency L1 and L5 signals plus 3D mapping aided corrections provides unprecedented accuracy in urban canyons. L5 plus



Android's 3D mapping aided corrections automatically works when the GPS is being used by a pedestrian in any of the 3850+ cities, on any phone that runs Android 8 or later

Google Maps is also getting updates that will provide more street level detail for pedestrians in select cities, such as sidewalks, crosswalks, and pedestrian islands. In 2021, you can get these updates for your app using the Google Maps Platform. Along with the improved location accuracy from 3D mapping aided corrections, we hope we can help developers like you better support use cases for the world's 2B pedestrians that use Android.

Google's corrections are a game-changer for GNSS use in cities," said Charles Abraham, Senior Director of Engineering, Broadcom Inc.

"Google's 3D mapping aided corrections is a major advancement in personal location accuracy for smartphone users when walking in urban environments. MediaTek's Dimensity 5G family enables 3D mapping aided corrections in addition to its highly accurate dual-band GNSS and industry-leading dead reckoning performance to give the most accurate global positioning ever for 5G smartphone users," said Dr. Yenchi Lee, Deputy General Manager of MediaTek's Wireless Communications Business Unit.

How to access 3D mapping aided corrections

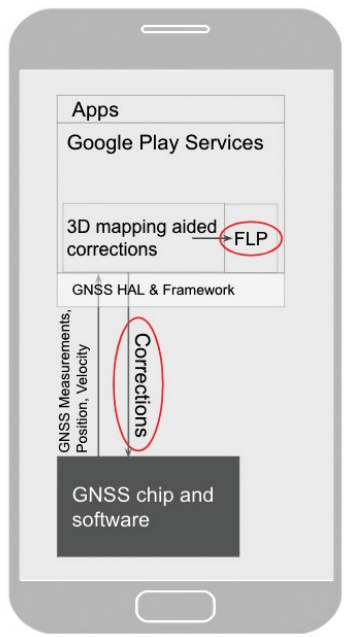
Android's 3D mapping aided corrections automatically works when the GPS is being used by a pedestrian in any of the 3850+ cities, on any phone that runs Android 8 or later. The best way for developers to take advantage of the improvement is to use FLP to get location information. The further 3D mapping aided corrections in the GPS chip are available to Pixel 5 and Pixel 4a (5G) today, and will be rolled out to the rest of the Android ecosystem (Android 8 or later) in the next several weeks. We will also soon support more modes including driving.

Android's 3D mapping aided corrections cover more than 3850 cities, including:

- North America: All major cities in USA, Canada, Mexico.
- Europe: All major cities. (100%, except Russia & Ukraine)
- Asia: All major cities in Japan and Taiwan.
- Rest of the world: All major cities in Brazil, Argentina, Australia, New Zealand, and South Africa.

As our Google Earth 3D models expand, so will 3D mapping aided corrections coverage.

Google Maps is also getting updates that will provide more street level detail for pedestrians in select cities, such as sidewalks, crosswalks, and pedestrian islands. In 2021, you can get these updates for your app using the Google Maps Platform. Along with the improved location accuracy from 3D mapping aided corrections, we hope we can help developers like you better support use cases for the world's 2B pedestrians that use Android.



Continuously making location better

In addition to 3D mapping aided corrections, we continue to work hard to make location as accurate and useful as possible. Below are the latest improvements to the Fused Location Provider API (FLP):

Developers wanted an easier way to retrieve the current location. With the new getCurrentLocation() API, developers can get the current location in a single request, rather than having to subscribe to ongoing location changes. By allowing developers to request location only when needed (and automatically timing out and closing open location requests), this new API also improves battery life. Check out our latest Kotlin sample.

Android 11's Data Access Auditing API provides more transparency into how your app and its dependencies access private data (like location) from users. With the new support for the API›s attribution tags in the FusedLocationProviderClient, developers can more easily audit their apps' location subscriptions in addition to regular location requests. Check out this Kotlin sample to learn more.

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https://android-developers.googleblog.com/

Poor land administration - the leading cause for informal land markets in informal settlements

Since 1992 local authorities in Namibia have created reception areas to address the demand for land

Menare Royal Mabakeng
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Poor land administration affects the collection of revenue for local authorities and contributes to slow land delivery that affects the poor in urban areas. Since 1992 local authorities in Namibia have created reception areas to address the demand for land. With the strategy to avail planned and serviced land at a later stage. Thus, the solution was temporary and resulted in fueling the growth of settlements as resettlement was slow. The general emphasis on what land administration is, is that it supports the management of land by providing the infrastructure to implement land related policies. With efficient and effective use of land information in administrating land, attaining sustainable development becomes that much easier (Krigsholm, Riekkinen, & Ståhle, 2018). In urban areas, land for informal settlements forms part of an essential inventory in support for meeting land delivery demands (Faye & Geh, 2014). The lack of services infrastructure in informal settlements can inhibit housing development (Faye & Geh, 2014). More important to note, informal settlement play an important role in the land and housing markets (Nassar & Elsayed, 2018). Providing the needed accommodation for those who cannot access formal housing due to slow delivery and unaffordability.

For decades local authorities in the global south have been working on reducing and curbing informal settlements. In order to reduce the formation of informal settlements as a result of household's growth, information to manage land allocation of land rights and reduce informal trading of land is vital. Without clear administration procedures, this growth can be a major contributor to the formation of new informal settlements. As a result, informal land markets flourish in instances when government is not able deliver affordable housing or services to residents(Nguyen, Duan, & Liu, 2018).

Land administration system

Land Administration systems support efficient and effective land markets that can contribute to the sustainable development of a country (Williamson, Enemark, & Wallace, 2010)Ian Williamson, Stig Enemark, and Jude Wallace have been fascinated by land issues. Five years ago Ian and Stig decided to document their lives' work in the land-related field. Both have a strong cadastral background with Ian having strength in institutions, particularly in the English speaking world, and Stig bringing knowledge of European systems with a focus on land management. They recognized the need for a strong legal perspective, which was provided by Jude, who has spent a lifetime working as a land policy lawyer. All recognized the need for solid technical support, with the expertise provided by Abbas Rajabifard, who has many years of experience in spatial data infrastructure (SDI. Effective land administration systems have been shown to improve the life's of people through the improvement of tenure security. As tenure security and access

This will ensure that all relevant sectors that contribute to the development of informal settlements are part of the planning and implementation. Furthermore, using a systems approach as a solution to informal settlement will promote good land governance. Through the promotion of participatory planning methods and transparent approaches to projects implementation

to land information increases investors' confidence within the land market. In order to make decisions that benefit the broader society sound land information is important (Sylla, Antonio, & Gitau, 2018). Despite a clear understanding on the use of land information for management, there is still a lack of knowledge in how land information can support planning, land development and revenue collection (Sylla et al., 2018). This is shown in the proliferation of informal settlements and poor management of land resources in urban areas.

Background to informal settlements in Namibia

Spatially, informal settlements are irregular areas with densely build structures subject to regular change(Gevaert, Persello, Sliuzas, & Vosselman, 2016). However, Kovacic and Giampietro, (2017), caution describing informal settlements based on physical characteristics, as this may mislead policy implementation. Because, descriptions of physical attributes navigate attention away from social constructs; that explains informality and growth (ibid).While Mahabir, Crooks, Croitoru, and Agouris, (2016) propose to consider both physical and social constructs to understand the complexities of slum/informal settlements. As this will provide details on what the main drivers are for people to stay in slums; therefore providing evidence for appropriate policies(Mahabir et al., 2016).The ending of informal settlements is reliant on an inclusive legal process (Reerink & van Gelder, 2010).

The main cause for informal settlement development is rapid urbanisation, population growth, poor urban governance, (Durand-Lasserve & Selod, 2007) and the high cost of housing, poor land information systems and inappropriate land tenure systems (Alemie, Bennett, & Zevenbergen, 2015). Urbanisation is related to a perception that moving from rural to urban areas will provide better economic activities (Sietchiping, 2005). The growth of informal settlements is incited by urban dwellers who cannot afford to access housing under the formal system .Moreover, according to (van Gelder, 2013) the reason for informality is due to failure of legal systems to provide recognition to occupants.

Since 1992 local authorities in Namibia have created reception areas to address the demand for land (Lankhorst, 2000). With the strategy to avail planned and serviced land at a later stage. Thus, the solution was temporary. As honourable as this plan for providing residential areas, it resulted in the overcrowding of reception areas due to the slow service delivery and poor management of land. Occupants in reception areas were left with no options to upgrade their housing and lived in constant fear of relocations (Lankhorst, 2000). Similar solutions are still being proposed for implementation to this date, as local authorities still provide temporary solutions for the informal settlement challenge. For majority of local authorities, securing the tenure of informal settlement residents is not a priority. Although, there was a difference observed during the campaigns for local authority elections. Occupants in Windhoek, the capital city of Namibia were given occupation certificates, which are similar to the Permission to Occupy certificates given to land right holders pre-independence.

