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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

GNSS Vulnerabilities

GNSS is no sole solver for each application - Guenter W Hein

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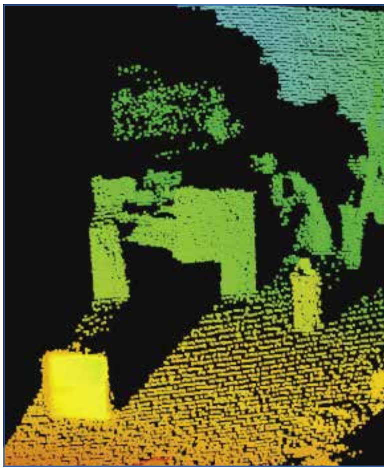

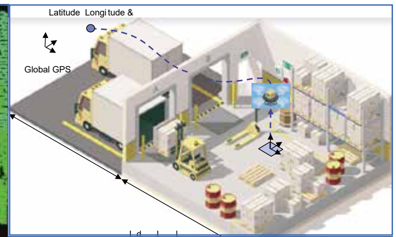

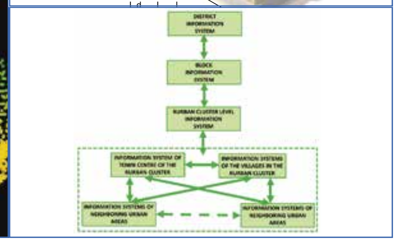

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Beyond sky

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India has a long cherished ambition

Of its own man mission in space.

The announcement by the Prime Minister of India recently

Has brought this mission on priority

Of the Indian Space Research Organization

Which has said that year 2022 deadline is very much doable.

The mission will not only be a pride of India

It will also be the capacity and capability to undertake such missions

Will be the actual achievement.

Bal Krishna, Editor
bal@mycoordinates.org

Developments for EGNOS V3 are underway at the European Space Agency

says Prof. (em.) Dr.-Ing. habil. Dr. h.c. Guenter W. Hein in an interview with Coordinates magazine

Prof. Dr. Guenter W. Hein is the former Head of EGNOS and GNSS Evolution Programme Department (until end of 2014) of the European Space Agency (ESA). Before he has been the Director of the Institute of Geodesy and Navigation of the University FAF Munich. Prof. Hein has more than 300 scientific and technical papers published, carried out at the University more than 200 research projects in satellite navigation and educated more than 50 Ph.D.'s. He received in 2002 the prestigious Johannes Kepler Award for "sustained and significant contributions to satellite navigation" from the US Institute of Navigation and became in 2011 a fellow of the US Institution of Navigation. The Technical University of Prague honored his achievements on satellite navigation with a Doctor honoris causa (Dr. h.c.) in January 2013. The University FAF Munich appointed him as "Emeritus of Excellence" in 2015. He is the chairman of the Executive Board of Munich Aerospace e. V. and a scientific consultant of the European Space Agency. Prof. Hein received on 15 June 2017 the "European Inventor Award" in the category "Research" together with its team for the invention of two new primary signals of Galileo for a better satellite navigation.

Last year, you and your team received the European Innovation Award from the European Patent Office for the signal design of the European satellite navigation system Galileo. Could you explain it our readers about the innovation by you and your team?

The team developed an innovative spread spectrum technique that creates a new single waveform called Composite BOC (CBOC). This signal will allow high-end receivers to compute accurate position and time and still be backward compatible with older and lower-end receivers (using e. g. BOC(1,1) on L1).

In addition, a modulation technique was developed that allows efficient transmission of four navigation codes in two adjacent frequency bands. This signal improves signal accuracy and saves satellite power. The modulation technique is called Alternative BOC (AltBOC) and is one of the enablers for GALILEO to offer an incredible enhancement in accuracy and performance (on E5a+E5b) while enabling interoperability with the GPS L5 signal (Galileo E5a), an enhanced signal with several users like aviation.

In general, the signalling technologies developed by the team enables compatibility (no interference with other GNSS sharing the same frequency spectrum), interoperability (a receiver can use signals coming from different GNSS) and better performance (more accurate positioning is possible).

You have been long associated with Galileo and EGNOS project in various capacities? How satisfied you are with their present status, progress and direction?

Developments for EGNOS V3 are underway at the European Space Agency for the first worldwide dual-system (GPS and Galileo) dual-frequency (GPS L1/L5 and Galileo E1/E5a) navigation augmentation system. This will be a major innovative step when available around 2023.

With the next launch of four Galileo satellites in 2019/20 will be the full constellation Galileo available. Developments for the second generation have started. A lot of people, especially our politician in Europe, were complaining about the long time in building-up Galileo. However, if we compare the time our US colleagues needed for GPS, namely about 23 years, with that of Galileo, about 16 years (between 2004 and 2020), then we can be satisfied.

This is a world of multi-GNSS systems. What advantages do you see about this scenario?

In fact, there are many advantages for the user being able to track four global and two regional satellite navigation systems (although the gain in performance of more than three GNSS is marginal). For example, with multiple Receiver Autonomous Receiver Monitoring (RAIM) we get a more secure PNT solution and can mitigate interferences, jamming and spoofing. Through interoperability between the different systems we can use a simple GNSS receiver. On the other hand, it creates competition between the various systems by the free market (and not by politics). There might be also disadvantages having more and more satellites transmitting on the same frequency. The internal noise is increasing which could create problems for receivers in acquisition of those signals.

Many countries plan GNSS systems primarily because of defence and security needs. Do you think that this may trigger a race with more countries joining in? What would be the implications?

There is no doubt that GNSS is nowadays a modern tool or even a “must” in defence. Considering the protection of the critical infrastructure of a state and the national security, it is understandable that many countries (with no alliances and corresponding agreements) want to have their own satellite navigation system.

Two decades ago we were convinced to avoid the misuse of a GNSS by third parties (in times of crisis) or terrorists by using various clever modulations and encryptions. Meanwhile we know that only high signal strength, in other words more power, can mitigate/avoid that problem

On the system evolution side, more secure and flexible signal generation and appropriate payloads have to be developed. For the user segment, the GNSS receiver, the same holds. Various efforts on the software side are possible, like multiple RAIM and interference, jamming and spoofing detection and mitigation algorithms, etc.

The critical issue, however, is the following: Two decades ago we were convinced to avoid the misuse of a GNSS by third parties (in times of crisis) or terrorists by using various clever modulations and encryptions. Meanwhile we know that only high signal strength, in other words more power, can mitigate/avoid that problem. This may lead to larger and more costly satellites. The power race in future leads perhaps not to a favourable situation for the civilian users (although we have ITU regulations).

With increasing dependence on GNSS, how do you perceive the threats like interference, jamming and spoofing?

In fact, these are the challenges of GNSS/RNSS in the next years. However, we can do more. On the system evolution side, more secure and flexible signal generation and appropriate payloads have to be developed. For the user segment, the GNSS receiver, the same holds. Various efforts on the software side are possible, like multiple RAIM and interference, jamming and spoofing detection and mitigation algorithms, etc. On the hardware side I like to mention the chip-scale atomic clocks, the inertial navigation system on a chip and appropriate antennas.

What is your opinion on GNSS back-ups?

GNSS is no sole solver for each application. Of course, we have now many global and regional satellite navigation systems which can control each other. However, there are many other (safety-related) applications which require additional sensors and a sensor fusion.

How do you think the GNSS positioning technology can take advantage of other positioning technologies?

I continue where I stopped at my response to the last question. 5G wireless networks and technology is expected to be a new mobile revolution in the next years and will cover new use cases and exploiting new frequency bands, ranging from low data-rate for narrowband Internet of Things (IoT) to ultrafast enhanced broadband exploiting technologies such as millimeter waves, small cells, etc. We have to think how to complement GNSS by 5G wireless technology.

Many LEO communication systems with hundreds or even thousands of micro-satellites will be built up in near future, see e. g. OneWeb, Iridium NEXT and SpaceX Starlink. Instead of ignoring them, we also have to consider, how we can use these systems for navigation in order to improve our GNSS PNT solution.

What influences you envisage in satellite navigation in the near future given the advancements in the field of AI, Autonomous Vehicles, etc.?

Artificial intelligence and robotics see a hype nowadays. In satellite navigation we are only at the beginning of taking advantage of these technologies. Given the long time to build navigation satellites and a corresponding system, we might become victims of a successful long-living satellite navigation system and the need to guarantee backward compatibility for decades.

Therefore, in the evolution of the satellite navigation systems, a high degree of flexibility in signal generation and payload capability changes is an absolute need. This holds also for the user segment, the satellite navigation receiver. However, I remember what a colleague once said to me: “The new applications and innovation in satellite navigation are not limited by technology, only by our imagination...”. Thus, I trust in our young and bright colleagues to get the innovative imagination!

Artificial intelligence and robotics see a hype nowadays. In satellite navigation we are only at the beginning of taking advantage of these technologies. Given the long time to build navigation satellites and a corresponding system, we might become victims of a successful long-living satellite navigation system and the need to guarantee backward compatibility for decades

You had a long association with academia. Given the pace of technology evolution, would challenges you see for the academic community? Where is now your main interest and activity?

I am presently chairman of the Executive Board of Munich Aerospace e. V., a non-profit company having as shareholders the Technical University of Munich, the University of the Armed Forces Munich (Bundeswehr University), the German Aerospace Center (DLR Oberpfaffenhofen) and Bauhaus Luftfahrt, a “think tank” of aviation, situated at the Ludwig- Bölkow Campus near Munich, in the vicinity of aerospace industry like Airbus, Siemens and IABG. Our mission is to bundle all competencies in the field of aeronautics including satellite navigation in the greater area of Munich.

Munich Aerospace is based on the expertise of numerous professorships in the field of aerospace in the Munich area, which are contributing to each other. Interdisciplinary combination results in a unique density of benefits and outputs. Munich Aerospace is promoting the education of young academics in strong cooperation with the universities, research institutions and industry and is connecting the partner’s research and development.

This is made possible by engaging in four main fields of work: Promotion of interdisciplinary research alliances, providing connected educational offers, organization of the Munich Aerospace Graduate School, offering a scholarship-program. This is where I see the academics should go: not working alone but bundling the forces by making alliances with other appropriate partners from universities and industry.

Our newest development of Munich Aerospace was quite recently the built-up of a Global Aerospace Campus consisting presently of seven regions over all continents with the lead of Bavaria. The goals are the same like the ones of Munich Aerospace: a tight cooperation in teaching and research in aerospace. For more information see www.munich-aerospace.de

What impacts do you think Brexit may have on Galileo?

We see already the first impacts of a coming Brexit in Galileo. The Galileo Security Centre in United Kingdom was transferred to Spain. Galileo is a European system, therefore the Galileo Public Regulated Service (PRS) will be no more available for UK. Most likely British industry will not be allowed to participate in the further development of Galileo. Negotiations are still going on, but it is a pity that the UK likes to leave the European Union...

We have heard voices in the press that the UK intends then to build-up its own satellite navigation system. Can we believe that?

We will see in spring 2019 what happens, how the Brexit looks like.

Leveraging national land and geospatial systems for improved disaster resilience

A project aimed at exploring the role of national land and geospatial systems in disaster risk management activities is currently being conducted by the Social, Urban, Rural and Resilience team of the World Bank and the University of Melbourne's Centre for Spatial Data Infrastructures and Land Administration

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Land Administration and Geospatial Specialist, The World Bank

Ivelisse Justiniano
Urban and Disaster Risk Management Specialist, The World Bank

The world is facing an increase in the frequency and severity of natural disaster events. Events which, when they strike, threaten the social, environmental and financial foundations of communities. And while these events cannot be prevented, their impacts can be limited. One strategy to meet these challenges is to leverage resources at hand, adopting the 'create once, use many times' viewpoint. It is in this line of thinking that this research project has emerged. National land administration systems are well-established in many countries, housing land, geospatial information and sophisticated data management systems including SDIs. These resources already facilitate disaster risk management practices, however wider application and incorporation of this information for improved disaster resilience has not yet been explored. Investigating and understanding this issue at a variety of contexts is the first step.

The current 2017-2018 research project on land resilience funded by the World Bank is taking on these issues, exploring at the national and local level a number of countries with the aim to deliver country-level detailed action plans for 5 of these countries. The project is framed around the two key points: firstly, that disasters impact not only the economy of a country, but also the citizens through their most valuable asset – their land and property, and secondly, that national land administration information and SDI are fundamental for effective implementation of disaster risk management. This project explores these ideas and develops a method that adopts a case study approach to explore the national land and geospatial systems and disaster risk management processes of a number of countries, and generates country specific action plans to improve resilience.

Project impetus

There is wide recognition that national land administration systems and spatial data infrastructure are fundamental for disaster risk management. They play a key role in facilitating pre and post disaster tenure, land use, land valuation and zoning information in a unified geospatial platform for planning, monitoring and implementing responses. The input of this information enhances resilience capabilities and enables stakeholders to carry out the required mitigation and preparedness actions. Better access to information, along with more secure tenure, will yield land use and management decisions that take resilience into account and reduce vulnerability.

The extent of the role that land and geospatial information, the function and responsibility of the institutions that govern the data, and the resulting impact that this data has on the overall resilience of society has not been extensively explored or clearly defined to date. This leaves a critical gap in knowledge regarding potential to significantly improve disaster resilience for stakeholders, particularly at the community level, using existing information and resources.

As a society, we are still trying to understand the concept of resilience and how it can be successfully established and implemented for stakeholders in our communities, taking into consideration the different priorities and needs of individuals. Land administration and the vast wealth of data that it captures is a key component that requires further study and consideration within the contexts of disaster risk management and disaster resilience. There is scope for national land and geospatial systems to play a larger role and create a bigger impact.

Disaster resilience

Disaster do not discriminate based on any jurisdictional, economic, or social borders, and thus the impact of such events is often spread far and wide, directly and indirectly. Combatting the impacts of these events is complex and requires thorough understanding of the hazards and the potential risks they pose, comprehensive disaster management practices, multi-disciplinary and cross-sectoral consideration and analysis, and most importantly – strong disaster resilience across all communities.

Developing resilience to disasters is key, but often a complex endeavour. As a society, we are still trying to understand disaster resilience and how it can be established, successfully implemented, and sustained – for a range of communities, with varying contexts, with different priorities and needs. In this mammoth task, input is required from all levels of society: top down from institutions and governments, bottom up from individual citizens and communities at the local level, and from national and global organizations spanning all sectors, industries and disciplines.

National land and geospatial information are important components for input that have considerable value to add to the establishment of disaster resilience, however the role of this information, the function and responsibility of the institutions that govern the data, and the resulting impact that this data has on the overall resilience of society has not been clearly defined.

Understanding the impact that national land and geospatial data has on disaster resilience requires examination of the literature across the wider areas of land administration, disaster risk management and disaster resilience. The intersection of these three key areas brings to light previous experiences and lessons learnt, and helps to define the role of the national land administration institutions themselves and the data they produce within the context of disaster risk management and disaster resilience.

Disaster resilience initiatives

Globally, several key initiatives that aim to build resilience to disasters have

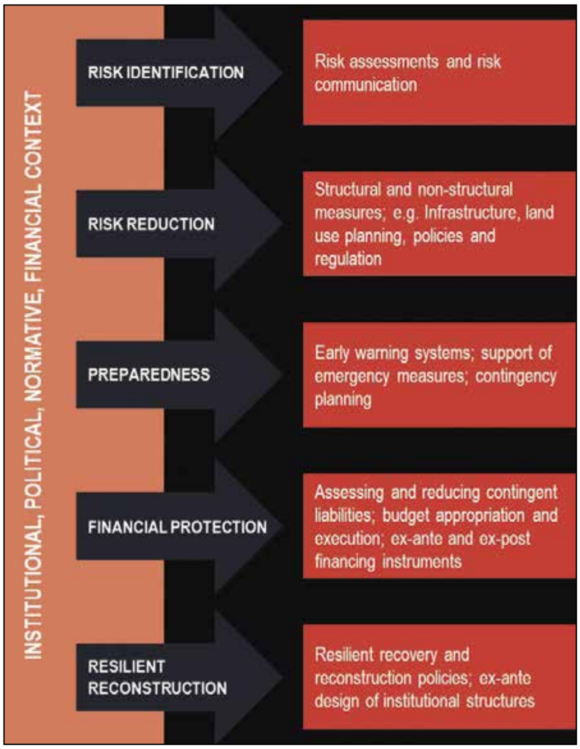

Figure 1: The disaster risk management process (Ghesquiere and Mahul, 2010)

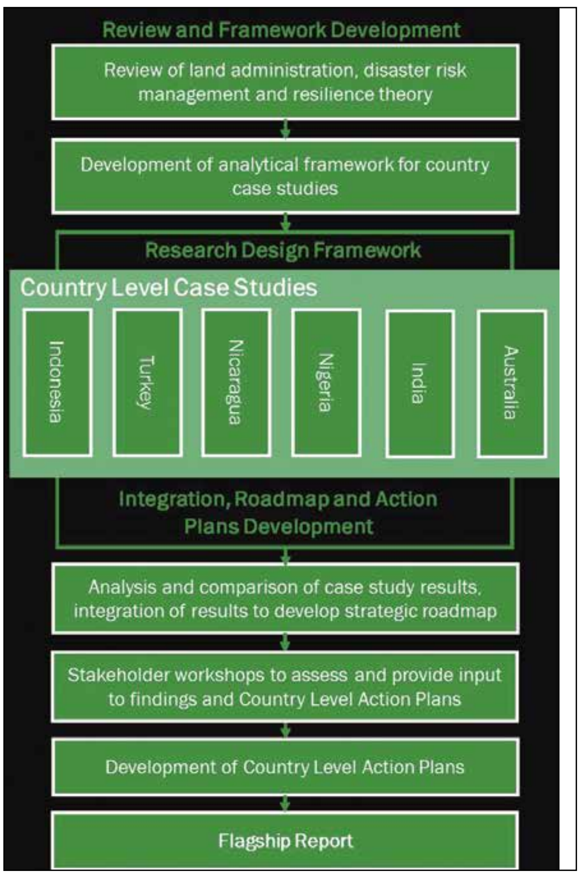

Figure 2: The overarching method

emerged in recent years. Many tackle a broad range of issues, at a number of levels ranging from global or national down to local and community levels. In particular, the 2030 Agenda for Sustainable Development, the Hyogo Framework for Action, and the Sendai Framework for Disaster Risk Reduction outline key points relevant in the context of improving resilience to disasters and the impact that national land and geospatial systems can have.