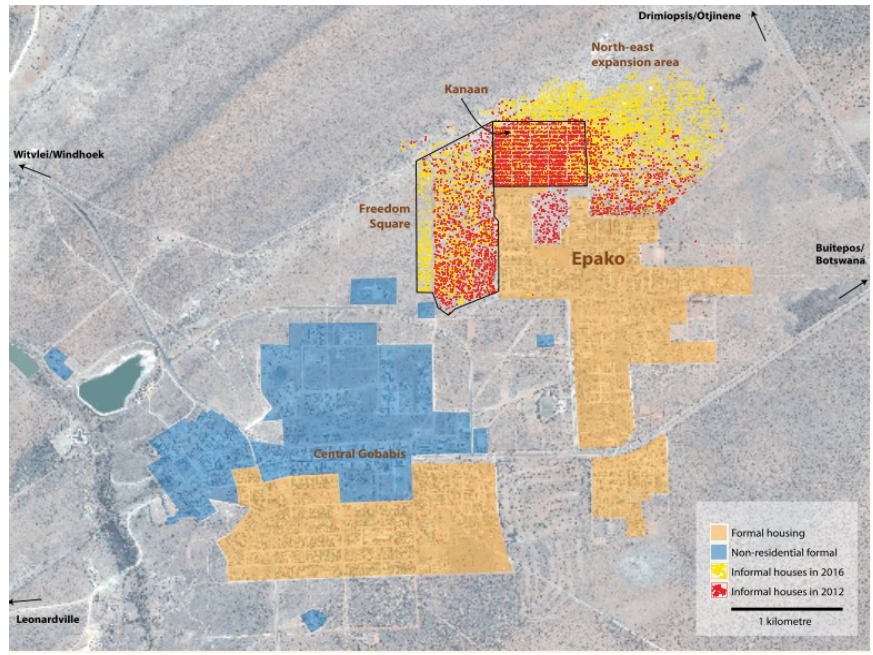


Figure 1 Informal settlements in Gobabis Source: (Weber & Mendelsohn, 2017)

The majority of occupants in informal settlements have limited access to water, toilets and electricity. In Earlier this year in the capital city; Windhoek residents were faced with cases of Hepatitis E outbreak within the informal settlements on the periphery of the city (Shikongo, 2020). The outbreak could have been avoided with better access to sanitation facilities for residents. The lack of service delivery affects 40% (Nakale, 2018) of the urban population in Namibia is living in informal settlements.

Stakeholders with the land administration sector do not have a common definition on which areas within urban areas are considered an informal settlement. Although a when a land related crisis is declared, a limited common understand of the problem hinders the design of sustainable solutions amongst the formal institutions responsible for upgrading informal settlements.

It is suggested, that as urbanisation continues to put pressure on land in Namibia, local authorities need to find strategies to better manage and improve land delivery(Indongo, 2015). The challenges faced by local authorities with the management of urban growth and lack of service delivery is derived from poor land policy implementation as it provides communities with an opportunity to contribute to the improvement of their houses. To understand use of data with the land administration systems for managing urban land Delivery, A Town In Namibia Was Selected.

The challenges faced by local authorities with the management of urban growth and lack of service delivery is derived from poor land policy implementation as it provides communities with an opportunity to contribute to the improvement of their houses

Study area

Gobabis is the regional capital of Omaheke region, 200 km from Windhoek. The town has a population of more than 19 000 according to the 2011 national census estimates, the local authority is a part two municipality according to the Local Authorities Act. The few functions of the municipality are to supply water to residents, provide and, maintain sewerage, and administer the land within its jurisdiction.

In 2012 Gobabis had four major informal settlements serving as a space for about 40% of the urban population in the town. One of the settlements identified for relocation was Independence Island, also known as Owambo Block. The settlement had a population of 585 people, in 145 households. The majority of structures were self-build, made from zinc, plastic and occasionally a few with cardboard. The residents were to be relocated, as the land they occupied was earmarked for servicing. Figure 1 shows the location of the settlement between freedom square and Epako. Residents in this settlement were relocated to other settlements within Gobabis, as the land had to be serviced for formal housing construction. To date, there land has been serviced, yet no developments have taken place on the land.

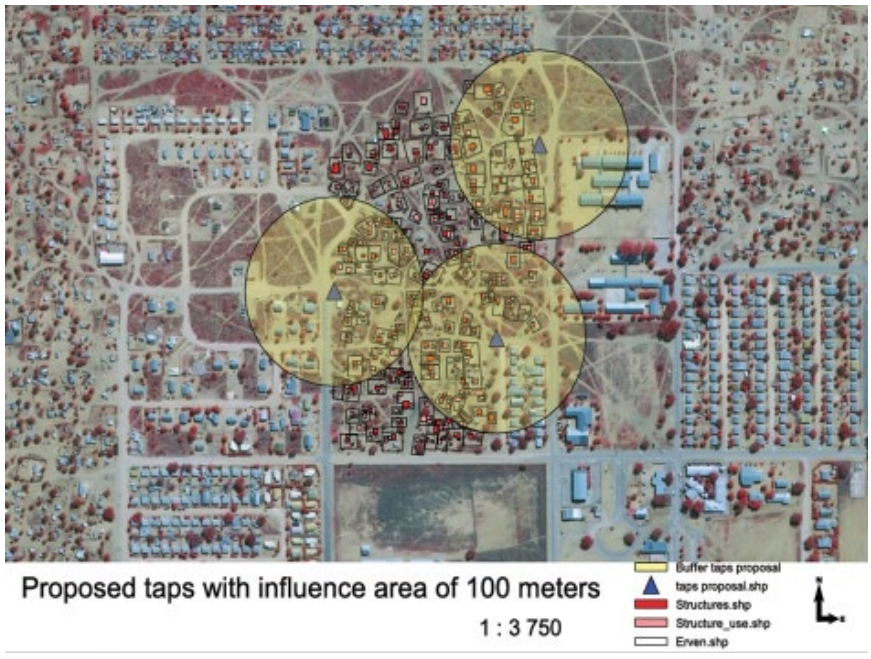


Figure 2 Owambo Block/Independence Island with analysis of water access for residents

Use of data by local authority

In Gobabis, community enumeration data is said to use for decision making. Enumeration data is information collected by communities focusing on demographics, location and socio-economic situation, supported by the Slum Dwellers International Affiliated group, the Shack Dwellers Federation of Namibia.

According to officials at the municipality, the information is important on informing the local authority on how the number of residents in informal settlements. As the municipality did not have this information before. Despite this confirmation by the officials, the author

If the data generated by the community is to be used in the future for; land recordation; decision-making or to prove ownership, there is a need for direct involvement of local authority officials in the management of the data. Allot of time is invested in the community data collection as observed in other studies, if this is not managed properly, it will be unusable in the future. The participation and ownership of community in enumerations is the element of power

could not identify specific decisions taken using data provided through community enumerations. Moreover, discussions with officials and community representatives showed that there is a disconnection between data collection and its use for planning. In 2017 respondents during field interviews raised concerns over the price of water meters for Freedom Square, saying they cannot afford the 300 NAD proposed by the local authority. If the local authority used the community enumeration data to decide on the price for water meters, the unemployment levels in the settlement and the affordability of households would have been taken into consideration. Majority of informal settlement residents in the town are unemployed. Rather, the pricing of water meters by the municipality was based on cost recovery and not information from the community.

The case of Independence Island informal settlement provides a clear picture on how local authorities relocate residents without using data to provide sustainable solutions. Figure 2 shows a map that was used to propose for informal settlement upgrading for residents within that area, and to date those residents were relocated by the local authority, and data on individuals was not used to secure land rights.

On tracing some household relocated, some residents have transferred their rights to use the land to other residents. The right to use the land is not issued by way of any certificate, rather it is inferred by the residents based on the relocation, access to services. Records do not exist on how this transactions took place at local authority level. The original occupiers either moved out of town or went to set up new structures in open spaces within or at the edge of existing settlements.

The transfer of land was more common in Kannan informal settlement that was provided with electricity by 2016 by the local authority. More than 60 percent of the original occupants of the houses in Kanaan were not the current owners during a study carried out in 2017 as part of the authors thesis(Mabakeng, 2018).

Securing land rights and Land Administration

Securing land rights through land registration could benefit occupants in informal settlements, as the confidence in investments is increased (Nakamura, 2017). Through the investigation, the research showed that, the poor administration of land in local authorities lead to increase in the informal land market in urban informal settlement. As occupants who are allocated land end up selling the land right and set up structures elsewhere. The sale of land and property not only affects the local authorities, it slows down upgrading projects and leads to an increase in illegal land occupation.

To curb the challenges experienced, local authorities should consider implementing pro-poor land administration for the management of land in urban areas in Namibia. This will ensure that data on informal settlements is collected and land rights are recorded. Stakeholders involved in the upgrading of informal settlements need to use a systems approach for the management of land. Taking into consideration all the services and institutions needed for a functioning upgrading project. This will ensure that all relevant sectors that contribute to the development of informal settlements are part of the planning and implementation.

Furthermore, using a systems approach as a solution to informal settlement will promote good land governance. Through the promotion of participatory planning methods and transparent approaches to projects implementation. Community awareness on the importance of land rights recordation and registration is vital to ensure that residents can derive benefits from the new registration approach.

If the data generated by the community is to be used in the future for; land recordation; decision-making or to prove ownership, there is a need for direct involvement of local authority officials in the management of the data. Allot of time is invested in the community data collection as observed in other studies (Rigon, 2017), if this is not managed properly, it will be unusable in the future.

The participation and ownership of community in enumerations is the element of power. However limited community engagement hinders the success of community enumerations especially in advancing community development priorities, which was a major element of success when the CLIP was initiated(Muller & Mbanga, 2012).

References

Alemie, B. K., Bennett, R. M., & Zevenbergen, J. (2015). A socio-spatial methodology for evaluating urban land governance: the case of informal settlements. *Journal of Spatial Science,* Vol. 60, pp. 289–309. https://doi.org/10.1080/14498596.2015.1004654

Durand-Lasserve, A., & Selod, H. (2007). *The formalisation of urban land tenure in developping countries.* 1–47. Retrieved from http://siteresources.worldbank.org /INTURBANDEVELOPMENT/Resources/336387-1269364687916/6892589-1269394475210/durand_lasserve.pdf

Faye, E. M. B. I., & Geh, Z. F. (2014). Market Dynamics Housing market dynamics in Africa. In *Texas Mineral Resources* (Springer e). https://doi.org/http://dx.doi.org/10.1057/978-1-137-59792-2

Gevaert, C. M., Persello, C., Sliuzas, R., & Vosselman, G. (2016). Informal settlement classification using point-cloud and image-based features from UAV data. *ISPRS Journal of Photogrammetry and Remote Sensing, in press,* 225–236. https://doi.org/10.1016/j.isprsjprs.2017.01.017

Indongo, N. (2015). The Effect of Urbanisation on Housing Conditions in Namibia. *International Journal of Humanities Social Sciences and Education, 2*(7), 1–8. Retrieved from www.arcjournals.org

Kovacic, Z., & Giampietro, M. (2017). Between theory and quantification: An integrated analysis of metabolic patterns of informal urban settlements. *Energy Policy, 100,* 377 –386. https://doi.org/10.1016/j.enpol.2016.06.047

Krigsholm, P., Riekkinen, K., & Ståhle, P. (2018). The Changing Uses of Cadastral Information: A User-Driven Case Study. *Land, 7*(3), 83. https://doi.org/10.3390/ land 7030083

Lankhorst, M. (2000). Land Tenure Reform and tenure secuirty in Namibia. In *Legalising Land Rights and Poverty :* (pp. 1–21).

Mabakeng, M. R. (2018). *Investigating the Impact and Use of Community Enumerations on Tenure Security in Informal Settlements - the Case of Gobabis Municipality in Namibia* (University of Twente). Retrieved from https://webapps.itc.utwente.nl/library www/papers_2018/msc/la/mabakeng.pdf

Mahabir, R., Crooks, A., Croitoru, A., & Agouris, P. (2016). The study of slums as social and physical constructs: challenges and emerging research opportunities. *Regional Studies, Regional Science, 3*(1), 399–419. https://doi.org/10.1080/21681376.2016. 1229130

Muller, A., & Mbanga, E. (2012). Participatory enumerations at the national level in Namibia: the Community Land Information Programme (CLIP). *Environment and Urbanization, 24*(1), 67–75. https://doi.org/10.1177/0956247811435891

Nakale, A. (2018, October 4). 40 % of Namibians live in shacks. *New Era.* Retrieved from https://neweralive.na/posts/40-of-namibians -live-in-shacks

Nakamura, S. (2017). *Tenure Security Premium in Informal Housing Markets: A Spatial Hedonic Analysis.* https://doi.org/10.1016/j.worlddev. 2016.08.009

Nassar, D. M., & Elsayed, H. G. (2018). From Informal Settlements to sustainable communities. *Alexandria Engineering Journal, 57*(4), 2367–2376. https://doi.org/10.1016/j.aej.2017.09.004

Nguyen, H. L., Duan, J., & Liu, J. H. (2018). State control versus hybrid land markets: Planning and urban development in transitional Hanoi, Vietnam. *Sustainability (Switzerland), 10*(9). https://doi.org/10.3390/su10092993

Reerink, G., & van Gelder, J.-L. (2010). Land titling, perceived tenure security, and housing consolidation in the kampongs of Bandung, Indonesia. *Habitat International, 34*(1), 78–85. https://doi.org/10.1016/j.habitatint. 2009.07.002

Rigon, A. (2017). Intra-settlement politics and conflict in enumerations. *Environment and Urbanization,* (1998), 095624781770033. https://doi.org/10. 1177/0956247817700339

Shikongo, A. (2020, March 11). Hepatitis E continues to spread. *The Namibian,* p. 6. Retrieved from https://www.namibian.com.na/198938/archive-read/Hepatitis-E-continues-to-spread#

Sietchiping, R. (2005). Prospective Slum Policies : Conceptualization and Implementation of a Proposed Informal Settlement Growth Model. *Information Systems, 1*, 4–6.

Sylla, O., Antonio, D., & Gitau, J. (2018). LOW-COST LAND INFORMATION SYSTEM FOR SUSTAINABLE URBAN DEVELOPMENT : CASE EXAMPLES IN KENYA AND ZAMBIA OUMAR SYLLA , DANILO ANTONIO, JOHN GITAU United Nations Human Settlements Programme, Nairobi, Kenya Presenting author: Danilo Antonio danilo.antonio. *FIG Congress 2018 Embracing Our Smart World Where the Continents Connect: Enhancing the Geospatial Maturity of Societies.*

van Gelder, J.-L. (2013). Paradoxes of Urban Housing Informality in the Developing World. *Law and Society Review, 47*(3), 493–522. https://doi.org/10.1111/lasr.12030

Weber, B., & Mendelsohn, J. (2017). *Informal settlements in Namibia : their nature and growth.* Retrieved from https://www.researchgate.net/publication/322200418_Informal_settlements_in_Namibia_their_nature_and_growth

Williamson, I., Enemark, S., & Wallace, J. (2010). Land Administration for sustainable development Land Administration for sustainable development. In *Sustainable Development.*

Ligado Networks' proposal is not 5G

All Americans benefit from a competitive 5G landscape, and that goal can be achieved without undermining U.S. Global Positioning System receivers and devices

J. David Grossman
Executive Director of the
GPS Innovation Alliance

The "race to 5G" continues to dominate news headlines, congressional hearings and the attention of U.S. federal agencies — and rightfully so. With faster speeds, lower latency and increased bandwidth, Americans will benefit from new and/or enhanced 5G wireless services, such as remote surgeries, autonomous vehicles, precision agriculture and even tools to help our first responders save lives.

Under the leadership of Federal Communications Commission Chairman Ajit Pai, the FCC has been working expeditiously to unleash additional 5G spectrum in low-, mid- and high-band frequencies. In August, the White House announced plans to free up 100 megahertz of mid-band spectrum from 3.45-3.55 GHz, an action made possible because of the Defense Department's commitment to 5G. As a result of this and other efforts, the FCC is set to make hundreds of megahertz of mid-band spectrum available for 5G services on a shared or exclusive basis.

The GPS Innovation Alliance, or GPSIA, applauds these efforts, which are a win for the public interest and an important step forward in advancing America's leadership on 5G.

Noticeably absent from the August announcement (or the chairman's comprehensive 5G FAST Plan) has been any mention of Ligado Network's proposal to repurpose satellite spectrum in the L-band for high-power terrestrial use. Though its omission may disappoint Ligado, who has repeatedly argued that it is "uniquely poised to facilitate America's 5G future," the facts demonstrate that the L-band is neither necessary nor relevant to winning the 5G race or maintaining U.S. leadership on 5G.

5G is not a futuristic concept. Millions of Americans already have access to 5G services from at least one of the nation's largest wireless providers. But by no means should we stop there. GPSIA believes all Americans benefit from a competitive 5G landscape, and that goal can be achieved without undermining U.S. Global Positioning System receivers and devices that are foundational to wireless technology in general, including 5G.

Despite many of Ligado's bold assertions, their spectrum blocks of 10 noncontiguous megahertz, represents less than 1 percent of the spectrum the FCC has auctioned or proposed be made available for 5G services. This is well below what is needed for 5G services in the U.S.

Despite many of Ligado's bold assertions, their spectrum blocks of 10 noncontiguous megahertz, represents less than 1 percent of the spectrum the FCC has auctioned or proposed be made available for 5G services. This is well below what is needed for 5G services in the U.S.

Second, Ligado's spectrum is not internationally harmonized, significantly diminishing its effectiveness as a 5G band. GSMA, an industry organization representing the interests of mobile network operators worldwide, has emphasized the importance of international harmonization to "make the best possible mobile services available for everyone and everything."

U.S. 5G leadership is not just about spectrum, modernizing infrastructure policy or eliminating outdated regulations. While each are essential components of any 5G plan, the economic and societal benefits of "real" 5G cannot be fully realized unless GPS receivers are protected from harmful interference

Finally, Ligado's proposed network simply will not offer a 5G service. Ligado merely plans to provide limited Internet of Things services, primarily delivered over custom private networks to specific geographic areas for limited vehicular and utility operations. Not only is this not a 5G service offering, but similar services are already being offered by wireless service providers and are doing so without interfering with GPS.

Even if one accepts Ligado's argument that it is providing additional spectrum for 5G, its use of the L-band for a high-power terrestrial service threatens to undermine the foundation for existing 3G and 4G networks as well as mainstream 5G networks. In other words, U.S. cellular networks could experience disruptions if Ligado is allowed to deploy its network. Let me explain.