The 2030 Agenda for Sustainable Development outlines a need for new data acquisition and integration approaches, including supporting developing countries in strengthening the capacity of national data systems to ensure access to high quality, timely, reliable and disaggregated data (UN, 2015). This includes national land and geospatial information, and the application of this data to address the identified sustainable development goals (SDGs).

The Hyogo Framework for Action underscores the need for, and identified ways of, building the resilience of nations and communities to disasters. Sustainable development, poverty reduction, good governance and disaster risk reduction are identified as mutually supportive objectives. It puts forward that in order to meet the challenges ahead, accelerated efforts to build the necessary capacities at the community and national levels to manage and reduce risk must be made (UNISDR, 2005). Further to this, within the Hyogo Framework for Action, land issues have been established as one of the key priorities for the period of 2005-2015, and have been gaining momentum within the disaster risk management community in recent years.

The Sendai Framework for Disaster Risk Reduction follows on from the Hyogo Framework for Action and aims to substantially reduce the risk of disaster and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of people, businesses, communities and countries through the implementation of integrated and inclusive measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience (GFDRR, 2012). The Framework has identified seven global targets which address areas such as global disaster mortality, number of people affected by disaster, direct disaster economic loss, damage to critical infrastructure and disruption to basic services, creation and implementation of disaster risk reduction strategies, international cooperation, and availability and access to multi-hazard early warning systems and disaster risk information and assessments.

Disaster risk management

Disaster risk management has a focus on the preservation and protection of land and property and is centred on stakeholders to promote a bottom up approach for managing disaster risks.

The comprehensive risk management framework focuses on five core areas: risk identification, risk reduction, emergency preparedness, financial resilience, and sustainable recovery and reconstruction, as illustrated in figure 1. This framework can be used to develop practical approaches to disaster risk management, and is based on the fundamental principle that citizens and governments must be empowered to make informed choices about their risks and how best to reduce, retain or transfer them (GFDRR, 2012).

Land administration

In the last two decades, the discipline of land administration has undergone a major evolution. The role land administration plays within society has become more defined and understood and the link between appropriate land administration and sustainable development has been established, largely through continued efforts from the International Federation of Surveyors (FIG) (Enemark, 2005). One element which is now strongly aligned with land administration, and land planning, use and development is disaster risk management (FIG, 2006), however the specific role of land administration within this area has not been extensively explored, particularly integrating land administration systems in a country context with land risk management practices. Land administration foundations are based on risk management principles and focused on decreasing risk through secure tenure.

Disaster risk management backed by land administration

Land administration information is fundamental in improving disaster risk management practices. Research has shown that the use of land and geospatial information for disaster and emergency management applications can improve operations and outcomes (Mansourian et al., 2004; Asante et al., 2007). Exposure information, which is derived from land and geospatial information is a key component and comprises information on people, buildings, infrastructure (transport, energy, communications and water), businesses, hazardous substances, primary and major industries (Nadimpalli et al., 2017). The argument which supports the use of land administration information in the process of disaster risk management is not complicated. The combination of hazard information with relevant information on land tenure, land value, and land use enables the necessary risk prevention and mitigation measures to be identified and assessed in relation to legal, economic, physical and social consequences (Enemark, 2009). Combined land and hazard information has been identified as a critical element in the mitigation of new disaster risk management developments (Emergency Management Australia, 2008). Hazard information presented using land administration information as a foundation can assist in making decision makers more aware of potential risks and more motivated to implement appropriate disaster risk management strategies (The World Bank, 2010). The ubiquitous nature of maps and other land and geospatial information today makes the interpretation of the visual information straightforward for the majority of stakeholders (Tate et al., 2010). The value in land administration data is that it enables the nature and extent of hazards to be visualized allowing the impacts of the hazards to be easily understood to informing disaster risk management strategies (National Emergency Management Committee, 2011; Tate et al., 2011). As some risk is relevant to specific areas, the land administration information can reveal vulnerabilities and exposure to certain hazards. Data regarding topography is particularly useful in its ability to reflect tsunami, storm tide, tropical cyclone, bushfire, and landslide risk (Middelmann, 2007).

The better the knowledge base of information that is available for assessment of the risks, the more informed the disaster risk management assessment is likely to be (Schneider et al., 2009), and recent research in this area has highlighted the increasing role of spatial information in disaster risk management. In this domain, land and geospatial information are a cornerstone in pre and post disaster management of land by facilitating land tenue, land valuation and effective land use planning (Zevenbergen et al., 2014a,b). Secure rights and access to land are crucial for the vulnerable groups most affected by a disaster. Tenure security in the face of disaster enables housing reconstruction, food security and recovery of production systems (UN-HABITAT, 2010). Accurate and up-to-date land valuation supports insurance, compensation, property tax, compulsory purchase and strategic advice to governments in disaster recovery (Mitchell et al., 2014a,b).

A key aim of this project is to develop a roadmap which demonstrates how national land and geospatial systems could improve resilience to disasters.

Further, effective land valuation and property taxation measures can support post-disaster emergency response, recovery and reconstruction activities. Flexible land use planning standards can facilitate reconstruction aimed at building back better and mitigating the risk of future disasters (UNHABITAT, 2010; Roy and Ferland, 2014).

A method for improving a country's land resilience

A key aim of this project is to develop a roadmap which demonstrates how national land and geospatial systems could improve resilience to disasters. This strategic roadmap in turn guides the development of the country action plan template, which when applied to a particular country context, can produce a country-specific action plan. In order to develop the strategic roadmap, and ultimately the country action plans, the research is structured into the three key phases of: review and framework development, research design framework, and integration, roadmap and action plans development (see figure 2).

The first phase informed the development of the country case study template. The template was organized into the 5 sections of: introduction, contextual analysis, land and geospatial information investigation, disaster risk management institutional and legislative framework, and challenges and lessons learnt.

This template was utilized in the second phase of the research to investigate the role of land administration and geospatial information systems, and disaster risk management practices in each country, and the status of national land, geospatial and NSDI systems, and the countries disaster risk management practices for the selected case countries. To complete the template, input from stakeholders and industry representatives from the national land and geospatial organization and disaster risk management organization was required.

In the third phase of the method the results of the case studies were examined, analysed, and inferences and comparisons were made. The results informed the development of the strategic roadmap and the initial development of the country action plan template. Figure 3 shows the process.

At the current stage of the project, the strategic roadmap is complete and the country action plan template has been drafted with a series of local stakeholder workshops organized to take place to further enrich the data. The workshops will be repeated for several countries and will involve a broader range of stakeholders from the national and local levels to attain multi-dimensional perspectives. The discussion topics will include: drivers and barriers to integrating land and geospatial information into DRM practices, current use of geospatial data in DRM and other relevant areas, and ways to incorporate information into DRM practices. The outcomes of these workshops will complete the data collection and validation required, and the final country-specific action plans will be produced.

The overall findings from this project and the final country action plans will be reported in a World Bank published Flagship Report.

Acknowledgements

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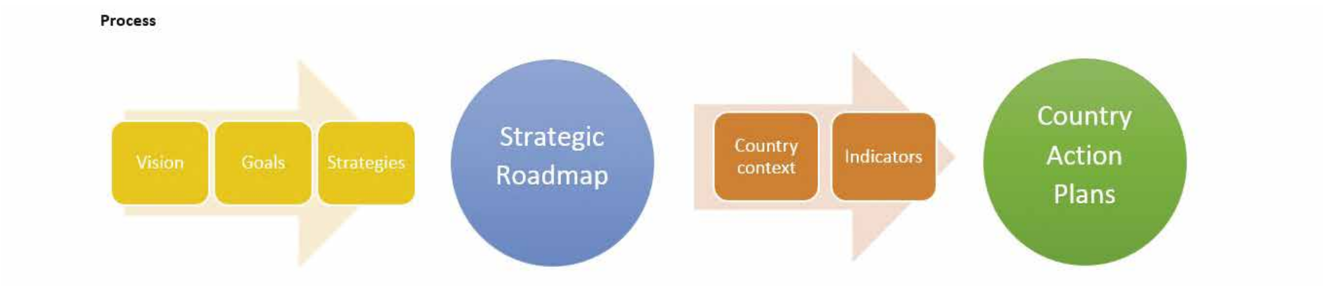

Figure 3: Process for developing Country Action Plans

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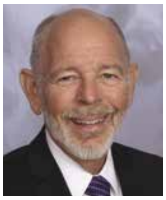
GNSS disruption – what's the risk?

A white paper by the Resilient Navigation and Timing Foundation offers some initial answers



Dana A. Goward
President, Resilient Navigation and Timing Foundation

GNSS signals are being disrupted all the time. Why should we care?

Those in the GNSS/PNT community will say it's because virtually every technology uses GNSS signals, and most depend upon them. When signals are disrupted, something bad could happen.

But how likely is that? What is the risk and are we willing to take it? These are questions that many governments are starting to ask.

To understand how this is being done, we must first understand how people think about and calculate risk.

We all calculate risks every day. How likely is a bad thing to happen, am I likely to be affected, and, if so, what will be the impact? Most of the time these calculations are unconscious. Shall I get on an airplane to go to a conference? There could be bad weather, the airplane could crash, I could die. But I think there is little chance of bad weather, and, if there is, the airplane and pilots can handle it, so there is almost no chance I could die. So, even though my dying would be a very, very bad outcome, I buy my ticket without a second thought.

For more complex decisions, risk managers in government and elsewhere make pretty much the same kind of calculations, though they are much more systematic and thorough. They look at risk as the product of three factors as a way to quantify risk:

> **Threat**, defined as the probability of an adverse event (like the weather),
>
> **Vulnerability**, or how likely the adverse event is to cause harm (affect the airplane), and
>
> **Consequence**, the harm that could be done (crashing and me dying).

Let's take a simple, non-aviation, example. If the probability of a category 5 hurricane (adverse event) striking New Orleans in any given year is 25%, and there is a 50% chance the levees will fail (vulnerability) and this will cause $2B in damage (consequence), then the risk to New Orleans from category 5 hurricane can be calculated as:

25% per year **Threat** x 50% **Vulnerability** x $2B **Consequence** = $250M per year Risk

In this case the risk is expressed in dollars. Often though, it is difficult to assign dollar amounts to consequences. In such cases, risk analysis will assign scores to different severities of consequence. This allows the risks associated with a wide variety of adverse events to be scored and evaluated. The relative risk of several different adverse can then be compared, and the impact and value of different mitigation efforts can be evaluated.

So how does this apply to GNSS disruptions? (We though you would never ask!)

> The good news is nothing really bad in the way of GNSS disruption has happened yet, and some nations are slowly moving to protect themselves. The bad news is that they are moving slowly, while both threats to GNSS signals and their national dependence upon them grow.

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To understand risks associated with GNSS disruptions, we have to know about:

Threats – What are possible GNSS disruptions, and how likely are they to occur?

Vulnerabilities – How likely are each of these adverse events to cause harm to GNSS users?

Consequences – What is the severity of the harm that could be done?

A white paper by the Resilient Navigation and Timing Foundation offers some initial answers to these questions. Note that while the paper addresses just GPS, its methods and findings are generally applicable to all GNSS systems and users.

Threats - Surveying professional literature we were able to describe 22 two types of adverse events (we called them "vectors") that could disrupt GPS services. These ranged from terrain and foliage obstructions and interference from solar activity, to military grade jamming and spoofing.

We then estimated on a scale of one to five how likely each adverse event or vector was likely to occur. Very unlikely (happens less than once a century) was scored as "1" and things that happen several times a year were scored as "5". The probability of malicious acts, like one nation jamming another, was defined as the product of "intent" and "capability" – or "how much they want to do it" multiplied by "how likely they are to be able to make it happen."

Vulnerability – Since we were looking at the cumulative societal impacts of GNSS disruption, we assessed vulnerability by what percentage of GPS users would be impacted. Very few users, for example are impacted by foliage (vulnerability score of "1"), but most all users would be affected by a massive solar flare that ionized the atmosphere and prevented GPS signals from reaching Earth (vulnerability score "5").

Consequence – We used a scale that ranged from "1 – No noticeable economic losses, unlikely impact to safety of life" to "5 – Economic Losses > $5B and/or Loss of Life"

Total Risk to GPS Services & US National and Economic Security
Table - 1

	Vector	Vulnerability	Consequence Intent		Threat Capability		Risk Score
I. Natural & II. Accidental	1. Built structure obstruction	1	2		5		10
	2. Terrain obstruction	1	2		5		10
	3. Foliage (pines, hvy canopy)	1	1		5		5
	4. Solar Activity – mild	1	1		5		5
	5. Solar Activity - moderate	3	2		4		24
	6. Solar Activity -powerful	5	5		2		50
	7. Human Error/software	5	1	5	3		15-75
	8. Satellite malfunction	1	1		4		4
	9. Control Segment Failure	5	5		1		25
	10. Space Debris	1	4		2		8
	11. Unintentional RF	5	1	4	5		25 - 100
III. Malicious	12. Privacy seeker (1 event)	5	3		√5	√5	75
	13. Criminal Jamming (1 event)	5	3		√5	√5	75
	14. Criminal + Privacy 1 Yr Total	5	5		√5	√5	125
	15. Criminal Spoofing (1 event)	4	3		√4	√4	48
	16. Terrorist Jamming	5	5		√5	√5	125
	17. Terrorist Spoofing	4	4		√3	√4	55
	18. Military-style Jamming	5	5		√5	√5	125
	19. Nat. Agent Spoofing	3	4		√4	√4	48
	20. Attack on Satellites	5	5		√1	√1	25
	21. Attack on Control Segment	1	1		√1	√2	1.4
	22. Cyber Attack Control Segment	2	5		√3	√2	24

Much of what we found is probably not a surprise to anyone.

Posing the least risk to society were things like built obstructions, foliage, and mild solar activity. Space debris and a single malfunctioning satellite also fell in that category.

The greatest risks were from high powered military and terrorist jamming, and the cumulative effects over the course of a year from wide-spread low power jamming by criminals and privacy seekers. (See table 2).

We also took a high-level look at nine different proposed mitigations, or ways to reduce the risk to society, from GPS disruptions. These varied from the US Air Force's "space fence," to implementing a high-powered terrestrial complement to GPS and requiring critical infrastructure and applications to be able to survive for 30 days without GPS signals. The space fence seemed to only mitigate one, low risk threat vector, while the terrestrial complement and 30-day mandate seemed to address all the threats and reduce the most risk.

But, of course, our single white paper is not the final answer. In fact, it is really only a methodology that points to questions that must be asked and decisions that must be made.