Ever since 2G CDMA networks were initially deployed more than 20 years ago, GPS has been used to align the timing between cellular base stations. With 3G and 4G networks, GPS grew in importance, providing a common clock to synchronize base stations while minimizing interference. Now, the advanced radio features associated with 5G have made extremely accurate timing alignment even more critical. For the consumer, the improved timing accuracy enabled by GPS translates into significantly higher data speeds, lower latency and a smoother handover between cell stations, thereby reducing delay and maximizing spectral efficiency.

The wireless industry's reliance on GPS also has major economic implications. A report commissioned last year on behalf of the National Institute of Standards and Technology concluded that a GPS outage of 30 days could result in an economic loss to the telecommunications sector of as much as $14.2 billion. This same study pegged the economic impact of GPS to the telecom industry at up to $686 billion, reinforcing why it is so critical that GPS be protected.

Ultimately, U.S. 5G leadership is not just about spectrum, modernizing infrastructure policy or eliminating outdated regulations. While each are essential components of any 5G plan, the economic and societal benefits of "real" 5G cannot be fully realized unless GPS receivers are protected from harmful interference. GPSIA supports the well-documented views of the expert agencies charged with preserving the integrity of GPS and will continue to champion the policies necessary to promote, protect and enhance this essential public resource.

The article was first published at C4ISRNET https://www.c4isrnet.com/opinion/2020/10/20/ligado-networks-proposal-is-not-5g/

Ligado Secures Significant New Capital to Advance 5G Plans

Ligado Networks has successfully raised nearly $4 billion in new capital, taking a major step toward realizing the company's 5G plans for mission-critical industries and expediting the Federal Communications Commission's (FCC) efforts to increase the country's use of mid-band spectrum for next-generation services.

Led by JPMorgan Chase & Co., Ligado secured $3.85 billion from existing and new investors, which will support the company's technology plan to expand the roster of vendors supporting the L-Band ecosystem.

Ligado has made important strides to realize the full potential of its spectrum and progress toward bringing next-generation services to market. In June 2020, Ligado's submissions into 3GPP – the industry forum that adopts technical specifications for terrestrial spectrum – were approved and, importantly, enjoyed the support of global vendors such as Nokia, Intel, Samsung, and Sequans. This capital raise will further strengthen the company's commercial collaboration with chipset designers, device manufacturers, and network infrastructure providers.

"Today is a great day, and now the fun begins. We've secured our license, we've raised the necessary capital, and we're in a great position to work with the industry to get this spectrum deployed for 5G to support critical industries across the U.S.," said Doug Smith, Ligado President and CEO.

"This new round of funding from existing and new investors validates our 5G plans to deploy this spectrum," said Ivan Seidenberg, Chairman of Ligado's Board of Directors. "We look forward to making continued progress to build the commercial ecosystem and fully execute on our vision for this spectrum as authorized by the FCC."

https://ligado.com/press/ligado-secures-significant-new-capital-advance-5g-plans-enhance-next-generation-connectivity-u-s-infrastructure.

PointFuse launches 'PointFuse Pro'

PointFuse software which enables the fast, easy creation of intelligent mesh models of any environment from point cloud data has extended its product portfolio in tandem with the latest release going live, version 2020.02. Available immediately following research with current customers, a new version of the software has been created called PointFuse Pro. Users can now choose between PointFuse Standard, and PointFuse Pro. *www.pointfuse.com*

Blue Marble Geographics' Geographic Calculator 2020 SP1

Blue Marble Geographics® has announced the release of Geographic Calculator 2020 SP1 — the leading geodetic software for coordinate conversion and datum transformation. It introduces many new features and improvements, including new IOGP data model types for Usage and Scope Objects, Dynamic Datums, and Ensembles. *bluemarblegeo.com*

LiDAR Survey for Delhi-Varanasi High Speed Rail Corridor

National High Speed Rail Corporation Limited will be adopting Light Detection and Ranging Survey (LiDAR) technique using Laser enabled equipment mounted on a Helicopter for conducting ground survey for the preparation of Detailed Project Report for the proposed Delhi-Varanasi HSR corridor. This technique uses a combination of Laser data, GPS data, flight parameters and actual photographs to give accurate survey data. Based on the findings of the survey, designing of the vertical & horizontal alignment, structures, location of the stations and depots, Land requirement for the corridor, identification of project affected plots/ structures, Right of Way etc are decided.

The aerial LiDAR survey technique, for the first time for any railway project in India, was adopted for the Mumbai-Ahmedabad High Speed Rail Corridor primarily because of its high accuracy. The ground survey using aerial LiDAR for MAHSR alignment was done only in 12 weeks against the 10-12 months if had been done through traditional survey methods. *https://pib.gov.in*

Ministry of Science and Technology, India invites proposals under National Geospatial Programme

Department of Science and Technology, in collaboration with the Accelerating Growth of New India's innovations (AGNIi) initiative of Office of the Principal Scientific Adviser to the Government of India under the Prime Minister's Science, Technology, and Innovation Advisory Council PSA office has invited short-term proposals from Geospatial start-ups and knowledge institutions of the country, with the aim of critically strengthening the nation's innovation ecosystem.

Financial support will be provided to selected organizations, focusing on area specific spatial analytics (including techniques/demonstration etc.) in the sectors of migration, employment generation (specially in agriculture and construction), strengthening of livelihood, resource mapping for community resilience, etc.

The details are as follows:

A. Migration

- Urban and regional mobilities: dwell times and movements to assess the situation and identify trends.
- Convergence, migration, and dispersal of population and migrant workers.
- Digital supply chain maps and analysis.

B. Strengthening Livelihood and Employment Generation

- Mapping and geo-analysis of reverse migrants for assessment of livelihood creation within village/district/state
- Geospatial analytics for Skilling/ reskilling of migrants
- Resource mapping for community resilience
- Site Suitability Analysis for livelihood creation and survival.
- Resource locator in a cluster for skill development trainings, as well as Geo-cultural indicators for livelihood.
- Modelling mitigating the situation for economic sectors such as industry, commerce, transport, and agriculture, based on satellite data.
- Modelling import substitution in tier 2/tier 3 cities, aligning with the need of rural catchment area
- Modelling urban unemployment in service sector and solution therein

C. Others

- Development of open source village level Geospatial information platform for villagers, school teachers, students
- Modelling/assessing forecast of potential Spread of COVID-19 beyond the lockdown and mitigation (city-centric infection percolation model)
- Predictive risk of each district for COVID-19 through sewage disposals and environment predictors
- Deep Reinforcement Learning model using COVID 19 databases to assist in optimal response in a dynamically varying scenario
- Social vulnerability mapping and analysis of COVID-19 impacts for initiating economic activities
- Dependency modelling of healthcare infrastructure with interrelated infrastructures, such as transportation, water supply, pharmacy/equipment, food supply etc
- Knowledge representation approaches (e.g. Ontologies) of the causal relationships between disease and geographical settings to enable reasoning for automated decision-making
- Geospatial analytics, based upon AI/ ML, for future disaster preparedness

NextNav introduces Unity Plug-In

NextNav has announced the release of a Unity plug-in for its vertical positioning service, Pinnacle, which delivers precise altitude data to unlock 3D experiences for geolocation applications. Its Unity plug-in makes it easy for developers to integrate vertical location into any application built with the Unity engine, including games, training applications, industrial and manufacturing apps and beyond.

In Coordinates

10 years before...

mycoordinates.org/vol-6-issue-12-December-2010

"GRAV-D has the potential to provide very significant benefits to the public"

Says, Dr Dru Smith, Chief Geodesist of NOAA's National Geodetic Survey while explaining the GRAV-D project

What are the current problems with 'height' that the GRAV-D project looks to address?

Firstly, there are many different definitions of "height". It is likely that the most common use of "height" is the orthometric height, which is colloquially (but inaccurately) called a "height above sea level". The orthometric height is the one most frequently plotted on topographic maps and is extremely good at telling the direction of water flow. Another different height is the ellipsoid height, which is a sort of mathematical abstraction which comes as an artefact of GPS positioning. Ellipsoid heights are determinable very accurately using GPS, but they are not good at determining the direction of water flow.

A study on GPS/ DR car navigation system using vehicle movement information

Jong-Hwa Song and Gyu-In Jee
Electronics Engineering Konkuk University, Korea

This paper represents the GPS/DR car navigation system using vehicle moving information. GPS and DR sensor measurements are analyzed to decide the car movement. We implement the multi- measurement model for heading filter using this additional information. When GPS signal is blocked, gyroscope bias error is estimated using car movement information. A car experiment was performed to verify the proposed algorithm. The results show that the supposed method provides smaller position and heading error than previous method. When GPS is blocked in 300 sec, the position error is smaller than 9 times in straight line area and 3 times in turning area.

From Galileo to Multisystem: Evolution of Integrity concept

Giovanni Dore and Mario Calamia
University of Florence, Dip. Ingegneria Elettronica e Telecomunicazioni Florence, Italy

The proposed solution starts from the integrity equation defined for the Galileo system and adapts it to the combined system Galileo+EGNOS with the aim of computing the Hazardous Misleading Information Probability. We focused our attention on the IR equation: the implemented code reproduces the IR equation as is presented in literature, that is with the SISA values relative to Galileo and GPS satellites and SISMA relative only to the Galileo ones, in faulty free and faulty mode respectively.

Galileo nominal service restored

The Galileo Service was affected from Dec 14, 00:00 UTC by an anomaly in the time determination function of the ground segment of the system.

This resulted in signals flagged as MARGINAL (SISA=NAPA) for all satellites. During this period, pseudorange errors in excess of nominal performance were experienced by user receivers.

The system was reconfigured and restored to a nominal situation as of Dec 14, 06:00 UTC. A NAGU will be published shortly with the exact chronology of the event. *www.gsc-europa.eu*

NavIC gets IMO recognition

The Indian Space Research Organisation (Isro) said that the International Maritime Organisation (IMO) has recognised NavIC as a component of the World-Wide Radio Navigation System (WWRNS). This recognition was awarded in the 102nd meeting of Maritime Safety Committee of IMO (MSC-102).

In April 2020, NavIC L5 was incorporated in the Radio Technical Commission for Maritime Services (RTCM) standard 10403.3 for differential Global Navigation Satellite System (GNSS) applications. These developments will enable the utilisation of NavIC in the fields of maritime navigation, surveying and others. *www.business-standard.com*

Otago's School of Surveying reaches the top of the world

A new accurate height of Mount Everest has been announced to the world and a University of Otago academic has been instrumental in supporting the Nepalese surveyors achieve that ambition.

Geodesist Dr Chris Pearson of Otago's School of Surveying led New Zealand's MFAT Head of Mission Fund project by providing technical expertise and training to Nepal's Department of Survey to undertake the work themselves.

"As Mount Everest holds immense national pride for the Nepalese, it has been immensely gratifying to support local surveyors reach this goal themselves and also contribute to the development of the country," Dr Pearson says. The new height of 8,848.86m has been announced in a joint statement by Nepal and China, marking a small increase from the commonly referenced height of 8,848m that was established by the Survey of India in 1954, the year after the late Sir Ed Hillary summited the world's highest peak.

Dr Pearson says that due to tectonic activity such as the significant 2015 Gorkha Earthquake, the height of Everest is constantly changing and using the latest technologies allowed the new accurate measurements to be made. He has led New Zealand's involvement in surveying projects in Nepal since the 2015 earthquakes which caused massive horizontal and vertical ground displacement across the land-locked country, resulting in significant inaccuracies in coordinates and geodetic databases.

Dr Pearson says a complication of determining the height of Everest is the summit is an ice cap that can change due to seasonal accumulation and melting, and therefore measurement of the height of the rock below this cap is important.

"The new measurement is by far the most accurate sea-level height for Sagarmatha due to the levels of technology used, and the new models will also make it easier to measure the exact heights of other mountains in Nepal using modern GPS techniques." *www.otago.ac.nz*

India seeks bids for manufacture of 10 lakh homegrown NavIC chips

The Indian government has invited proposals for the manufacture of 10 lakh receiver chips that have GPS and NavIC, in an attempt to improve the overall signal availability of positioning systems, and increase the use of the indigenous positioning system.

In a bid titled, "Request for Proposal Design, Manufacture, Supply and Maintain Integrated NavIC and GPS Receivers," the ministry has stated it wishes to use the NavIC integrated receivers for areas such as navigation on land, air and water, disaster management, vehicle tracking, location services on mobile phones. *www.thequint.com*

New Glonass satellites to cost four times more

Russia's next-generation Glonass-K2 navigation satellites that will be launched into orbit starting from next year will cost four times as much as the older, Glonass-M, models currently in operation, according to the Russian space agency, Roscosmos.

The Glonass-K2 satellites appear to be twice as expensive as the Glonass-K1 model, which, in turn, is twice as expensive as the Glonass-M satellite. *www.urdupoint.com*

GPS III SV04 receives operational acceptance

Global Positioning System III Space Vehicle (SV) 04 received United States Space Force's Operational Acceptance approval on Dec. 1- marking yet another significant milestone for the GPS III program, Space and Missile Systems Center and USSF. It is the fourth GPS III satellite delivered into the operational constellation in the past 12 months and the second in the past three months.

Additionally, this is the first GPS III vehicle delivered to the warfighter through an expedited satellite control authority transfer process, which cuts ten days off the previous operational acceptance timeline.

SV04 was launched on a SpaceX Falcon 9 Block 5 vehicle on Nov. 5. The Air Force has been flying 31 operational satellites for years in order to ensure the United States' commitment to have 24 operational GPS satellites available 95% of the time. *spaceforce.mil*

Remote sensing data based on neural networks

Russia's State Space Corporation Roscosmos will launch the experimental operation of its services for processing the Earth's remote sensing data based on neural networks, according to Roscosmos representative Denis Shvedov.

This year, Roscosmos has established the Forest Control, Quarries, Disturbed Lands, Construction Control, Emergencies and Agricultural Monitoring services, he said.

"From the beginning of next year, the experimental operation of these services will start. This year, we have carried out experimental testing in some regions," he said at a conference on present-day problems of Earth's remote sensing from outer space.

These services particularly use neural networks that make it possible to maximally identify particular objects and the accuracy of identifying facilities under construction currently makes up 80%, he said. *https://tass.com*

SimActive Software integrated in LiDAR solution for drones

SimActive announces the integration of its Correlator3D™ product into LiDAR systems for drones developed by LiDAR USA. Possible configurations include two side-by-side cameras that allow matching the footprint of the LiDAR sensor, a particularly useful setup for corridor mapping. *www.simactive.com*

Phase One unveils PAS 880

Phase One has unveiled the PAS 880 fully integrated large-format nadir and oblique camera system for aerial mapping. It integrates a 280-megapixel (MP) nadir camera with four oblique150 MP cameras into a single pod to simultaneously capture photogrammetric 2D and 3D digital imagery.

Operating at a remarkable 2 frames/second capture rate, it covers extremely wide flight lines with 20,000 pixels across in nadir and 14,000 pixels in each of the oblique angles. The system can be operated at a variety of airspeeds, altitudes, and lighting conditions for cost-effective blur-free image collection, with a maximum spatial resolution of 2.5 centimeters at 600 meters altitude. The combination of 90mm nadir and 150mm oblique camera lenses ensures balanced ground resolution. *www.industrial.phaseone.com*

Smart satellite data from Australia's LatConnect 60

UP42 has announced that image data and information from the planned LatConnect 60 constellation of mid-inclined orbit remote sensing satellites will be available on the UP42 developer platform for Earth observation data and analytics.

In early 2022, LatConnect 60 will launch its first two "smart" small satellites equipped with onboard Artificial Intelligence (AI) for data pre-processing and advanced tip-and-cue functionality. This on-board AI has the possibility to significantly reduce costs for resellers and end users, making enterprise-quality satellite data available to a wider range of small and medium enterprises.

UP42 gives users direct access to extensive Earth observation datasets and advanced processing algorithms – along with cloud computing power – to create their own geospatial solutions easily and inexpensively. Users purchase just the data needed to cover their area of interest and then leverage out-of-the-box processing capabilities to analyze the datasets without investment in their own computing infrastructure. *www.up42.com*

Lockheed Martin wins $511 million contract

The U.S. Space Force has awarded Lockheed Martin a $511 million contract for two new GPS 3F satellites. GPS 3F, the latest version of the satellites, offer global positioning, navigation, and timing services. They are also equipped with a completely digital navigation payload, and their signals possess better protection against jamming and other kinds of interference. *https://spacenews.com*

India proposes easy access of satellite-based RS data

The Government of India has proposed to come out with a new space-based remote sensing policy to enable enhanced participation of Indian industry and ease of data access with simplified procedures.

The Department of Space has published a draft "Space- based Remote Sensing Policy of India (SpaceRS Policy 2020)" along with draft "Norms, Guidelines and Procedures (SpaceRS NGP 2020)" for its implementation.

SpaceRS Policy 2020 is aimed at enabling wider stakeholders' participation and ease of data access. The new draft policy has taken into consideration the global trends, advancement of technology, wide ranging demand for remote sensing data - both within and outside the country - and the recent initiative of the government towards 'self- reliant' India.

The government shall promote Indian industries to carry out space based remote sensing activities within and outside India, and enable easy access to space-based remote sensing data, except for "sensitive data and information, the draft policy said. It shall also provide a timely and responsive regulatory environment for the commercial Indian industry to establish and operate space based remote sensing systems.

Any service provider will be free to provide remote sensing data and services to any user in the country, it added. However, a simple process of registration/authorisation of space asset is envisaged to keep the government informed about the space asset whose data and services are being offered to the users in the country.

Due to national security considerations, a category of data will be identified as 'sensitive' and a different mechanism for dissemination of such data is envisaged, it was stated. *www.hindustantimes.com*

Velodyne Lidar announces autonomous driving collaboration with Ford Otosan

Velodyne Lidar, Inc. has announced that it is collaborating with Ford Otosan on product development and testing of autonomous heavy commercial trucks. Ford Otosan is testing and planning to use Velodyne Velarray H800 lidar sensors to enable safe navigation and collision avoidance in next generation vehicles.

Velarray H800 is a powerful solution that can greatly improve automated safety and advanced driver assistance systems (ADAS). Designed for automotive-grade performance and durability, the Velarray H800's compact, embeddable form factor makes it ideal for seamless integration in internal and external vehicle mounting locations. *velodynelidar.com*

Brazil sets up national AI innovation network

With the aim of increasing the production capacity and competitiveness of local companies, the Brazilian government has announced the launch of a national innovation network focused on artificial intelligence (AI). The announcement of the AI Network follows launch of Artificial Intelligence Center (C4AI), Brazil's largest research facility focused on AI.