And some governments are beginning to ask the questions. The European Union is addressing some aspects of the threat. Their STRIKE3 project has found hundreds of thousands of low level GNSS

Table 2 - Vectors by Risk Score	
14. Criminal + Privacy 1 Yr Total	125
16. Terrorist Jamming	125
18. Military-style Jamming	125
11. Unintentional RF	25 - 100
7. Human Error/software	15 - 75
13. Criminal Jamming (1 event)	75
12. Privacy seeker (1 event)	75
17. Terrorist Spoofing	55
6. Solar Activity - powerful	50
19. Nat. Agent Spoofing	48
15. Criminal Spoofing (1 event)	48
20. Attack on Satellites	25
9. Control Segment Failure	25
22. Cyber Attack Control Segment	24
5. Solar Activity - moderate	24
2. Terrain obstruction	10
1. Built structure obstruction	10
10. Space Debris	8
3. Foliage (pines, hvy canopy)	5
4. Solar Activity – mild	5
8. Satellite malfunction	4
21. Attack on Control Segment	1.4
Colors added to show natural groupings	

Table – 3 **Proposed and Ongoing Mitigation Measures Vs Risk Vector**		Protect – Space Fence for debris detection	Protect – Offensive (anti-Satellite weapons (deterrence)	Protect – Quiet adjacent bands, no authorized in-band terrestrial transmissions	Protect – Legal changes to counter jamming and spoofing equipment and use	Protect – Establish jamming detection systems & enforcement capability	Toughen – Improve receivers standards, implement better receivers	Toughen – Improve GPS signal., supplement with other GNSS signals	Toughen – Require critical users to be able to operate 30 days w/o space-based PNT	Augment – Provide 2nd Wide Area PNT signal (e.g. eLoran) for US free to users**
Vector	Risk Score									
14. Criminal + Privacy Jamming (1 Year)	125									
16. Terrorist Jamming	125									
18. Military-style Jamming	125									
11. Unintentional RF	25 - 100									
7. Human Error/Software	15 - 75									
13. Criminal Jamming (1 event)	75									
12. Privacy Seeker (1 event)	75									
17. Terrorist Spoofing	55									
6. Solar Activity - Powerful	50									
19. Nat. Agent Spoofing	48									
15. Criminal Spoofing (1 event)	48									
20. Attack on Satellites	25									
9. Control Segment Failure	25									
5. Solar Activity - Moderate	24									
22. Cyber Attack on Control Segment	24									
2. Terrain Obstruction	10									
1. Built Structure Obstruction	10									
10. Space Debris	8									
3. Foliage (pines, hvy canopy)	5									
4. Solar Activity - Mild	5									
8. Satellite Malfunction	4									
21 Attack on Control Segment	1.4									
Some Risk to US Security/Economy Mitigated*				Most or All Risk to US Security/Economy Mitigated*						

interference events, over 50,000 intentional jamming events, and identified 300 jammer "families." The United Kingdom has studied consequence and estimated that a five-day GNSS outage would cost the nation at least £5.2B. And South Korea is beginning to implement a mitigation in the form of a terrestrial eLoran system to augment GNSS signals and eliminate their critical dependence on space.

While all of these are good and needed efforts, comprehensive national approaches to protecting GNSS and PNT services seem most appropriate. We believe that every nation needs to simultaneously protect GNSS signals by actively combatting interference, ensure users are toughened with receivers that reject interference as much as possible, and to augment GNSS signals with sovereign terrestrial systems so tht they won't be dependent upon weak, easily disrupted signals from space.

The good news is nothing really bad in the way of GNSS disruption has happened yet, and some nations are slowly moving to protect themselves. The bad news is that they are moving slowly, while both threats to GNSS signals and their national dependence upon them grow.

Should nations move more quickly? Should we all be worried? Well… what's the risk?

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STRIKE3 http://www.gnss-strike3.eu/

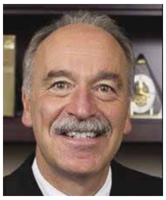
London Economics report – UK impact from GNSS disruption https://www.gov.uk/government/publications/the-economic-impact-on-the-uk-of-a-disruption-to-gnss

South Korea eLoran http://insidegnss.com/ursanav-awarded-contract-to-supply-eloran-transmitter-test-bed-system-in-the-republic-of-korea/

Vector Assessment Criteria		
Vulnerability		
1	Low	Vector able to impact less than 5% of users
2	Moderate	Difficult for this vector to impact overall GPS service, or more than 10% of users
3	Significant	Fairly easy for this vector to impact many unsophisticated users and high performance users
4	High	Fairly easy for this vector to impact all or most users
5	Severe	Very easy for this vector to impact all or most users
Consequence		
1	Low	No noticeable economic losses, unlikely impact to safety of life
2	Moderate	Probable economic losses, possible safety of life impacts
3	Significant	Documented economic losses, probable safety of life impacts
4	High	Economic losses > $1B, injuries, probable loss of life
5	Severe	Economic losses > $5B, and/or loss of life
Threat of Natural Phenomena & Accident = Probability of Occurrence		
1	Low	Probability/history of occurrence < once every 100 years
2	Moderate	Probability/history of occurrence > once every 100 years
3	Significant	Probability/history of occurrence > once every 50 years
4	High	Probability/history of occurrence > once every 10 years
5	Severe	Probability/history of occurrence > once every year
Threat of Malicious Acts = Bad actor intent x Bad actor capability		
Intent		
1	Low	No expressed desire or interest
2	Moderate	Rarely expressed desire or interest
3	Significant	Repeat expressions of interest, some attempts, possible successes
4	High	Repeat expressions of interest, some attempts, some successes
5	Severe	Repeat expressions of interest, many attempts, many successes
Capability		
1	Low	No known ability to access and use this method
2	Moderate	Available to some nations & sophisticated actors (global criminal networks, terrorist organizations)
3	Significant	Available to all nations & sophisticated actors
4	High	Available to moderately sophisticated actors (individual technologists, criminals, etc.)
5	Severe	Available to unsophisticated actors (low cost, easy to access or build and use)

Reducing GNSS receiver vulnerabilities

The objective is to raise the bar enough that successful attacks causing significant consequences are difficult to carry out



John W. Betz
MITRE Fellow Emeritus,
The MITRE Corporation

Reports of problems with GPS appear with increasing frequency. As two of many examples:

- USA Today, on October 3, 2017, reported a "Mysterious GPS glitch telling ships they're parked at an airport…", apparently due to intentional broadcast of spoofing signals.
- Some mobile devices in the exhibition hall at the September 2017 ION GNSS+ conference began reporting time in the year 2014, and locations in Europe. Because of the date change, these devices suffered secondary problems with email and text messaging. The problem was caused when the devices received signals leaking from a GPS constellation simulator.

All satellite-based navigation and timing (satnav) systems in the Global Navigation Satellite System (GNSS) consist of three segments: space segment (the constellation of satellites), ground segment (which monitors and controls the satellites and their signals), and user segment (the antennas, antenna electronics, and receivers), as well as the signals broadcast from the satellites to the user equipment.

In many cases, the reported problems are either caused by, or at least could be mitigated by, satnav user equipment. Yet, like the USA Today headline quoted above, often the problem is blamed on the satnav system, leaving the mistaken impression that there has been a flaw in the space or ground segment, or in the signals.

In these examples and many other cases, the space and ground segment and signals are correct, but imperfect user equipment is the vulnerability. For example:

- Regardless of what their inputs are, should maritime receivers on large maritime vessels report position changes of tens of kilometers in a few seconds, altitude under water, and location on an airport runway?
- Should mobile devices report "time travel" from 2017 to 2014 and moving thousands of kilometers in a few seconds or minutes?

Sometimes a satnav system's ground segment or space segment does malfunction, causing signals to provide flawed or erroneous information. GPS experienced this situation in January 2016, when some satellites broadcast an incorrect offset between system time and Universal Coordinated Time. This error did not affect calculation of position or velocity, but did affect some timing receivers. Even in this case, however, since the erroneous broadcast did not conform to the GPS signal interface specification, receivers could have detected and rejected the erroneous information. Yet some receivers were affected by it.

When computer viruses and other malware appeared in the 1980s and 1990s, users did not discard their IBM PCs and Apple Macintoshes, reverting to typewriters and calculators or slide rules. Instead, virus detection, firewalls, and other defenses were introduced. Software assurance practices reduced the presence of exploitable bugs and other vulnerabilities. Users adopted smarter practices in dealing with emails and using the Internet, while more diligently maintaining their software and hardware to address newly found bugs and vulnerabilities. While threats have continued to evolve, so have defenses, allowing personal computers to become an integral part of today's society.

Modern GNSS receivers are actually computers with specialized inputs and interfaces. Yet in many cases they have been specified, developed, and tested as if they are mere radio receivers. Software assurance practices common in development and maintenance of other types of computers may not be rigorously employed in development of GNSS receivers. Techniques that protect computers from malicious or faulty inputs may be lacking in GNSS receivers, and handling of valid but rare conditions (such as GPS week rollovers or insertion of leap seconds) may not be adequately implemented or tested. Absent are algorithms that apply simple common sense to preclude many of the problems that are experienced, like those in the Black Sea and at ION GNSS+ 2017. Signals from multiple satnav systems are available, but not consistently used to crosscheck each other. Although low cost, low power, inertial sensors and precision clocks exist, they may not be used to crosscheck computations and provide fallback capability. Users may not be thorough or current in installing and maintaining hardware and software, and in practicing the same kind of "cyber hygiene" (such as updating passwords

> It's time for users to demand competent GNSS user equipment that is specified, developed, and tested to exhibit common sense, with receivers that respond appropriately to attacks, rare events, and even erroneous inputs

and blocking back doors) that they practice with routers and firewalls.

It's time for users to demand competent GNSS user equipment that is specified, developed, and tested to exhibit common sense, with receivers that respond appropriately (maintaining operation when possible, failing gracefully when necessary) to attacks, rare events, and even erroneous inputs. It's time for manufacturers of GNSS chips and receivers to adopt practices and implement capabilities that enable user equipment to operate appropriately in imperfect and threatened environments, rather than implicitly trusting all inputs as valid and correct. It's time to employ the standards and compliance requirements used for computers and computer software to GNSS receivers and their software.

Perhaps it's time for an organization to perform independent testing, evaluation, and rating of GNSS user equipment against various attacks and challenging conditions, just as the Insurance Institute for Highway Safety does for automobile crashworthiness in the United States.

Cybersecurity for personal computers is never perfect, and defenses need to evolve to defend against new attacks. Similarly, more competent and robust GNSS user equipment will never be perfect, and there will need to be secure ways to upgrade user equipment as improvements become available. There will be challenges in developing and sustaining competent GNSS user equipment, with new opportunities for organizations that can do this well. Even then, the result may not be perfect.

But perfect may be the enemy of good enough. Every technology we use has vulnerabilities that can be successfully attacked, given sufficient resources and skill. The objective is to raise the bar enough that successful attacks causing significant consequences are difficult to carry out, and would expose the attacker to enough risk that most attacks are dissuaded.

Let's work together so that competent GNSS user equipment is developed, employed, and maintained to address the challenges of today and tomorrow.

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>>> See backside

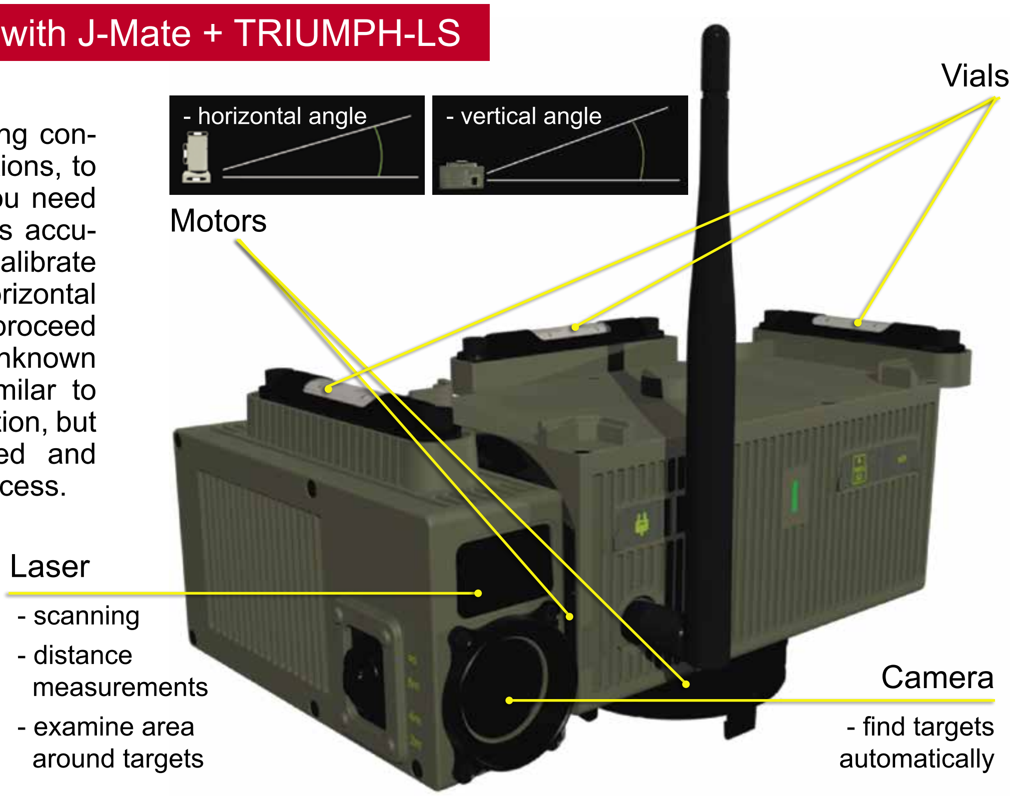
Why follow a workflow designed for yesterday's equipment?

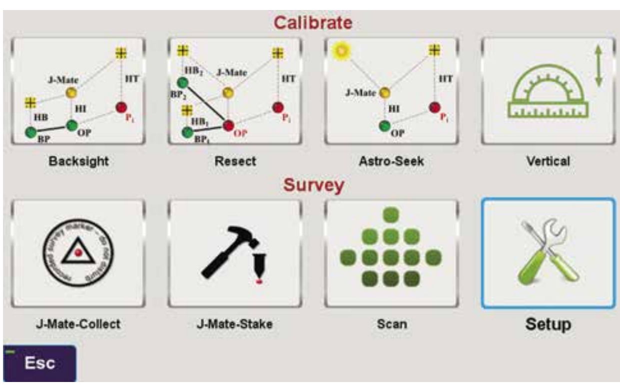
This is J-Mate

J-Mate features a **camera** that can also find targets automatically, and a **laser module** for accurate distance measurements. It scans and examines the area around the intended target to ensure reliable identification. Two **precision encoders** measure vertical and horizontal angles to the target. Three **precision vials** allow a visual check on levelness of the instrument.

Take control with J-Mate + TRIUMPH-LS

Similar to using conventional total stations, to use the J-Mate you need first to establish its accurate position and calibrate its vertical and horizontal encoders. Then proceed to shoot the unknown points. This is similar to using any total station, but we have improved and automated the process.





With J-Mate you can establish your occupied position via three different ways: 1) Backsight; 2) Resection; or 3) our new Astro-Seek (more of that later).

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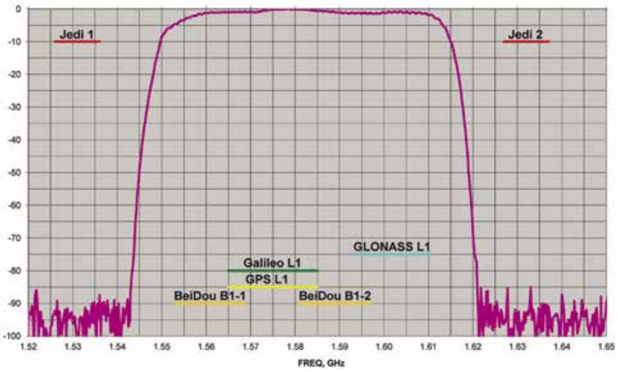
These are ways that we defend against jammers and spoofers and inform users of details.

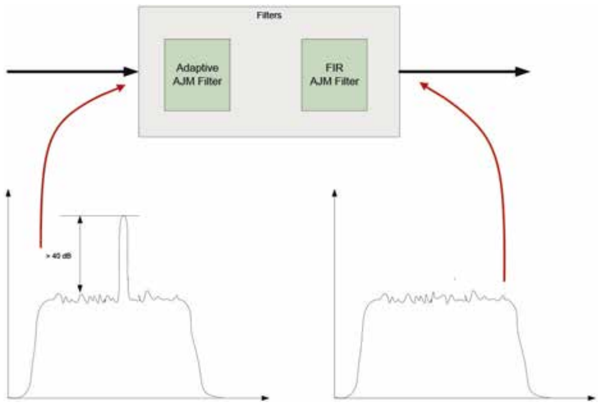
J-Shield Filter
and Near Band Interference

J-Shield is a robust filter in our antennas that blocks out-of-band interference. In particular signals that are near the GNSS bands like the LightSquared signals. The graph on the right shows the protection characteristics of our J-Shield filters. It has a sharp 10dB/KHz skirt which provides up to 100 dB of protection. It makes the precious near band spectrums available for other usages and protects GNSS bands now and in the future.



FIR (Digital Filter)
and In-Band Interference

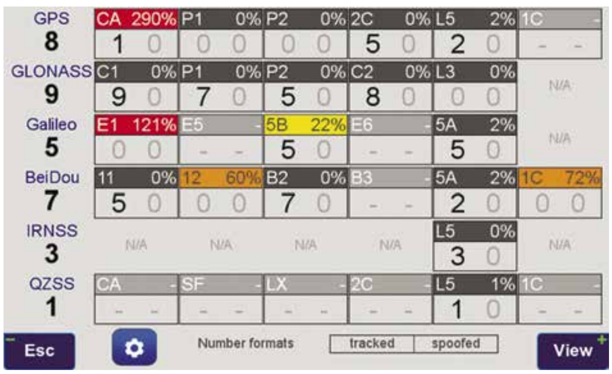
Our In-Band protection digital filter protects against in-band interference like harmonics of TV and radio stations when you get close to them, or against illegitimate in-band transmissions. Our in-band interference protection is based on the 16 adaptive 80th-order filters. AJM-filters can be combined in pairs for complex signal processing. This filter can simultaneously suppress several interference signals.



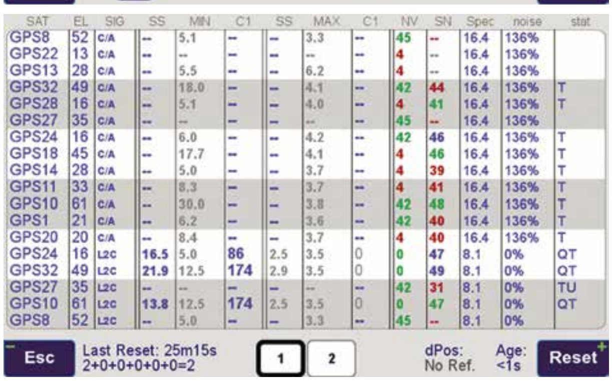
The 16 FIR AJM-filters can be combined in any number in chain. Each filter is a 255 order FIR-filter. It can be used to suppress the stationary interference signal in programmable (in compare with adaptive AJM-filter) area or for spectrum shaping. To have more suppressing areas or more aggressive suppressing one can combine FIR_AJM serial.

In-Band noise
Measurement

This figure-of-merit number shows the level of interference as percentage of noise above the normal condition. The first row of the first screenshot shows the condition in a clean environment. 8 GPS satellites were visible (according to the almanac). 8 C/A, 6 P1, 6 P2, 6 L2c and 2 L5 GPS signals were tracked. The noise level is 2% on C/A and L5, and 0% on P1,P2,and L2C. The screenshot below that, shows 290% noise in GPS C/A and %121 on Galileo E1. Only one of 8 GPS C/A code and none of 5 Galileo E1 signals were tracked.



This typical screenshot shows details of each signal. In the last column (T) indicates the signal was tracked by the main channels, (Q) by the Fast Acquisition Channels and (U) signal was used in position calculations. The SN color coded column shows the signal-to-noise ratio of tracked signals. Blue is perfect, green is 3 dB down, and red is 6 or more dB down. Percentage numbers show the percentage of interference above the normal level. We explain other columns later.



SAT	EL	SIG	SS	MIN	C1	SS	MAX	C1	NV	SN	Spec	noise	stat
GPS8	52	C/A	--	5.1	--	--	3.3	--	45	--	16.4	136%	
GPS22	13	C/A	--	--	--	--	--	--	4	--	16.4	136%	
GPS13	28	C/A	--	5.5	--	--	6.2	--	4	--	16.4	136%	
GPS32	49	C/A	--	18.0	--	--	4.1	--	42	44	16.4	136%	T
GPS28	16	C/A	--	5.1	--	--	4.0	--	4	41	16.4	136%	T
GPS27	35	C/A	--	--	--	--	--	--	45	--	16.4	136%	
GPS24	16	C/A	--	6.0	--	--	4.2	--	42	46	16.4	136%	T
GPS18	45	C/A	--	17.7	--	--	4.1	--	4	46	16.4	136%	T
GPS14	28	C/A	--	5.0	--	--	3.7	--	4	39	16.4	136%	T
GPS11	33	C/A	--	8.3	--	--	3.7	--	4	41	16.4	136%	T
GPS10	61	C/A	--	30.0	--	--	3.8	--	42	48	16.4	136%	T
GPS1	21	C/A	--	6.2	--	--	3.6	--	42	40	16.4	136%	T
GPS20	20	C/A	--	8.4	--	--	3.7	--	4	40	16.4	136%	T
GPS24	16	L2C	16.5	5.0	86	2.5	3.5	0	0	47	8.1	0%	QT
GPS32	49	L2C	21.9	12.5	174	2.9	3.5	0	0	49	8.1	0%	QT
GPS27	35	L2C	--	--	--	--	--	--	42	31	8.1	0%	TU
GPS10	61	L2C	13.8	12.5	174	2.5	3.5	0	0	47	8.1	0%	QT
GPS8	52	L2C	--	5.0	--	--	3.3	--	45	--	8.1	0%	

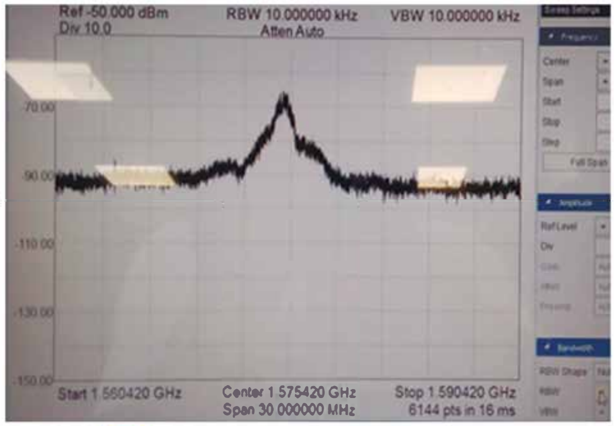
No jammer can escape our figure-of-merit test.

Spectrum Shape

We have a very powerful spectrum analyzer within our GNSS TRIUMPH chip. Each spectrum shows the power and the shape of the interfering signals and jammers. This is more powerful and more efficient than having a $30,000 commercial spectrum analyzer to evaluate the environment. The screenshot on the right shows the shape of the GPS L1 band spectrum when the band is not jammed. The GPS C/A code peak at the 2-MHz center of the L1 band is visible.

The height of the spectrum is 11.2 dB.

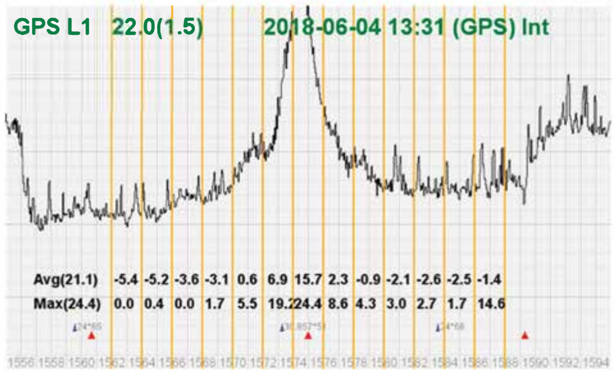
This is an example of GPS L1 spectrum with a commercial $30,000 spectrum analyzer.



Our integrated spectrum analyzer has the advantage that it monitors the spectrum inside the chip where it matters. It has effective bandwidth of 1 KHz.

Our embedded spectrum analyzer also has the advantage that it can be programmed to automatically record the spectrum (and other information) periodically or according to the set conditions, and monitor the environment continuously.

This is the spectrum example of a GPS L1 band when it is jammed. There is a huge peak in the center where the C/A code is. The number on the bottom left is the height of the peak.

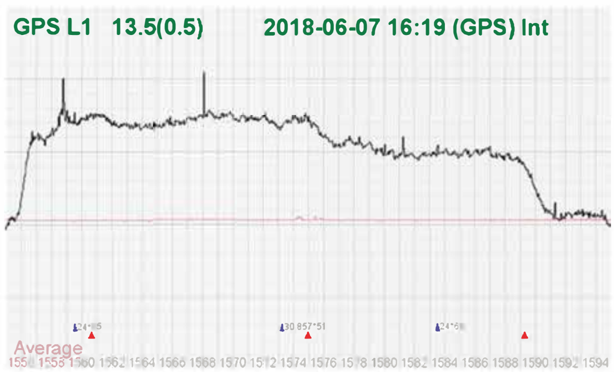


The height of the spectrum is 21.1 dB, which compared to the calm 11.2 dB, indicates about 10dB of jammer.

Although we label the bands as three GPS and 3 GLONASS bands, but they represent all bands of all GNSS signals, because bands are shared by all GNSS signals.

AGC
Automatic Gain Control

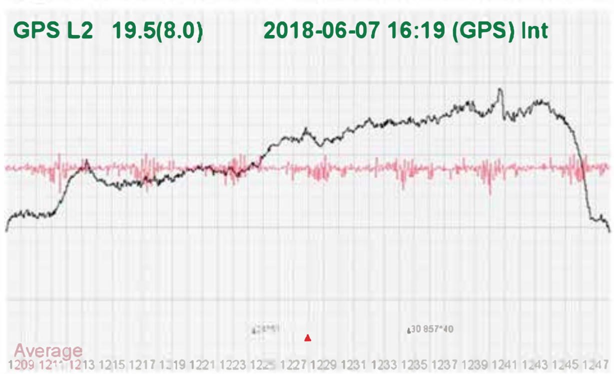
In addition to the spectrum, we also keep record of Automatic Gain Control which is another indicator of external signals.



The AGC monitors the environment and adjusts the gain to keep the voltage at a certain level. The change in AGC is an indicator of interference existence.

The narrow orange line in the middle of the band in this screenshot shows a quiet AGC.

AGC in this screenshot shows there are activities in this band which our AGC was able to defend against it.



We believe it could be harmonics of GSM cellular phone near our site.

Our AGC mitigates the effect of such interference completely.

Spoofers & 2 Peaks

Spoofers are quite different from jammers. They don't disturb the environment and the spectrum shape. They broadcast a GNSS-like signal to fool the GNSS receivers to calculate wrong positions.

In the top screenshot 10 GPS satellites were visible (according to the Almanac). 6 of the 9 GPS satellites that we tracked were spoofed, as indicated by the red number, while the noise level was 0% in the GPS C/A band.

In the second screenshot, 5 of the 6 GPS C/A signals were spoofed while the noise in the band was only 2%.

We detect spoofers by digital signal processing. With 864 channels and about 130,000 Quick Acquisition Channels in our TRIUMPH chip, we have resources to assign more than one channel to each satellite to find ALL signals that are transmitted with that GNSS PRN code.

If we detect more than one reasonable and consistent correlation peak for any PRN code, we know that we are being spoofed and can identify the spoofer signals. Figure on the right is an example of two peaks. We isolate and ignore the wrong peak.

The screenshot on the right shows details of each signal. The first six lines in this screenshot show the spoofed signals that we detected as soon as they appeared (numbers "1" in those line). The two section columns represents the characteristics of each peak. Second SS column show if the second peak is a consistent signal.

While six satellites were spoofed, there was no indication on the noise level (0%) and no indication on the spectrum shape and level as shown on the screenshot on the right below the chart.

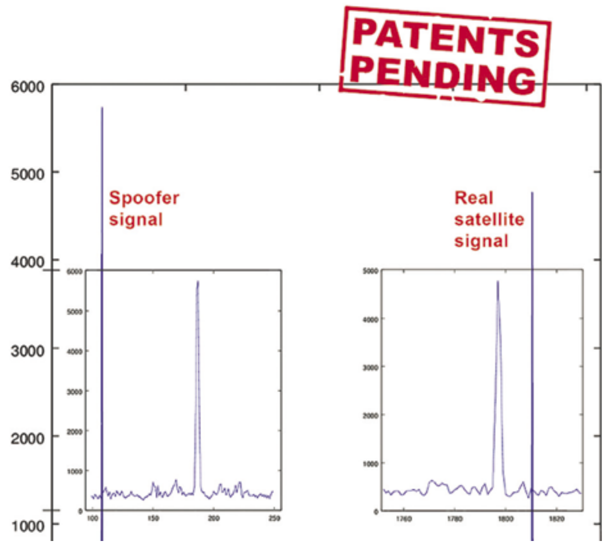
If the spoofer strategy is to cover the real satellite signal and then put the fake signal on top of it to produce only one peak, we notice that by more that 200% of noise level that it has to introduce.

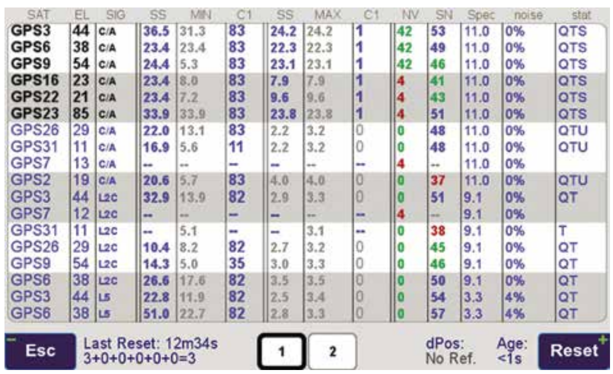
We reject infected signals and then among all the available GPS, GLONASS, Galileo, BeiDou, IRNSS and QZSS multiple signals we use the healthy ones.

Usually there are over 100 signals available at any given time, and we need only four good signals to compute position. In rare cases that all signals are affected, we inform the user and guide them to use compass and altimeter to get out of the Jammed area.

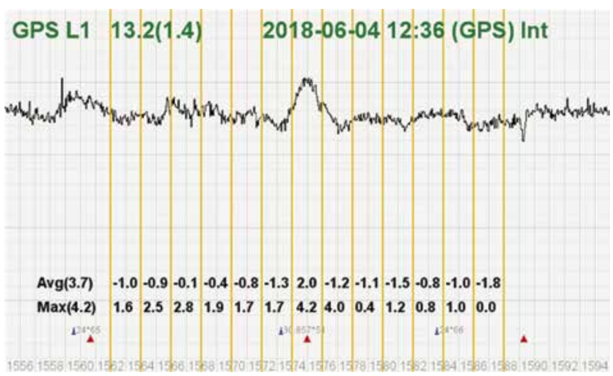
There is absolutely no way that we can be spoofed without our knowledge. We will immediately recognize and take corrective action.

Jamming and Spoofing protection option is available in all of our products and OEM Boards.





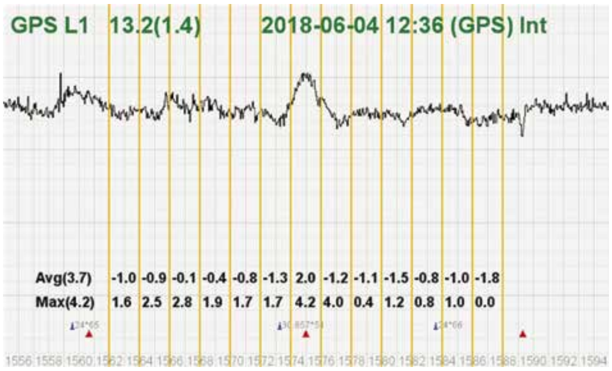
SAT	EL	SIG	SS	MIN	C1	SS	MAX	C1	NV	SN	Spec	noise	stat
GPS3	44	C/A	36.5	31.3	83	24.2	24.2	1	42	53	11.0	0%	QTS
GPS6	38	C/A	23.4	23.4	83	22.3	22.3	1	42	49	11.0	0%	QTS
GPS9	54	C/A	24.4	5.3	83	23.1	23.1	1	42	46	11.0	0%	QTS
GPS16	23	C/A	23.4	8.0	83	7.9	7.9	1	4	41	11.0	0%	QTS
GPS22	21	C/A	23.4	7.2	83	9.6	9.6	1	4	43	11.0	0%	QTS
GPS23	85	C/A	33.9	33.9	83	23.8	23.8	1	4	51	11.0	0%	QTS
GPS26	29	C/A	22.0	13.1	83	2.2	3.2	0	0	48	11.0	0%	QTU
GPS31	11	C/A	16.9	5.6	11	2.2	3.2	0	0	48	11.0	0%	QTU
GPS7	13	C/A	--	--	--	--	--	--	4	--	11.0	0%	
GPS2	19	C/A	20.6	5.7	83	4.0	4.0	0	0	37	11.0	0%	QTU
GPS3	44	L2C	32.9	13.9	82	2.9	3.3	0	0	51	9.1	0%	QT
GPS7	12	L2C	--	--	--	--	--	--	4	--	9.1	0%	
GPS31	11	L2C	--	5.1	--	--	3.1	--	0	38	9.1	0%	T
GPS26	29	L2C	10.4	8.2	82	2.7	3.2	0	0	45	9.1	0%	QT
GPS9	54	L2C	14.3	5.0	35	3.0	3.3	0	0	46	9.1	0%	QT
GPS6	38	L2C	26.6	17.6	82	3.5	3.5	0	0	50	9.1	0%	QT
GPS3	44	L5	22.8	11.9	82	2.5	3.4	0	0	54	3.3	4%	QT
GPS6	38	L5	51.0	22.7	82	2.8	3.3	0	0	57	3.3	4%	QT

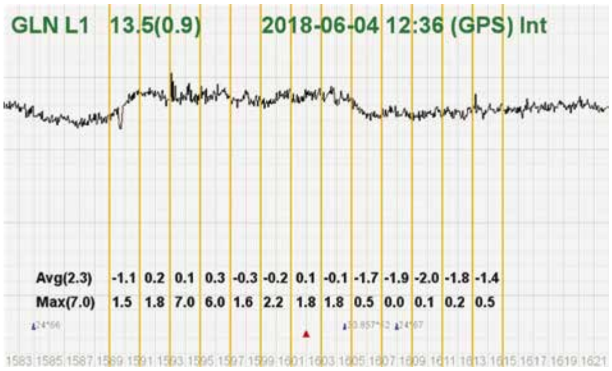


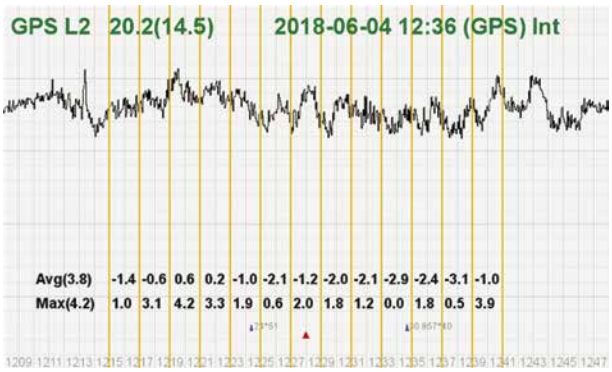
And Examples of when the world is peaceful.