Developed as the result of cooperation between the Ministry of Science, Technology and Innovations (MCTI) and the Brazilian Industrial Research and Innovation Company (EMBRAPII), the network is the largest in the country.

The initiative intends to create a network of 17 research centers with infrastructure and skilled professionals in areas such as machine learning, Internet of Things, Big Data. The research centers will be used to strengthen national research, development and innovation capabilities in the field along with intensifying international exchange of knowledge and collaboration with primary AI networks in the world, especially those in Europe, Israel and North America. *www.zdnet.com*

Discussion draft of the National Unmanned Aircraft System (UAS)

The Government of India has released the discussion draft of the National Unmanned Aircraft System (UAS) Traffic Management Policy framed by the UTM Committee constituted under the Ministry of Civil Aviation. This policy is drafted under the overarching framework of the Draft UAS Rules 2020 and in the unlikely event of any incongruence; the Draft UAS Rules 2020 shall prevail. The draft National Unmanned Aircraft Traffic Management policy paper has sought comments from various stakeholders.

The Unmanned Aircraft System Traffic Management (UTM) system plans to provide flight planning capabilities, facilitate flight authorisation, provide real-time situational awareness, provide weather and terrain data apart from managing the unmanned aircraft system (UAS) traffic.

The need for UTM Systems is now being felt as drones will soon need to fly alongside manned aircraft so there is a need to maintain high levels of aviation safety in such scenarios, apart from which integrating drones in current Air Traffic Management (ATM) systems may be complex and expensive.

This draft document comes in the backdrop of several instances globally of drones coming in the way of aircraft taking off or landing at busy airports affecting their operations. *www.thehindubusinessline.com*

Innovation 5G wireless drone technology

T-Mobile and global professional drone racing property The Drone Racing League (DRL) have announced a broad-reaching partnership to advance 5G-powered drone technology. As part of the multi-year deal, T-Mobile has made an investment in DRL via the company's T-Mobile Ventures fund, and the Un-carrier has signed on as the league's exclusive U.S. 5G Wireless partner. Together, T-Mobile and DRL will innovate 5G racing drone technology to create the first integrated 5G racing drones, with the aim of authentically building them into the sport. DRL will develop first-of-its-kind, custom racing drones powered by T-Mobile 5G, during the 2021 DRL Allianz World Championship Season. *www.t-mobile.com*

New tactical UAS sensor data management solution

Kongsberg Geospatial has announced the release of the Modular ISR Data Analysis and Storage (MIDAS) solution. It is a Processing, Exploitation and Dissemination (PED) Solution for rapid intelligence analysis of data from tactical drones.

MIDAS was developed to provide a rapid capability for the exploitation and further distribution of drone sensor data.

Kongsberg Geospatial's MIDAS addresses the "lack of standards" problem that the vast majority of tactical UAVs encounter – no standards-compliant PED capability for their organic sensor data. MIDAS provides a fully standards-compliant system that allows intelligence analysts to exploit sensor data in near real-time, from where the drone is being operated – without having to wait for post mission analysis from headquarters. *www.kongsberggeospatial.com*

US Committee repeals National Defense Authorization Act

Congressmen in the U.S. have rejected a House version of the National Defense Authorization Act which would ban the purchase of Chinese drone tech by U.S. federal agencies or with federal funding.

Manufacturers, government agencies, and public safety agencies that utilize public funding have been awaiting the outcome of negotiations on the National Defense Authorization Act. A version of the Act in the House of Representatives called for a broad prohibition on "procuring any commercial off-the-shelf drone or covered unmanned aircraft, or

any component thereof for use in such a drone or unmanned aircraft, that is manufactured or assembled by a covered foreign entity, including any flight controllers, radios, core processors, printed circuit boards, cameras, or gimbals."

The provision could have affected drone programs across the country: and two former House representatives were among those who spoke out against the ban, saying that "these proposals have been developed in a haphazard and far-reaching manner that will lead to unintended consequences." The Senate version of the NDAA did not contain the ban on foreign drone tech.

Now, the conference committee, responsible for reconciling differences between the House and Senate proposals, has rejected the ban in the version of the NDAA that will be voted on. *https://dronelife.com*

FAA and NASA complete drone demonstrations

The Federal Aviation Administration (FAA) has concluded the second phase of its Unmanned Aircraft System (UAS) Traffic Management Pilot Program (UTM/UPP).

The agency ended the phase with virtual demonstrations in partnership with the National Aeronautics and Space Administration (NASA) and two UAS Test Sites: the Virginia Tech Mid-Atlantic Aviation Partnership (MAAP) and the New York UAS Test Site(NYUASTS).

The UPP results will provide a proof of concept for UTM capabilities and serve as the basis for policy considerations, standards development and the implementation of a UTM system. The demonstrations showcased emerging UTM capabilities that will support beyond-visual-line-of-sight (BVLOS) operations

Each event attracted more than 100 participants and included local and state elected officials and representatives from international civil aviation authorities. Both test sites collaborated with drone operators and local public safety agencies to demonstrate scenarios that featured various complex UTM capabilities working together to support BVLOS operations with increasing volumes and densities. *https://www.faa.gov/*

Dedrone announces partnership with Vodafone and AWS

Dedrone, Vodafone, and Amazon Web Services (AWS) have entered into a partnership to provide airspace security for critical infrastructure. Sites of critical importance, including airports, stadiums, correctional facilities, energy facilities, corporate headquarters, government buildings, and military installations, can now seamlessly upgrade their security programs with Vodafone Business and Dedrone. By using Vodafone Business's Multi-Access Edge Computing (MEC) solution, organizations can accelerate the delivery of Dedrone's counter-drone solution.

The MEC solution will be rolled out from the spring of 2021, starting with the first commercial centre in London, UK, and with other locations in the UK and Germany to follow. *https://aws.amazon.com*

Drone delivery of COVID-19 test kits

Flirtey and Vault Health has announced a partnership to test drone delivery of the first FDA authorized saliva test for COVID-19.

Vault Health distributes a COVID-19 saliva test kit that can be used at home under supervision from a health professional through video call. Using Flirtey's drones to deliver the test kits to homes will eliminate exposure risks and create further convenience, especially for those who do not live in proximity to on-site testing locations.

The Vault Health COVID-19 Test Kits have been added to Flirtey's existing drone delivery test program underway in the Reno, NV area. Through the partnership, which will begin immediately, Vault Health will send kits to distribution centers based on historical market demand data. *www.flirtey.com*

Hardware-agnostic drone APIs by FlytNow

FlytBase, Inc has announced the release of hardware-agnostic cloud-based drone APIs, enabling enterprises to easily integrate drones with their business applications.

FlytNow API is a collection of endpoints to help developers quickly integrate drones with other enterprise applications and to create custom workflows to suit business requirements. This is targeted at enterprises looking to deploy fully-automated drones at scale, via integration with sub-systems, powered by a reliable cloud platform. *https://flytnow.com*

India gets a Drones Directorate

In a step to strengthen the drone ecosystem of India, the finance ministry has given the Directorate General of Civil Aviation (DGCA) approval to set up a Drones Directorate. Currently, the Directorate consists of eight DGCA officials. The Directorate, while primarily focusing on managing the drones' ecosystem in the country, will also look into delays in rolling out permissions, managing drone training schools and fast tracking drone certifications.

Department 13 joins Australian Industry & Defence Network

Department 13 has placed its industry-leading advanced drone technology in front of global defence and security sectors after being recognised as a member of the Australian Industry & Defence Network (AIDN).

It marks yet another milestone for the Australian drone technology company since it re-launched earlier this year to service government, private and public sector enterprises. *https://department13.com*

Klau Geomatics releases GNSS/IMU hardware and software integration platform

Klau Geomatics is releasing the 7700C integration platform, a GNSS hardware system designed to integrate with external IMUs and IoT devices.

The KlauPPK hardware/software product has been an industry leader in aerial mapping for over 5 years, with ongoing improvements leading to the release of the 7700C. It is a big step up in technology, offering connectivity to a range of external devices configurable through a user-accessible menu. *https://geomatics.com*

Swift Navigation's precise positioning technology

Swift Navigation announced that its precise positioning platform can improve the performance of existing single-frequency GNSS positioning, found on most production vehicles today, from the standard average of 3 meters to lane-level accuracy without changing existing hardware and antenna.

These findings are demonstrated during the regular test drives the Swift team conducts to confirm the efficacy of its solutions and software updates. The graph depicts the improved positioning accuracy and availability when a single-frequency receiver is used with corrections from the Skylark precise positioning service and the Starling positioning engine. A performance improvement from 2 meters to 0.7 meters for 95% of this mixed-environment drive was achieved on a production vehicle with a low-cost automotive receiver and antenna. *www.swiftnav.com*

Rail antennas updated for multi-constellation GNSS

Huber+Suhner, a global supplier of optical and electricity connectivity solutions, updated its range of SENCITY Rail antennas to receive signals from all four GNSS: BeiDou, Galileo, GPS and GLONASS.