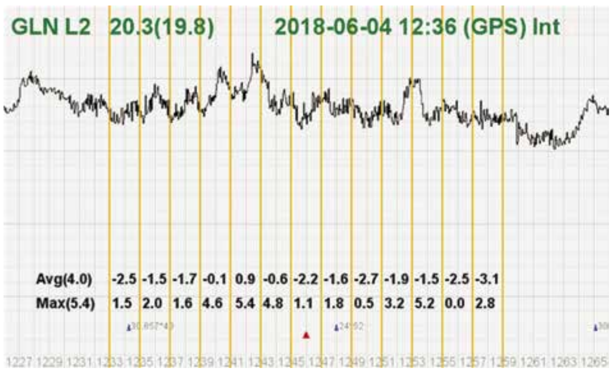
Jamming and Spoofing protection option is available in all of our products and OEM Boards.

All screenshots are from our TRIUMPH-LS Receiver.



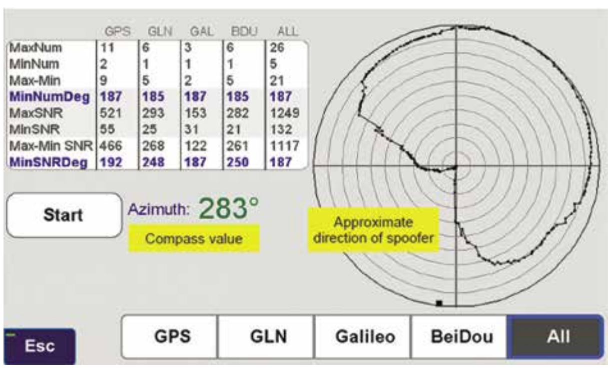






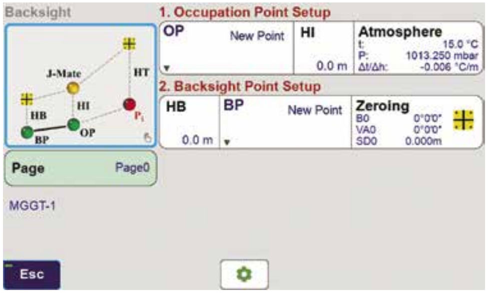
When you detect that spoofers exist, you can also try to find the direction that the spoofing signals are coming from. For this, hold your receiver antenna (e.g. TRIUMPH-LS) horizontally and rotate it slowly (one rotation about 30 seconds) as shown in the picture and find the direction that the satellite energies become minimum. This is the orientation that the spoofer is behind the null point of the antenna reception pattern.

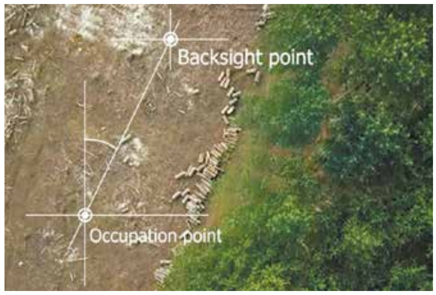
After one or more full rotations observe the resulting graph that shows approximate orientation of the spoofer as shown in figure below.



Backsight icon

If GNSS signals are available at the job site, click the J-Mate Backsight icon.

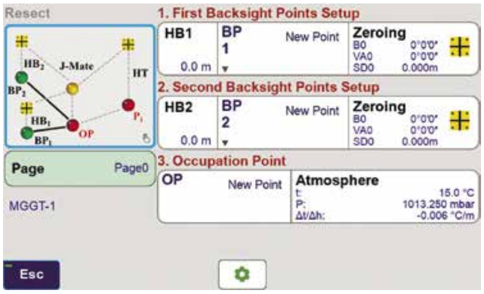


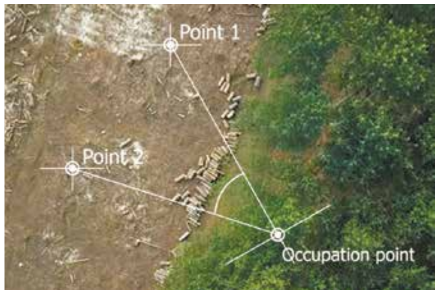


This screen appears which guides you to determine the accurate positions of the Occupation Point and the Backsight Point, to establish an azimuth and calibrate the J-Mate angular encoders.

Resect icon

If GNSS signals are not available at the Occupation Point, click the “J-Mate-Resect” icon

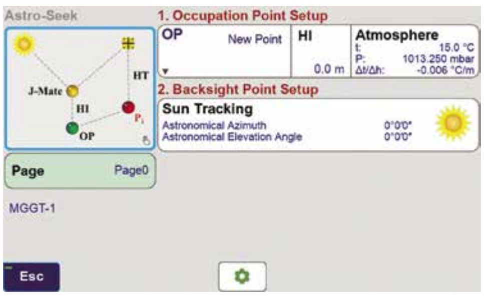




Shoot two or more known points to establish an accurate position and calibrate the encoders. Then continue to shoot the unknown points.

Astro-Seek icon

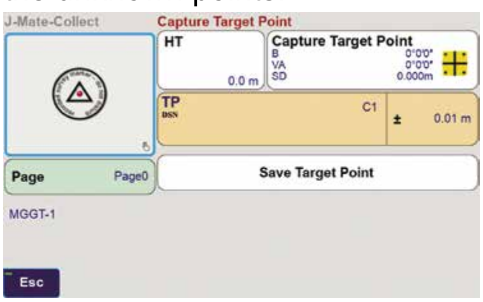
And now our new feature!



We have added a new innovative feature to the J-Mate that it can automatically calibrate itself via its automatic Sun or other astronomical objects-Seeking feature.

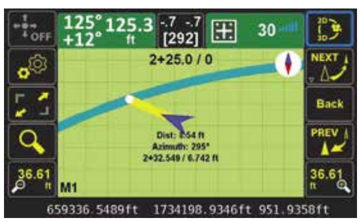
J-Mate-Collect

After calibration is performed, click the J-Mate-Collect icon to shoot the unknown points.



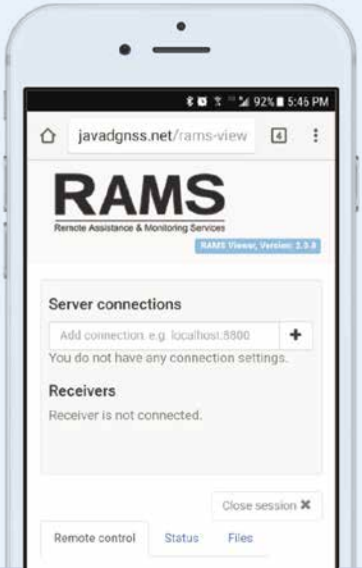
J-Mate-Stake

Click the J-Mate-Stake icon to use for stakeout.



The functions and features of the J-Mate stakeout are very similar to our conventional GNSS stakeout: RTK solutions guide you to the stake points. But with the J-Mate the camera follows the “+” sign that you carry and then the encoders and laser measurements (shown on screenshots) provide guidance to the stakeout features. This is similar to Visual Stakeout and other useful and innovative features of our TRIUMPH-LS GNSS RTK stakeout.

Remote Assistance & Monitoring Services (RAMS)



Every function of J-Field that is available to the operator of the Triumph-LS that's in the field, is available to the remote viewer!

Push and Pull Files Wirelessly

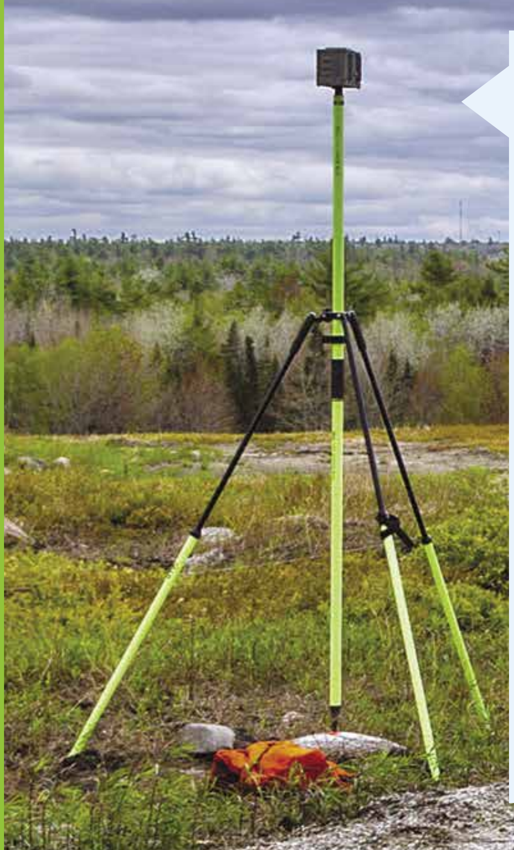
From the office to the field in case a file was forgotten.

Live support by the PLS

Support Team directly to Javad customers in the field, structural monitoring, training and other educational opportunities presented to large audiences in real time.

Rich is a surveyor in Massachusetts who is demoing a Triumph-LS with the MaCORS RTN network (no base).

Here are his comments:



Had our first real world experience today, and we are blown away! I should've taken pictures, and I'm sure you've heard it all before, but WOW! We were looking for a pin on an existing job that we'd already done most of the work for, and which was tied in to MaCORS. Plugged in the coords while in the field, and were directed by the LS to proceed west through a "wall of green" 50' high! 15' in to said wall of green was the pin in question. We were now completely canopied in, no big holes, mostly just green, very little sunlight getting in. Set the LS up over the pin and start the waiting game: a click here and a click there, when suddenly, rapid fire clicks and we're under a tenth from our first shot (Precise Topo mode), all in less than 20 minutes. We did this 3 more times on this mile long, 150 acre site, and it was amazing!

We're sold! We started this job today as a test, comparing the iG8 to the LS. The test lasted about 10 minutes, the amount of time it took the iG8 to get its first fix, when the LS was already fixed and collecting data for 5 minutes. No comparison at all.

Rich

Self driving and flying robots

While no localization technology claims to work in every possible environment, use of combination of multiple sensors is the path forward to a fully autonomous future

Akshay Bandiwdekar
Director of Product - area17, Experienced Product Professional - Indoor and Outdoor Precise Localization & Navigation

Picture this - In a not so distant future, you are a self-employed small business owner selling organic homemade lip balm through e-commerce sites like Amazon or Flipkart. You wake up in the morning to see that a customer across your city has placed a large order for a large shipment of your product. While having coffee, you pack a cardboard box with your product, walk outside to your backyard sipping coffee and keep the packaged box, ready to be shipped, on the lawn and open up your e-commerce portal account and click 'Ready for Collection'. This simple click starts a domino effect of a chain of events that will ensure your package safely reaches its destination and you get your payment. After placing your request for pickup, at an e-commerce facility not so far from your house, your delivery request is received and their Warehouse Order Management (WMS) system gets to work. An autonomous drone (flying cargo delivery robot) wakes up and flies to your backyard within ten minutes, skipping most of the early morning traffic and locates your address (and the pickup package) with pinpoint accuracy and gently lands on it. The drone then secures the package in its payload bay, lifts off and heads back to the e-commerce facility and gently drops of the package to an automatic conveyor belt that takes it to a dispatch bay. The package is picked up by an autonomously operating ground robot that scans the address label using a pair of stereoscopic cameras and drives to a nearby fully autonomous truck and places the package in the truck's cargo hold. Once the truck is fully loaded, it starts from the warehouse facility and self-navigates itself to another ecommerce facility across the city. The same process is reverse repeated and the package is delivered to the final destination. Sounds science fiction? It's a lot closer to reality than one would think. Let's understand some of the localization and navigation technologies that are making this possible today.

In order to understand how robots navigate and accomplish the above tasks without any human intervention, let's look at the technological advances through a magnifying glass and understand:

- How the drone is able to navigate and fly fully autonomously with pinpoint accuracy.
- How the small ground robot is able to navigate precisely indoors where no GPS is available.
- What advances are enabling the fully autonomous truck to drive itself through heavy traffic without incident.

Indoor Robots and Visual Inertial Navigation

In the example use case above, the indoor ground robots that are required to precisely localize and navigate through an indoor warehouse to deliver goods and packages

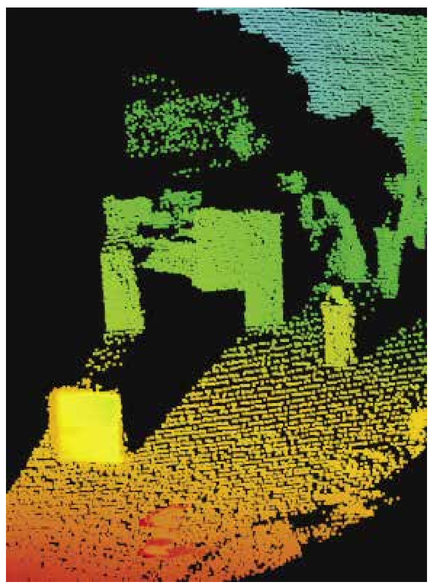


Image 1: A generic example of a 3D point cloud

cannot rely on GPS (GPS does not work indoors) and often use other forms of SLAM (Simultaneous Localization and Mapping) techniques for navigation such as WiFi, Bluetooth or RFID positioning. In most cases, they require some form of support infrastructure deployment such as Wifi Routers, Bluetooth Sensors or RFID tags to be deployed in warehouses. Often, these are cumbersome and can significantly drive up cost and deployment time. Advances in newer techniques that are using commercial off the shelf (COTS) sensors such as low cost cell phone components and cameras have enabled precise indoor localization & navigation, for robots and factory automation (forklifts, cranes, etc.) without the need for additional underlying support infrastructure. Using a low cost consumer grade pair of cameras, stereoscopic vision sensing and navigation is gaining traction because it not only eliminates the need for any such support infrastructure, but also provides the ability to be useful in other auxiliary vertical turn-key features such as inventory barcode scanning or accurate inventory mapping. Stereographic vision sensing involves placement of a pair of cameras to mimic the human eyes. By placing these at a certain distance to each other, they are able to provide an accurate 3D perception of objects and use to find specific points in 3D space.

How does Indoor Localization using Visual Inertial Navigation Work?

Visual Inertial Navigation typically blends two positioning techniques - *Visual Inertial Odometry* which uses Dead Reckoning to produce a POSE (Position & Orientation) estimate by using raw measurements from the inertial sensor and visual cues. A second *Map-matching* step that relies on known surveyed external landmarks to correct the predicted POSE to produce a better corrected estimate. The map-matching step typically makes use of a 3D point cloud that is generated using vision or LIDAR sensors. A generic example of a 3D point cloud is shown in image 1. As we humans see the world in color and depth, sensors allow robots to visualize the world and

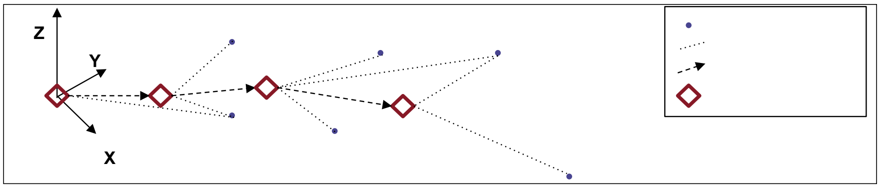


Fig 1(a): Visual schematic showing basics of Visual Inertial Odometry

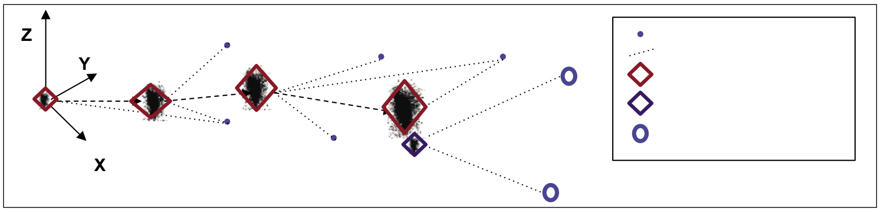


Fig 1(b): Visual schematic showing basics of Visual Inertial Odometry and Visual Inertial Navigation

objects in a similar 3D depth representation that gives them a sense of 'awareness'.

However one of the challenges of just using Visual-Inertial Odometry is that the POSE error estimate grows over time as the distance traveled from a known point (origin) increases. This is due to accumulation of residual errors in the measurements. As seen in the image below, the position error, as shown by a scatter plot, increases with distance from origin and when the system gets a known external landmark it does a POSE adjustment and 'snaps' or corrects itself to the accurate position by matching the known landmark to a pre-existing copy of it that it already has during a previous mapping run.

This can be demonstrated by a simple experiment that you can do yourself at home (Image 2).

Stand at precisely one arm distance from a known object such as a pillar with enough open space ahead of you. Touch the pillar such that your fingertips are just touching it.

With your eyes open and using approximately same paces, walk three steps to waypoint [2].

Now turn left 90 degrees and walk to waypoint [3]. Follow the track as shown from waypoints [3] through [7] to return back to your original position [1].

Once back at your original position, turn around 180 degrees and see how far you are from your original position - by extending your arm and measuring how far your fingertips are from the pillar as compared to when you first started walking.

You will notice that you would be roughly in the same position that you first started with a little bit of variation or difference. Now attempt to do the experiment again, this time with your **eyes closed** (use caution and have someone accompany you as a safety precaution). Once you finish retracing your entire path and have ended up in the starting position (and orientation), open your eyes. What is your observation this time?

If you were able to accurately get back to the precise position from where you started, try repeating the experiment by doubling or tripling each distance

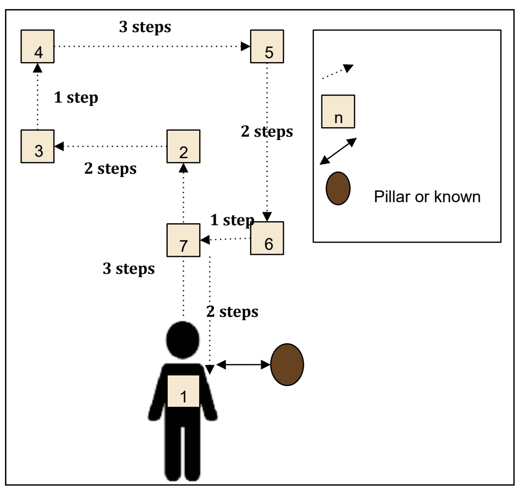


Image: 2

segments. You might notice that in the second experiment with your eyes closed, you should be within a reasonable distance of your starting point but not exactly at it and there will be some error in your position. This type of navigation is called **Dead Reckoning.** The reason for the error in your position is due to the fact that as you were tracing your path and measuring your steps or paces, there was a minor amount of error introduced in each step or direction (after you completed each straight line path). These minute errors accumulate over time and incrementally add up to cause a drift in your position.

Visual-Inertial Navigation is now possible using low cost stereographic cameras on robots that mimic the human eyes. These pair of cameras use visual cues and points in 3D space along with inertial measurements to create a POSE estimate that is pretty accurate. As we have seen how accumulated dead reckoning errors grow over time, navigation algorithms correct for the deviated position when a particular known external landmark (already stored in memory during a previous space mapping run) becomes visible. This new measurement is used by the navigation filter to correct (or reset) the POSE uncertainty thereby reducing the overall position error. One of the fundamental aspects about Visual-Inertial Navigation is that it relies on a **Local Coordinate Frame or Frame of Reference.** That is, in the above experiment example that you tried, your orientation was always measured with respect to your starting point (origin). This type of localization is great when you want objects or robots to localize and navigation in a particular custom frame of reference - example if a particular e-commerce facility designates a particular point inside the factory structure as the origin, then all the machines operating within that facility can use the same frame of reference to navigate.

Outdoor Robots and Global Navigation Satellite Systems (GPS/GNSS)

In our above example, an outdoor package delivery drone is tasked with flying to a customer's address. As the customer requests for pickup, the E-Commerce WMS places the order and converts the pickup address (House number, street name, city, state, etc.) into precise GPS coordinates (Latitude, Longitude and Altitude) that the drone will now fly to. Advances in GPS / GNSS (Global Navigation Satellite Systems) technologies have allowed for precise centimeter level position capabilities that unlock such applications. One of several challenges faced by GPS is the fact that regular GPS / GNSS receivers that are available in mass market applications such as cellphones and wearables do not use precise positioning techniques and are limited in position accuracies of a few feet (best case). Position accuracies degrade rapidly in challenging environments such as downtown urban canyons, and could easily be tens of meters. For the longest time, inherent errors in GPS did not allow for robust sub-meter positioning accuracies, however, with the advancements in techniques such as Real Time Kinematics (RTK) and Precise Point Positioning (PPP), GNSS receivers these days are able to easily output positions within a few centimeters.

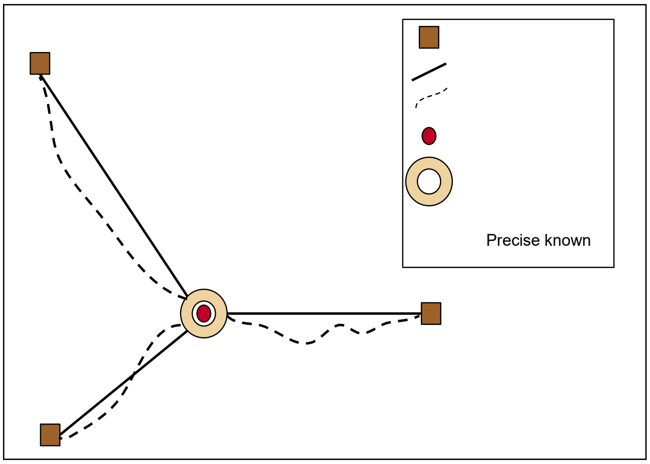


Image: 3

How does regular & precise GPS work?

Let's do another simple experiment that you can try at home to see how GPS and Precise GPS (RTK / PPP) work. Using 3 pieces of strings and tape, we will demonstrate how GPS should work in an ideal world free of any position error sources to give us perfect position. GPS works on the basic principle of Trilateration - knowing the exact location of 3 or more objects fixed in space, one can accurately determine the position of any other object that is placed within their collective sphere(s) of influence of the 3 static objects by determining the precise distance to those 3 objects and finding the point of intersection of the spherical arcs. This can be demonstrated by the simple string experiment as shown below where the pillars or fixed objects represent the GPS / GNSS satellites orbiting our planet.

Take 3 pieces of string and a tape (image 3).

Stand at a location in your house or office that is approximately equidistant from 3 fixed objects such as pillars.

Take the first string and tape it to the first pillar at the intersection of the pillar and floor such that there is no gap between the floor and the string.

Now walk up to your original position while keeping the string completely taut (no slack) touching the ground and tape it on the floor at your original location.

Repeat steps 3 & 4 for the remaining strings.

Knowing the precise distance X,Y & Z from the pillars, one can precise calculate the location of the observer in a common coordinate frame.

However, in real life, unfortunately due to a lot of error sources, the distances measured to each GNSS satellite are not accurately measured as they have a lot of error in them due to various sources of error such as atmospheric (Ionospheric & tropospheric), local (multipath), Relativity, Clock Error, etc. that lead to a diluted distance measurement. To understand how errors affect positioning, from our above experiment, let us now introduce a bit of slack in each string (say about 5 - 10 cm) such that the strings now have some wiggle room are are not taut (shown by dashed lines). Now, if you were to take the 3 ends of the strings and start drawing a spiral with increasing diameter such that it creates a circular area within which each string is taut at a particular orientation, this circular area is the positioning error that is introduced due to the various error sources.

This phenomenon explains why sometimes when you use a GPS based taxi or ride sharing app in a downtown city area with tall dense buildings, often your GPS shows you a location that might be different from your actual location and you have to then call and coordinate with the driver. In this case, typical[1] consumer[2] grade GPS / GNSS receivers do not use error correction techniques that can remove such errors to offer precise Decimeter or Centimeter level positioning accuracies. The basic principle of Precise GPS / GNSS (such as RTK or DGNSS) relies on the core assumption that if you already know the precise location of a particular GNSS receiver (such as one installed in a high quality Geodetic reference or weather monitoring ground station) that is situated within relative close proximity of the user's GPS / GNSS receiver, then the errors in both of these units will be roughly of similar magnitude. Using this assumption, one can reverse calculate the position errors being observed the Ground stations (whose precise Latitude, Longitude and Altitude is already known with historical data) and send them via corrections to the user's GPS receiver that can then apply these error corrections to improve the position accuracy. The same principle is also used in other differential techniques such as Network RTK or Precise Point Positioning (PPP). As commoditization of precise positioning GPS technology continues to occur, more and more low cost RTK and Differential GPS / GNSS receivers are entering the market and are starting to offer low cost high accuracy position solutions.

Fusion of various positioning technologies for varying application environments

Now we have looked at how Indoor and Outdoor positioning technologies are fundamentally different, let us explore how some applications require use of both of these and pose a particular systems engineering problem that is created due to the use of different coordinate frames in each respective technologies. From our above example use case of the drone or UAV that is situated in an e-commerce warehouse and flies to your backyard to collect a package, it first wakes up in an indoor environment where GPS signals are

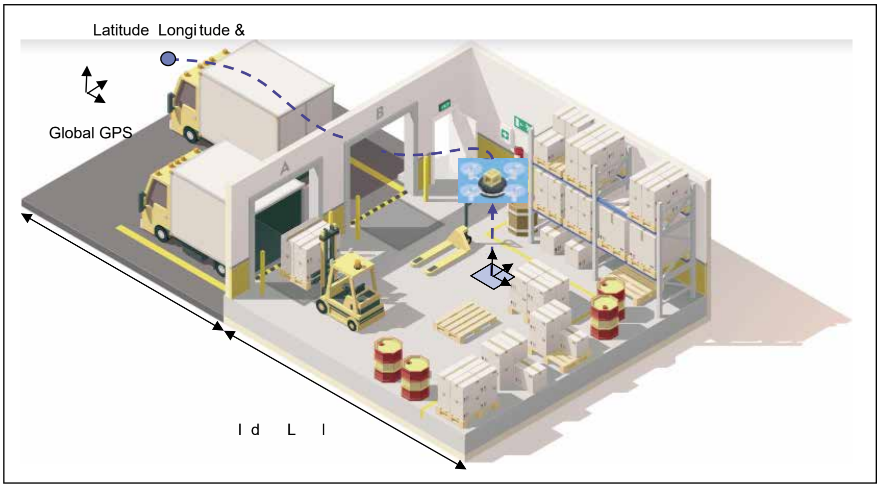


Image 4: Source: Akshay Bandiwdekar (purchased via Shutterstock)

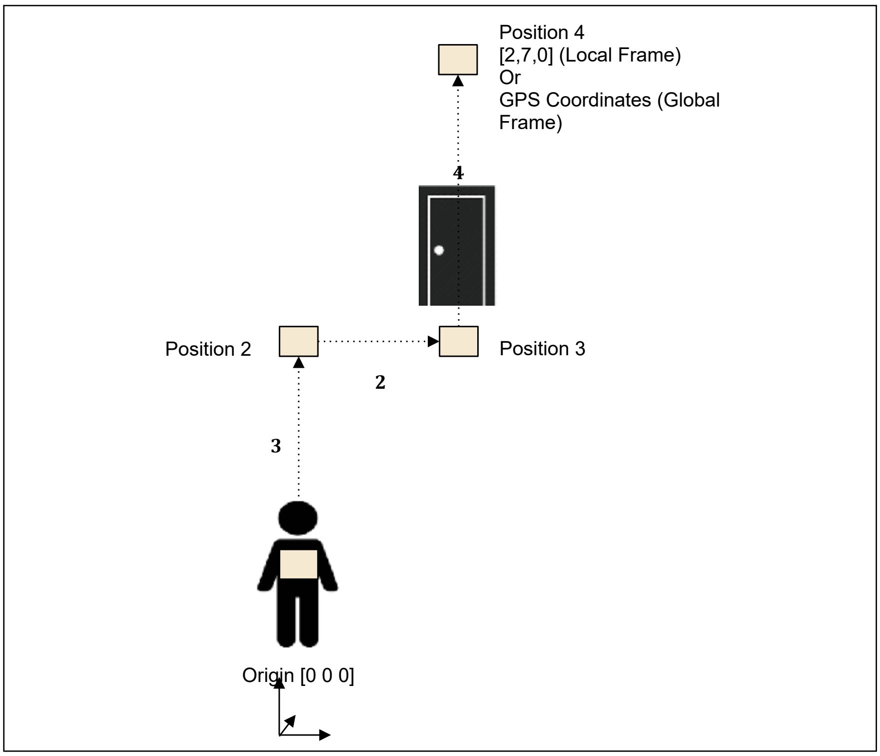


Image 5

[1] There are new receivers that are just entering the consumer market that will be much more accurate.

[2] GPS / GNSS receivers used in consumer applications such as smartphones, smart wearables or activity monitors.

> the indoor ground robots that are required to precisely localize and navigate through an indoor warehouse to deliver goods and packages cannot rely on GPS (GPS does not work indoors) and often use other forms of SLAM (Simultaneous Localization and Mapping) techniques for navigation such as WiFi, Bluetooth or RFID positioning

unavailable and all indoor flying is done via Visual-Inertial Odometry. Further as seen in the image 4, the drone navigation system quickly needs to transition to a GPS global coordinate frame as it now seeks to automatically find your address and when returning with the package it needs to transition to the local frame without incident.

This can be demonstrated in a simplified manner by the image 5, where let us assume that a person starts off indoors from their living room and transverses the path to point [4] via waypoints [1], [2] and [3]. As they start navigating from point [1] in a local coordinate frame, their position coordinates are relative to the starting point (local coordinate frame) - especially if they are using stereographic visual-inertial navigation and transition to a global coordinate frame once outdoors as they switch to their phone's GPS. While this problem might seem straightforward for most people, it actually presents a lot of challenging scenarios when one starts to think about complex environments where robots have to navigate, such as a fully autonomous self-driving car that is exiting a closed or underground parking garage or a delivery drone that is trying to enter and navigate an e-commerce facility loading dock full of people, trucks, forklifts and other equipment.

As more and more autonomous and robotic applications start emerging, the applications and manufacturers that solve the overall systems problem using multiple localization sensors (GPS, Inertial, Stereographic Visual, LIDAR, Ultrasonics, Radar, etc.) working seamlessly together using sophisticated and robust sensor fusion techniques will emerge as winners. While no localization technology claims to work in every possible environment, use of combination of multiple sensors is the path forward to a fully autonomous future.

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Geo-spatial information approach to planning for rurban clusters

It must be the development agenda at the state and national level utilize geo-spatial data to ensure the efficiency, effectiveness and equity that is currently missing from planning and implementation

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The 110 year old transition from 10.8% (in 1901) to 31.2% urban (in 2011) depicts India as an inarguably rural nation (Buch, 2015). Urban settlements in India are islands dispersed in a loosely knit ocean of rurality. We are no strangers to the problems that arise due to lack of integration in our pattern of development: spatially isolated, disempowered communities, inadequate contributions to the GNP (2/3 of the total population producing 1/3 of the total output), lack of availability and accessibility to infrastructure and information, and inefficient, hegemonic socio-economic institutions creating major roadblocks on our long arduous journey towards progress. Following independence, the Indian government launched a plethora of piecemeal approaches to rural development with an understanding of the rural being widely isolated and unintegrated with the urban. By the 1990s, these fragmented approaches were infrequently successful and the 73rd and 74th Constitutional Amendment Acts, exposed the dire need for an integrated comprehensive bottom-up planning methodology from the settlement to the regional scale.