The SENCITY line of antennas are omni-directional railway roof-top antenna family for all types of trains. They are designed to meet the special requirements of railway applications including high current and high voltage protection. *www.hubersuhner.com/*

Trimble and SiriusXM establish alliance

Trimble and Sirius XM Connected Vehicles Services Inc., a subsidiary of Sirius XM Holdings Inc. have announced that Trimble RTX® GNSS corrections are being transmitted through the SiriusXM® satellite radio network. As a result, new cars sold in the contiguous U.S. and Canada equipped with SiriusXM›s Gen8 satellite chipset will be able to receive RTX GNSS corrections enabling high-accuracy positioning—a key component of autonomous on-road applications.

With the simple addition of the Trimble RTX Auto™ software library, any new vehicle that receives SiriusXM broadcasts with a Gen8 satellite chipset can leverage a positioning solution ideal for Advanced Driving Assistance Systems (ADAS), Autonomous Driving (AD) and Vehicle-to-Everything (V2X) applications. *www.siriusxmcvs.com*

DMI expands Precision Reality™ digital twin platform

DMI, LLC, a digital transformation company, has announced the release of a remote monitoring solution package on their Precision Reality™ digital twin platform, featuring Leica BLK247. This offering expands Precision Reality's robust ecosystem of hardware and software integrations for IoT, 3D visualization, and analytics.

Hexagon's "RTK From the Sky"

Research from Hexagon's Autonomy & Positioning division has resulted in breakthrough innovations in precise point positioning (PPP) that enable nearly instant global centimeter-level accuracy. These developments pave the way to bring "RTK From the Sky" performance to worldwide users through correction service products and GNSS receivers from Hexagon.

"RTK From the Sky" technology provides the quick accuracy of an RTK solution with the high accessibility and availability of PPP. Users will no longer have geographic or regional infrastructure restrictions – they will be free to operate anywhere around the world with the same premium level of positioning performance. "RTK From the Sky" technology removes the traditional PPP barrier of long convergence times as well as internet and radio communication limitations, delivering instantaneous convergence anywhere in the world. This breakthrough establishes the foundation for assured positioning with no downtime in marine, agriculture, and autonomous applications.

GMV selected for Galileo Second Generation ground segment

The technology multinational GMV is playing a key role in the Galileo Second Generation (shortened to G2G) ground segment. Galileo First Generation (shortened to G1G), running since December 2016, consists of space infrastructure (26 satellites to date) and ground infrastructure. Galileo is now providing 20-cm-precision positioning, navigation and timing services for over 400 million users around the world.

G2G's main objectives are to phase in new services, improve existing services and boost system robustness and security while also cutting both operating- and maintenance-costs, all with the prime purpose of cementing Galileo's position as one the future's top GNSSs.

G2G is divided into several phases. In the first, led by ESA, mission requirements were defined at system level. This was followed by a preparation phase, leading on in turn to the implementation phase. As well as priming several mission-requirement projects, GMV, since 2018, has been heading one of the consortia working on G2G's complete ground segment during the preparation phase.

ESA has recently once more turned to GMV as one of the three main phase-B contractors of the G2G ground segment. *www.gmv.com*

Orolia's distress tracking emergency locator transmitter

Orolia has been awarded a single source, multi-year program contract to supply its next-generation Emergency Locator Transmitter, Distress Tracking type (ELT-DT) for all Airbus aircraft programs.

The Ultima-DT is the latest solution from Orolia's ELT line, based on its proven Kannad technology. It was developed in response to recent aviation safety mandates to enhance global aircraft tracking, following the MH370 and AF447 accidents.

As per the ICAO Global Aeronautical Distress and Safety Systems (GADSS) recommendation and European Union mandate, all new aircraft delivered from January 2023 shall be able to autonomously report their location anywhere in the world and determine the end of flight location to help rescue teams rapidly locate the aircraft and recover flight recorders.

Orolia's Ultima-DT will be installed on a standard basis on all Airbus commercial aircraft programs, including the A220, A320 family, A330 and A350. First units will be delivered to Airbus for final assembly line installation in 2022, ensuring that aircraft delivered from January 2023 meet the autonomous distress tracking requirements. *www.orolia.com*

TW5382 smart GNSS antenna for high accuracy 5G timing

Tallymatics® Inc. has announced the TW5382 Smart GNSS Antenna for High-Accuracy 5G Timing. It is a multi-band, multi-constellation 5G smart GNSS antenna/receiver that provides 5 ns (1-sigma, clear sky view) timing accuracy. It consists of two industry-leading components: a Tallysman® GNSS Accutenna® technology antenna and a professional-grade GNSS timing receiver module. *https://tallymatics.com*

Antzertech unveils its GNSS expansion cards for cm-level positioning

Antzertech, an Internet of Vehicles (IoV) and telematics solution provider based in Taiwan, announces its high precision GNSS expansion card, which can achieve centimeter-level accuracy. The product is designed in mini-PCIe form factor with u-blox ZED F9P/F9R GNSS module, which can be easily integrated with embedded system to make a compact solution. Antzertech's unique CAN-to ADR technology extends its usage to tunnels and urban canyons where satellite signal is poor or blocked. *antzer-tech.com*

Sonardyne for pioneering Armada fleet

Sonardyne technology has been selected to support the world's largest and most environmentally sustainable fleet of ocean-going, multi-role robotic vessels, which is being launched by marine robotics company Ocean Infinity.

Sonardyne systems will provide part of Ocean Infinity's new Armada fleet with key sensor technologies for underwater platform navigation, tracking, control and communications, as well as ensuring uninterrupted surface navigation, even when GNSS services are degraded or denied. *www.sonardyne.com*

NovAtel introduces new marine-certified GNSS receiver for nearshore applications

NovAtel recently unveiled their marine-certified GNSS receiver specially designed for nearshore applications: the MarinePak7. The multi-constellation, multi-frequency receiver has been specifically engineered to receive Oceanix Correction Service from NovAtel, providing horizontal accuracy up to three centimeters (95%) in a marine environment.

With SPAN GNSS+INS technology capabilities, the MarinePak7 deeply couples GNSS and inertial measurement units (IMUs) for a 3D understanding of your position. Delivering exceptional positioning, heading, attitude, velocity and heave measurements, the MarinePak7 is optimized to succeed in the demanding marine environment for nearshore applications. An intuitive user interface reduces training and setup time, making it an ideal solution for use in demanding marine applications, including dredging, hydrographic survey, marine construction and nearshore renewable energy operations. *novatel.com*

Leica Cyclone ENTERPRISE Project Management Hub

Leica Geosystems announces Leica Cyclone ENTERPRISE, a new, user-managed, enterprise-level reality capture collaboration and project management platform. It enables collaboration and deliverable creation across platforms. The new platform provides a central tool for managing, collaborating and accessing reality capture projects to view, share and analyse rich data via Leica TruView LIVE - a new free web-browser based viewer.

Cyclone ENTERPRISE facilitates reality capture project management; provides access to rich, reality capture data though desktop programs and web browsers; and ensures secure, flexible, self-managed deployment. *hexagon.com*

eCognition Suite Version 10.0.1

Trimble Geospatial has announced the availability of the latest version of the Trimble® eCognition® Suite. eCognition Suite 10.0.1 is a maintenance release that includes improvements and bug fixes. Most notable are the fixes to supervised classification and deep learning tools:

Ecobot joins Trimble's GIS Partner Program

Trimble has announced that Ecobot, a software company that provides cloud-based applications to speed

environmental regulatory reporting, has joined Trimble's Mapping & GIS Partner Program. As part of the program, Ecobot has implemented Trimble integration tools to add high-accuracy positioning capabilities within its wetland delineation app. The app, which runs on iOS mobile devices, connects with the Trimble® R1, R2, and R12 GNSS receivers to record precise field data. The combined solution allows Ecobot customers to provide fast, accurate U.S. Army Corps of Engineers (USACE) wetland delineations, which establish the location and size of a wetland for government regulatory purposes. *www.trimble.com*

SBG Systems releases the virtual base station feature in Qinertia

SBG Systems releases the Virtual Base Station feature in its in-house post-processing software called Qinertia. Geospatial professionals benefit from an optimal centimetric position accuracy in all their projects, even for corridor mapping and in poorly covered RTK areas.

Qinertia is SBG Systems' in-house GNSS and INS post-processing software. It gives access to offline RTK corrections from more than 7,000 base stations located in 164 countries. Trajectory and orientation are then greatly improved by processing inertial data and raw GNSS observables in forward and backward directions.

Qinertia PPK software now includes a brand new Virtual Base Stations (VBS) functionality. The VBS consists in computing a virtual network around your project in which position accuracy is maximized, homogeneous, and robust like a PPK short baseline is. Surveyors can collect data far from base stations or over large areas, making it ideal for corridor mapping. After the mission, Qinertia chooses the most relevant reference stations, builds a virtual network, and brings your project to the centimetric accuracy with no jump on accuracy nor convergence effects, even in urban areas.