Moreover, 90% of information required for a regional administration have a geo-spatial character as parcels of land, road networks, infrastructure facilities, land use/ cover, etc., which is currently missing from micro-level planning in India. This impacts not just the implementation and evaluation of projects directed at these levels, but its very formulation as a basis for equitable distribution of resources. In this context, the need for geo-spatial Information is further stressed upon since it is a necessity for spatial integration; it may be quite ineffective, if not completely inefficient to govern, administer, plan, or monitor the unique spatial spectrum that such an integration creates. It is therefore indicated here, that the dream of equitable and integrated bottom-up planning can translate into reality only when there is a tool for the identification and geo-spatial planning of the micro-regional unit. This unit in itself cannot be purely urban or rural in itself, but a complex, interlinked and interdependent socio-spatial hybrid of both. One such unit, the rurban is discussed in this paper.

A reconnaissance of the literature on rurban helped us realize that it is a relatively new concept whose definitions at different frameworks have been in flux. In order to make it more relevant with the contemporary Indian context, the definition of rurban upheld by the government schemes was given preference. According to the Shyama Prasad Mukherji National Rurban Mission (SPMNRM), the latest programme of the Ministry of Rural Development and Panchayati Raj (2016), a rurban cluster is basically a cluster of villages around a central town, which can be developed together to create various economic, social and physical linkages and bridge the rural urban divide between the two. Since, the arrival of the 'rurban' in the vocabulary of the Indian Government is quite recent, it can be expected that the methodology for its planning and development is in an embryonic stage; more so when it comes to integrated spatial planning which is as new and dynamic a concept, as the rurban itself. In this backdrop, a very specific hiatus in spatio-temporal and spatio-economic planning was identified: the need for a standardized geo-spatial planning methodology and a geo-spatial information support system that would support the various stages of this methodology. Together they constitute "A Model for Geo-Spatial Information Approach to Planning for Rurban Clusters".

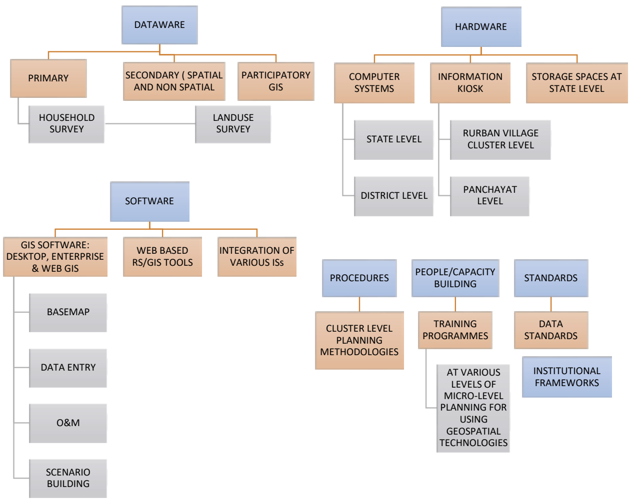

Figure 1 (clockwise, from top left) Dataware, Hardware, Software, Orgware for Geo-Spatial Rurban Cluster Planning

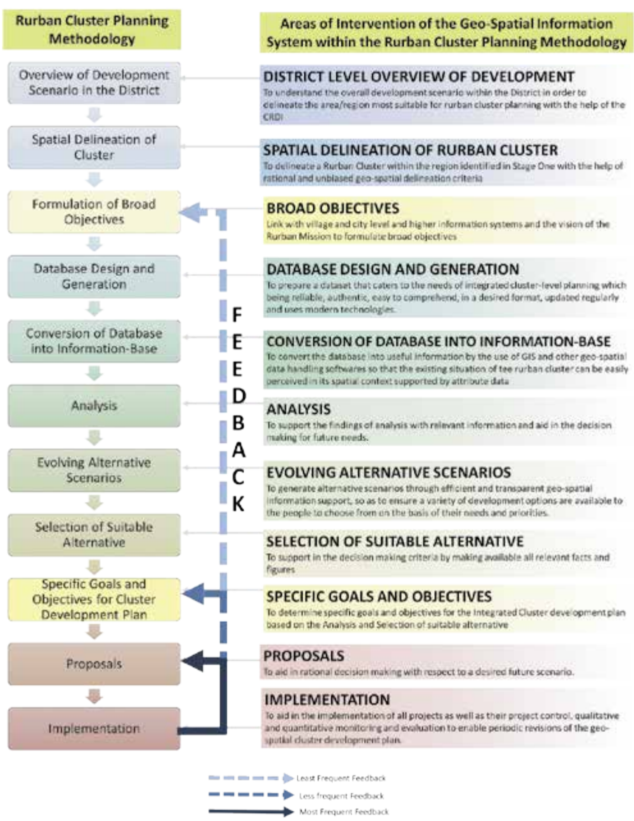

Figure 2 Standardized Methodology for Planning of Rurban Clusters

The theoretical roots of the rurban concept can be traced back Von Thunen's Centre Periphery Model and Christaller's Central Place Theory. The definition of rurban was in a state of flux from the 1940s up till the 1990s. Clarity on the subject was acquired as the definitions became more and more specific and started distinguishing itself as a phenomena different from suburbanization, peri-urbanization or the rural-urban fringe. Further, its on-ground applications through the "Controlled Area" of the Punjab New Periphery Control Act, 1966, the PURA Cluster in 2004 and finally the SPMNRM of 2016 helped further contextualize the definition of the 'rurban cluster'. Post literature review, it was concluded that the rurban would be defined as:

A spatially contiguous cluster of villages around a central town, each unique in their demographic and socio-economic identities, but intimately related to one another through rural-urban linkages which can be developed to bridge the rural urban divide and foster an integrated development for both.

The complexity of the rurban settlement can be only appreciated through the system's view of planning which visualizes a settlement or a region to be a complex system, composed of a number of sub-systems, each working simultaneously towards the same common objective. This conception required a multilayer approach to planning in order to understand the various sub-parts that constituted the complex whole, and therefore it had larger, more complex data and analysis needs. Growing out of Ian McHarg's layering technique (highlighted in his iconic Design with Nature) and the use of computers to handle multilayered analyses, the rudimentary definitions of information systems saw them as 'a chain of operations from observation, collection of data to storage and us of derived data for decision making'. Information systems with further specialization led to the birth of GIS in the early 1990s. At this time, the use of GIS was limited to cartographic observations only. Subsequent iterations to the definition of GIS saw it transform into a holistic system that was could handle every stem of the system's approach to planning. The following presents the most advanced stage of the evolution of the concept of a geo-spatial information system:

Geo-Spatial Information System is a combinations of dataware, hardware, software and networks of humans and organizations (orgware) that work together collect, process, store, retrieve, manipulate and disseminate information to support decision making, coordination, control, analysis, and visualization of geo-spatial data.

At present, the geo-spatial information systems for planning in the country are not only limited but largely unintegrated with one another. A look at some of the foremost geo-spatial information systems in the country, namely, DISNIC, NUIS, ENVIS, BHUVAN and GIS Based Master Planning for AMRUT Cities reveals that the number of available information systems were positively biased towards the urban. Those information systems which did not confine themselves to the urban had data on scales unfit for rurban cluster planning (e.g. ENVIS). DISNIC contained some relevant parameters for rurban cluster planning, whereas others contained discrete parameters which would be relevant if integrated with

DISNIC. Despite containing some of the parameters that were required for rurban cluster planning, there was no system for integrating them and bringing them under a common umbrella. This created a demand for a dedicated, integrated geo-spatial information system for rurban clusters and a conceptual outline for the dataware, hardware, software and orgware for the geo-spatial planning information system for rurban clusters was briefly chalked out. These components were later detailed out under each stage of the standardized planning methodology for rurban clusters and if a mapping is made, these components can clearly be traced to their relevant stages in the planning process (Figure 1).

The first step in developing an approach for rurban cluster planning was to look at the existing approaches for spatial entities which closely resembled the rurban. The constantly evolving and relatively recent nature of the rurban concept were important contributors to its absence of a tested standardized planning methodology. Parallel concepts (Mandal Model, Gujarat Model, Micro-regions by FAO, etc.) were explored, each of which enriched our understanding of what is required in the planning of rurban clusters. Mandal, in 1989, was one of the first Indians to research on rurban areas, which he defined as overgrown villages with a distinctive rural character that is reserved within them. Some of the important considerations that were borrowed from Mandal's work was the delineation criteria for rurban areas using a Rurban Index (10 parameters), Functional hierarchy of settlements on the basis of their nodal approach. This a rational, objective and systematic approach to planning laid the foundation of the geo-spatial approach to planning.

The Gujarat Summit of 2001 and 2012 which gave birth to the PURA and Gujarat Models for rural cluster development was used to define the objective of rurban development as the promotion of integrated development, better connectivity, employment and

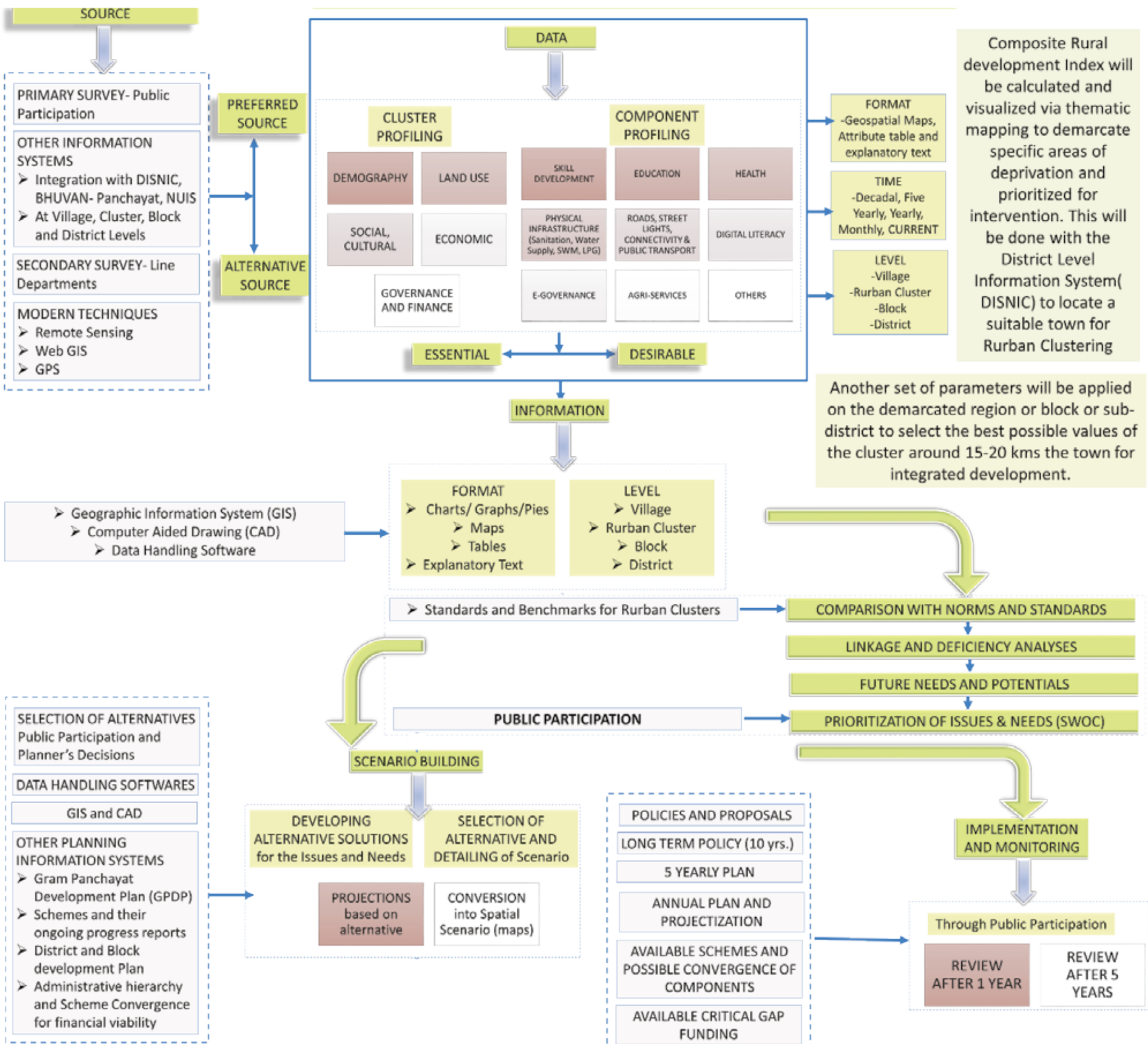

Figure 3 Conceptual Geo-Spatial Information System for Planning of Rurban Clusters

infrastructure. "Planning for Micro-Regions", FAO inculcated the values of bottom-up, participatory, action-oriented and sustainable in planning through a four phase (analysis-scenario writing-sectoral strategy building-project profiling) approach. Earlier works of the authors on rural and rurban development was used as the ground-work for the spatial criteria for rurban cluster delineation with the help of a Composite Rural Development Index. As a result of this, spatially identifying the area most suitable for rurban development in the district became possible. It also led to an understanding the prominent linkages between the town centre and the village cluster and providing a brief idea of their future spatial growth to assist further planning. Finally, borrowing from all neighboring concepts, literature study and a brief understanding of the legislative frameworks within which the rurban shall conform to, a 10 stage, standardized system's approach to planning of rurban clusters was laid down (Figure 2). These stages were reexamined, developed and detailed to expose the need for the intervention of a geo-spatial information system in every step of the planning process (Figure 3).

The unique and definitive aspect of the model is the intervention of a geo-spatial information in every stage of the standardized planning methodology. The model tries to improvise the existing nature of rurban cluster planning by adding new stages as well as exploring them through a geo-spatially oriented delineation, data-base generation, analysis, scenario building up to implementation, monitoring and evaluation.

- "Database Design and Generation" looks at six times the total number of areas that are addressed in the Integrated Cluster Action Plan (ICAP) Guidelines of the SPMNRM to provide a comprehensive basis for plan making. It divides the data into "Essential and Desirable" such that planning can commence without the unnecessary delay for non-critical data items. The data-base is designed keeping in mind the consequent conversion of data into information. This is facilitated by the specifying the type of profiling, source (most probable/alternate), criticality of data (essential/desirable), type of data (spatial, attribute, non-spatial, a-spatial) and type of derivative information
- Information base, which is derived from the database is categorized on the basis of its format for representation, level of information, time of updation. In total, it looks at 4 times more areas than the ICAP Guidelines do, while facilitating data standardization, multi-hierarchical planning based on critical thinking through spatial representation and securing its claim for efficiency and effectiveness.
- An intelligently designed information base enriches the analysis stage by provide multiple ways of analyzing the data to yield multi-faceted interpretations. This stage explores 4 times the type of analyses performed by the ICAPs.
- A democratic and participatory process of alternative scenario building and selection, post-analysis, helps both the administration and the beneficiaries understand the consequences of their choices through Participatory GIS.
- Proposals take into consideration an in-depth spatial analysis of the present needs, strengths, weaknesses, opportunities, challenges and resources. They are further divided into phases that help incrementally achieve a broad vision for the area.
- Spatially identifiable proposals foster an equitable, transparent and accountable distribution of resources. A geo-spatial MIS, instead of a non-spatial one, helps maintain a spatial and hence tangible record of all projects and their ongoing progress, helps lay the groundwork for the establishment of successful integrated spatial e-governance.

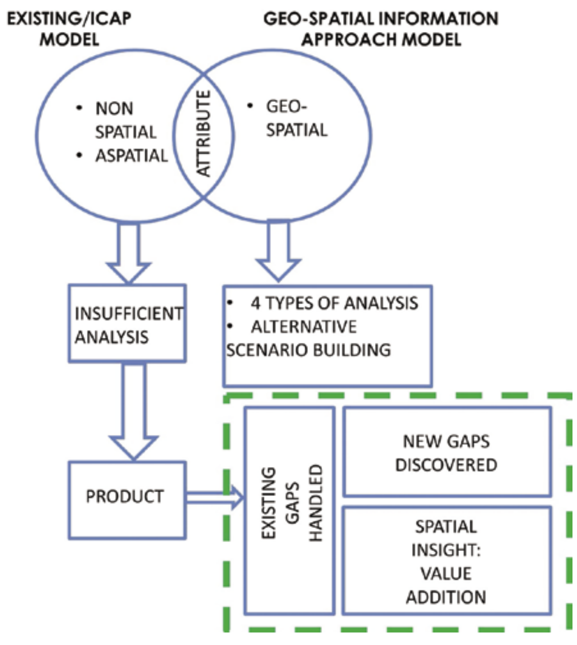

Figure 4 Conceptual Comparison between the Existing ICAP Model and the Proposed Geo-Spatial Information Approach Model (in terms of input→analysis→output)

In order to test the applicability of this model, it was applied on a tribal cluster in the Khunti District of Jharkhand. This led to an in-depth analysis of the on-ground functioning of the geo-spatial approach to rurban cluster planning and helped bring about certain essential modifications to smoothen out the process of its application. It also helped us understand the core function of the geo-spatial information approach vis-à-vis the old ICAP model for rurban cluster planning, which can be summarized accurately with the help of Figure 4. The Geospatial Information Systems Model with clearly defined and easily available inputs and analysis yields better and efficient results as compared to the traditional method. This was demonstrated through all the stages of the application of the model. The old/ ICAP model did not have stages such as formulation of goals and objectives, database design and generation, conversion of database into information base and alternative scenario building. These stages are crucial to sequential flow of the planning logic and were completely ignored in the old method inviting confusion and unrequited subjectivity in the planning of rurban clusters. Even the analysis phase is not clearly outlined and lacked the usage of alternative analysis techniques to prioritize results. The geo-spatial information approach model takes care of the issues highlighted while adding to the overall value of the planning process.