Qinertia has been designed to support all GNSS receivers and third-party IMUs. It automatically adjusts the VBS network to compensate for any base station position inaccuracy and provides full quality control indicators to assess the expected accuracy and reliability. It automatically selects the best positioning technology that applies to your project, whether it is a single base station mode, the Virtual Base Stations mode, or a Precise Point Positioning computation. *sbg-systems.com*

FalconEye satellite by Airbus launched

The Earth observation satellite FalconEye was successfully launched from the European Spaceport (CSG) in Kourou, French Guiana, on December 2nd, by an Arianespace Soyuz rocket. Owned and operated by the United Arab Emirates, it was developed by Airbus Defence and Space and Thales Alenia Space as co-prime contractors. The FalconEye system will support the needs of the UAE's Armed Forces. The satellite weighed 1190 kg at launch and will be raised to a helio-synchronous orbit of 611 km. *www.thalesgroup.com*

Teledyne e2v receives UK Space Agency grant

Teledyne e2v's Space Imaging team, a part of the Teledyne Imaging Group, has secured funding from the UK Space Agency's National Space Innovation Programme (NSIP) that will demonstrate and help support intelligent image processing platforms. The funding is in response to the 2020/2021 NSIP theme for "Earth Observation to Tackle Climate Change" and will be jointly delivered with Craft Prospect, based in Glasgow.

The NSIP is the UK Space Agency's programme established to support the development of innovation in the UK's space sector. In collaboration with Craft Prospect, the RAPID project establishes a new consortium bringing together Teledyne e2v's world-leading space imaging capabilities with Craft Prospect's cutting-edge machine learning and artificial intelligence (AI) algorithms. In the discovery phase the consortium will use space-ready hardware to establish the RAPID test and demonstration system. *www.teledyne-e2v.com*

Restyled Eclipse Cross with TomTom connected navigation

TomTom has announced that its full stack of navigation components – maps, connected navigation, and real-time traffic services – has been chosen by Mitsubishi Motors to power the new Eclipse Cross' infotainment system. The restyled SUV is the latest Mitsubishi model to be equipped with TomTom's automotive-grade solution; other models include the Outlander, the ASX/Outlander Sport/RVR, and the Pajero Sport. *www.tomtom.com*

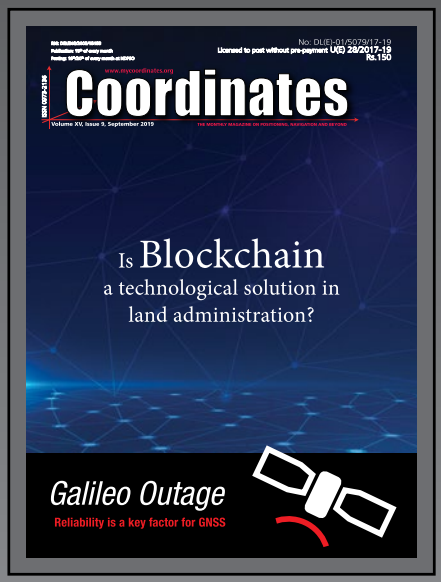
Digitisation of public buildings to go green

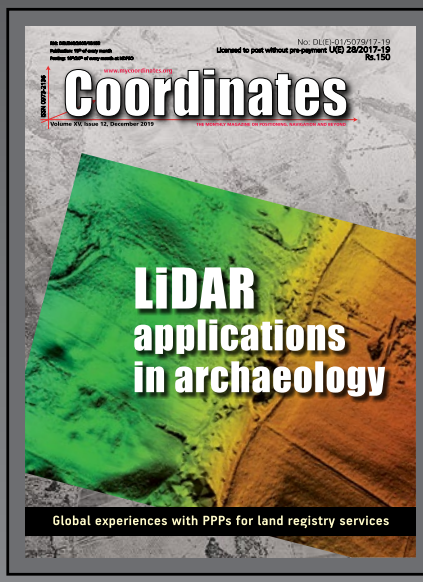
Hyvinkään Lämpövoima, the district heating company owned by the city of Hyvinkää (situated 30 miles north of Helsinki), has engaged AI specialist Nuuka to digitise the city's public buildings. It has a target of reducing its greenhouse gas emissions by 80% by 2030.

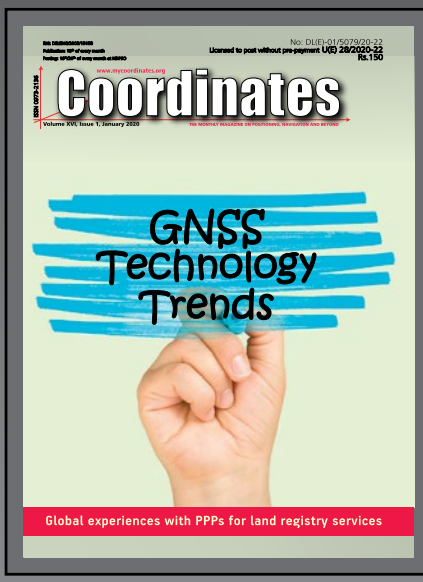
Nuuka's cloud-based platform will be used as part of Hyvinkään Lämpövoima's control room service. The solution will collect and analyse all building automation system data and diagnose all building processes. *www.bimplus.co.uk*

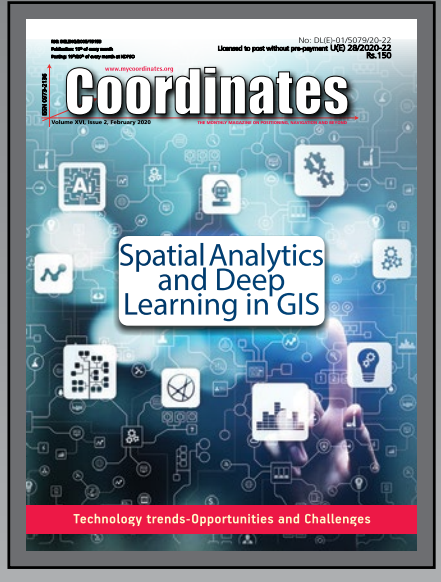
HERE Technologies achieves AWS Public Safety & Disaster Response competency

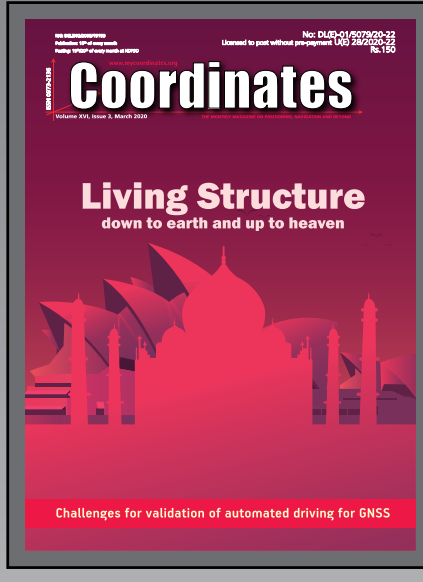
HERE, has announced that it has achieved Amazon Web Services (AWS) Public Safety & Disaster Response (PSDR) Competency status. This designation recognizes that HERE delivers proven technology and deep expertise in location-based services to help customers leverage the power of AWS to protect the public and prepare, respond, and recover from natural or man-made emergencies and disasters. *here.com*

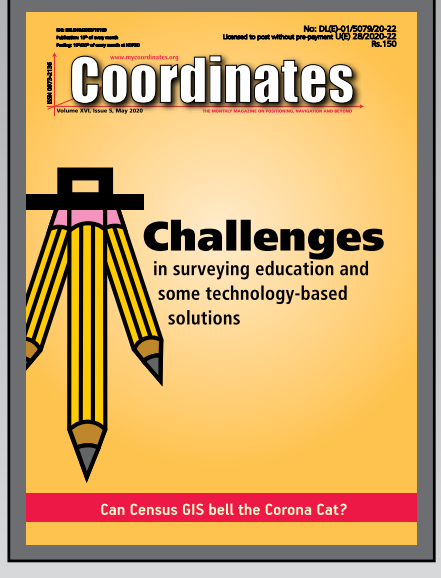


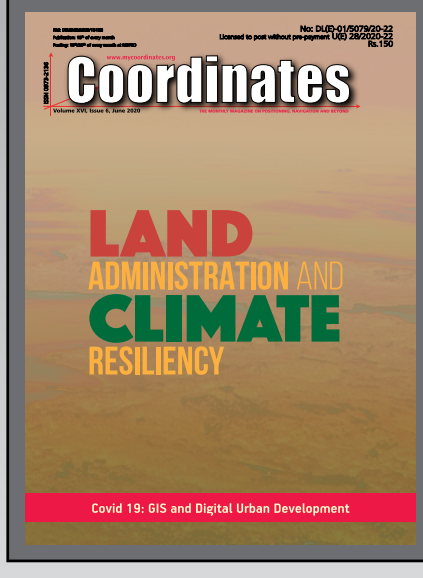


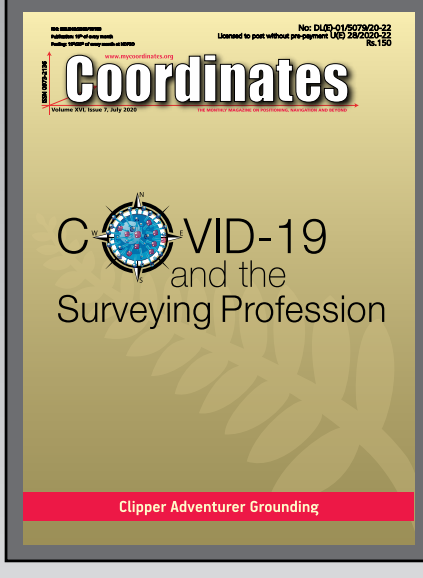












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