The Integrated Cluster Action Plan does talk about a spatial approach to planning for rurban clusters, but fails to achieve so by conceiving that spatial planning is only limited to the mapping of existing land use. The primary aim of the study was to recommend that the ICAP Guidelines need to be oriented more towards the spatial (rather geo-spatial) since it brings an unparelled amount of insight and value addition by addressing the gaps the existing method cannot. Since no planning activity can take place in the absence of data (especially geo-spatial data), the guidelines need to lay special emphasis on designing database and condensing it into an information base (focusing on essential, geo-spatial data). The delineation criteria for the rurban cluster needs to be based on data that is easily available and can be spatially represented (input parameters instead of output parameters). The criteria, weights, baseline and other desirable elements need to be explored in depth and detailed out geo-spatially in the ICAP Guidelines to prevent political bias in the delineation of the cluster.

The geo-spatial information support can be integrated with the existing framework of the District Level Information System since most of the parameters required for rurban planning is already collected (on a statistical and not spatial format) by the DISNIC. A link between the various platforms for geo-spatial information systems flowing from the district to the block, rurban cluster and its component rural and urban settlements and their neighbors has also been proposed (Figure 5). It is one of the goals of the geo-spatial information system model to standardize the planning of settlements in order to make them compatible for an integrated multi-hierarchical system of plans. Such Geo-spatial Information Systems should be available in Hindi and other local/regional languages for efficiency, effectiveness and better participation from the public in planning and implementation.

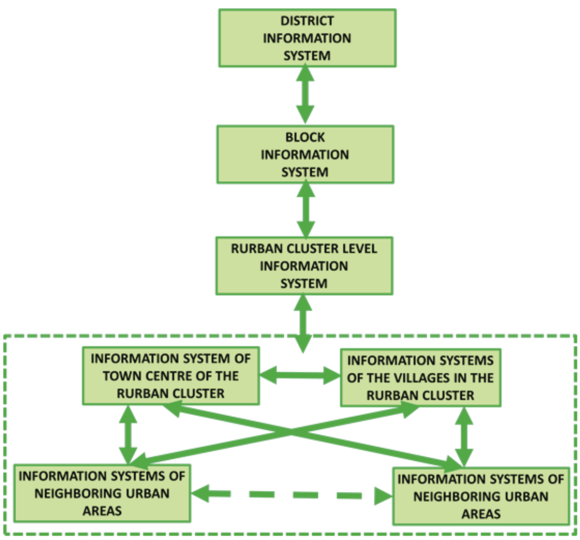

Figure 5 Linking of Cluster Level Information System with Others

The geo-spatial information approach to rurban cluster planning has certain pre-requisites for successful functioning. These include adhering to the database and information base design while ensuring it is adaptable to the evolving needs of the area, ensuring adequate stakeholder participation, multi-hierarchical framework for planning, technical knowledge and expertise and the sharing of resources skills and ideas.

Overall, the main characteristics of SPMNRM is that it cannot be implemented with the effort of an individual or an organization only. The existing institutional framework as per the 73rd and 74th CAA does not provide legitimacy to the rurban cluster and therefore the model is not backed by a statutory provision of rurban clusters. Therefore, without a few necessary changes in the institutional framework, the model may not be applicable. It is a task in coordination, enthusiasm, knowledge and the deliberate intention to make faster, better, cost-effective and transparent plans for the people, of the people and by the people. Therefore, it must be the development agenda at the state and national level to procure and utilize geo-spatial data to ensure the efficiency, effectiveness and equity that is currently missing from planning and implementation.

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Ocean' satellite Sentinel-6A beginning to take shape

The integration of Sentinel-6A, the first of two satellites to continue measuring sea levels from 2020, has reached a new milestone and its critical phase: the propulsion module has been "mated" with the main structure of the satellite at Airbus.

In a complex operation, the Airbus satellite specialists hoisted the approximately five-metre-high satellite platform with pin-point precision over the drive module, which had already been positioned. The two components were then fixed in place and assembled. Before this could happen, the propulsion module, which includes the engines, control devices and a 240-litre tank with an innovative fuel management system, had to undergo technical acceptance, since this subsystem can no longer be accessed once it has been integrated. The propulsion module now needs to be 'hooked up', which will then be followed by the system tests.

Two Sentinel-6 satellites for the European Copernicus Programme for environment and security, headed by the European Commission and ESA, are currently being developed under Airbus' industrial leadership, each weighing roughly 1.5 tonnes. From November 2020, Sentinel-6A will be the first to continue collecting satellite-based measurements of the oceans' surfaces, a task that began in 1992. Sentinel-6B is then expected to follow in 2025.

ESA's Aeolus wind sensing satellite successfully launched from Kourou

Aeolus, the European Space Agency's wind sensing satellite, built by Airbus, has been successfully launched from Kourou, French Guiana. The satellite will now undergo a series of tests in its operational orbit at 320km before beginning operations. Built by Airbus, Aeolus is the first satellite capable of performing global wind-component-profile observation on a daily basis in near real-time. The 1.4-tonne spacecraft features a LIDAR (Light Detection And Ranging) instrument called Aladin, which uses the Doppler effect to determine the wind speed at varying altitudes.

CASIS and Teledyne Brown Eng announce remote sensing challenge

The Center for the Advancement of Science in Space (CASIS) and Teledyne Brown Engineering (TBE) recently announced a sponsored program up to $4.5 million, offering researchers the ability to propose flight project concepts for the International Space Station (ISS) focused on remote sensing and Earth observation. Within this opportunity, up to $1 million will be available for researchers to support sensor development. Prospective awardees will utilize the Multi-User System for Earth Sensing (MUSES) platform, developed and managed by TBE. This funding opportunity will run through December 7, 2018. www.spacestationresearch.com

Phase One Industrial launches 150MP metric camera

Phase One Industrial has launched the iXM-RS metric camera series and new Aerial Systems. The flagship iXM-RS150F camera is full frame, 150 megapixels and available in RGB and Achromatic models. Its ultra-high resolution (14204 x10652) backside illuminated CMOS sensor, fast capture speed (2 fps) and enhanced light sensitivity enable increased productivity in a wide range of aerial image acquisition projects. https://industrial.phaseone.com

DLR-developed MACS camera measures changes to permafrost soil

The operating conditions might be unconventional, and the means of transport is certainly far from common, but a modular aerial camera system (MACS) developed by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) has been installed on board the POLAR 5 research aircraft of the Alfred Wegener Institute for Polar and Marine Research (AWI). Its purpose is to acquire images of the Inuvik region in Canada. The measurement campaign being conducted by the AWI seeks to investigate and acquire a better understanding of climate processes in the Arctic. The DLR engineers and scientists are making the most of this mission north of the Arctic Circle to test the MACS polar aerial camera that they have developed and built.

Changes to the permafrost soil are being measured to better understand the effects of global warming, as large amounts of the greenhouse gas methane are stored within it and are increasingly being released. *www.dlr.de*

Bathymetric lidar system improves near-shore, coastal mapping capabilities

Fugro is introducing a new bathymetric lidar system that delivers industry-leading depth penetration and point densities for near-shore and coastal mapping. Known as RAMMS (Rapid Airborne Multi-beam Mapping System), the field-proven technology promises to deliver an efficient and cost-effective solution, dramatically improving upon other bathymetric lidar mapping capabilities.

RAMMS was developed in partnership with Areté Associates. The system utilises push-broom laser technology and is based on 20 years of cutting-edge military technology for mine detection, developed via the U.S. Navy Small Business Innovated Research (SBIR) programme. It is also underpinned by over 25 years of bathymetric lidar experience for nautical charting.

ISRO keen to outsource PSLV, small satellite launch vehicle

ISRO and its commercial wing Antrix has said they are willing to outsource manufacturing of Polar Satellite Launch Vehicle (PSLV) and the Small Satellite Launch Vehicle (SSLV) so that the space agency could focus on the proposed human space programme.

The Indian Space Research Organisation held discussions recently with a consortium of industries regarding PSLV industrialisation with the objective of easing ISRO to focus on human space programme and researchand development activities.

India allows flying commercial drones day-time from Dec 1

India has finally permitted commercial flying of drones with effect from December 1, 2018, according to a press release from the Ministry of Civil Aviation on August 27.

The ministry announced Drone Regulations 1.0 on August 27 to enable safe, commercial usage of drones. The regulation is intended to enable visual line of sight daytime-only and a maximum of 400 feet operations. The regulations partition the air space into three categories – Red Zone (Flying not permitted), Yellow Zone (controlled airpsace), and Green Zone (automatic permission).

"Today we start an exciting new chapter in India's aviation history by allowing commercial use of drones. I am sure that many new and exciting applications will emerge that will propel India's economy forward. Our progressive regulations will encourage a vast Made in India drone industry," Minister of Civil Aviation, Shri Suresh Prabhu said.

Safety regulator Directorate General of Civil Aviation has put drones into 5 categories based on their weight, namely nano, micro, small, medium and large.

An operator permit will be required to fly the drones except for flying nano drone below 50 feet and micro drone for flying at less than 200 feet. Government agencies will not need permits to fly the drones.

There are two key restrictions that have been put in place for safe use of drones. The drones will be allowed to fly only along visual line-of-sight and only during day-time with a maximum altitude of 400 feet.

All RPAS except nano and those owned by NTRO, ARC and Central Intelligence Agencies are to be registered and issued with Unique Identification Number (UIN).

Unmanned Aircraft Operator Permit (UAOP) shall be required for RPA operators except for nano RPAS operating below 50 ft., micro RPAS operating below 200 ft., and those owned by NTRO, ARC and Central Intelligence Agencies.

The mandatory equipment required for operation of RPAS except nano category are (a) GNSS (GPS), (b) Return-To-Home (RTH), (c) Anti-collision light, (d) ID-Plate, (e) Flight controller with flight data logging capability, and (f) RF ID and SIM/ No-Permission No Take off (NPNT).

As of now, RPAS to operate within visual line of sight (VLoS), during day time only, and upto maximum400 ft. altitude.

For flying in controlled Airspace, filing of flight plan and obtaining Air Defence Clearance (ADC) /Flight Information Centre (FIC) number shall be necessary.

Minimum manufacturing standards and training requirements of Remote Pilots of small and above categories of RPAS have been specified in the regulation.

DroneDeploy releases Intelligent Cloud Photogrammetry

DroneDeploy has announced the release of Map Engine— the industry's first machine learning-driven photogrammetry software. The Map Engine generates high-resolution maps and 3D models from drone imagery collected in the construction, energy, agriculture, and surveying sectors. *www.dronedeploy.com*

Boeing completes autonomous synchronised flight tests in Australia

Boeing has successfully completed the first suite of synchronised UAV flight tests using new on-board autonomous command and control technology developed by Boeing in Australia.

Conducted at a regional Queensland airfield, the test flights saw five UAV test beds equipped with Boeing's new on-board system safely complete in-air programmed missions as a team without input from a human pilot. The milestone comes six months after establishing the company's largest international autonomous systems development program in Queensland. *www.boeing.com*

Tersus GNSS unveils UAV PPK solution

Tersus GNSS has announced the introduction of new solution for UAV, PPK (Post Processed Kinematic) applications. It includes a BX316R PPK Receiver, AX3705 Helix Antenna, and Tersus GeoPix Software. Combined with the forward and backward filter during post-processing, Tersus' new PPK solution can provide more reliable positioning and a higher fixing rate.

The BX316R PPK Receiver supports multiple constellations and dual frequencies. It has an in-built 4Gb of memory for GNSS observation data recoding. The compact, lightweight AX3705 Helix Antenna is specifically designed for UAV applications. The Tersus GeoPix software integrates GNSS observation functions,

Epson Launches the Epson Drone Soar App

Epson, provider of the Moverio® augmented reality (AR) smart eyewear platform, has announced the Epson Drone Soar app, the first full-featured AR app for DJI drone pilots using the Epson Moverio AR Smart glasses platform. *www.dji.com*

Topcon introduces new software for UAV inspection applications

Topcon Positioning Group has announced new software designed to facilitate data processing workflow for UAV infrastructure inspection — MAGNET Inspect. The software efficiently manages large UAV data sets to create inspection reports.

Nevada launches Drone Center of Excellence

The Nevada Institute for Autonomous Systems (NIAS) has announced the launch of the Nevada Drone Center of Excellence for Public Safety (NDCOE). The mission is to save lives and reduce air hazards from drone incursions by empowering a shared safety vision with the FAA's integration of drones into the commercial air traffic system.

Located in Las Vegas, Nevada, with facilities donated by Switch, the NDCOE will provide safety incursion research data, drone technology best practices, educational materials, and the new center will conduct public workshops that promote and protect the public's safety and privacy in an open and ethical manner. NDCOE staff will inspire audiences to join the NIAS public safety movement.

Pilot project to use drones for data collection in agricultural sector

Tunisia and the African Development Bank have signed an agreement for the launch of a pilot project to use drones for data collection to enhance management of agricultural projects in the country.

The project, to be implemented over the next ten months, would receive technical management and assistance from South Korea. The pilot project will focus on agricultural operations in Sidi Bouzid in central Tunisia, under the management of Busan Techno Park, a Korean government agency based in Busan, South Korea. Laadhari said the agency would provide equipment - drones and associated computer systems- training, as well as technology transfer. *www.afdb.org*

Drona Aviation to launch the ultimate aerial robotics kit for makers

With a growing interest of makers in aerial robotics, IIT Bombay based nano-drone startup, Drona Aviation, is set to empower drone innovations at the grass-roots level. Their latest product PlutoX, the most open and affordable aerial robotics kit for makers, is set to accelerate the development of drone ideas into reality.

Using Cygnus IDE, PlutoX brings never-seen-before agile development in a single nano-drone DIY kit, making it easier to modify its activity by simply flashing a pre-written code through the Pluto phone app. Additionally, it enables existing drone tinkerers to accelerate their aerial robotics journey by optimizing hardware modularity with 16 GPIOs, all supported on an original, proprietary designed board.

Product Suite accepted to the GSA Schedule

DroneShield Ltd has announced that its full product suite has been approved for placement on, and placed on, the GSA Schedule.

- Full DroneShield product suite approved by the U.S. government for placement on the GSA Schedule.
- The GSA Schedule is a list of products pre-approved for purchase by U.S. government agencies (and includes pre-negotiated prices and purchase terms of these products).
- DroneGun, DroneSentry and DroneSentinel, as well as DroneShield's other products now available to U.S. government agencies with the click of a button.

The GSA (General Services Administration) is an agency of the United States government that supplies products for U.S. government offices and operates the Federal Acquisition Service (the FAS). As part of this effort, it maintains the GSA Schedule, which other U.S. government agencies can use to buy goods and services. Procurement managers from various U.S. government agencies can seamlessly make purchases of the products that are on the GSA Schedule, knowing that the terms of such purchases have been preset between the vendor and the GSA. The process is further streamlined through GSA Advantage, an online government purchasing service run by the GSA in order to provide a streamlined and efficient purchasing portal for U.S. governmental agency procurement. The official description of GSA Advantage refers to it as "the Federal Government's premier online shopping superstore."

As part of the placement on the GSA Schedule and GSA Advantage for federal procurement, DroneShield's products have also been approved as qualifying for purchase through GSA Advantage by state and local governments. *www.droneshield.com*

Siemens and Bentley Partnership

Siemens PLM Software has announced with Bentley Systems, an integrated solution for enterprises to deliver capital projects more efficiently, combining the Teamcenter® portfolio with Bentley's ProjectWise and its Connected Data Environment (CDE). Teamcenter is the world's most widely used product lifecycle management (PLM) system, and ProjectWise is the project delivery collaboration platform for 43 of Engineering News Record's global Top 50 Design Firms. *www.siemens.com/plm.*

Introducing dscover maps

Dstillery, the leading applied data science company, has launched Dscover Maps (DMaps), a geospatial insights tool that provides a detailed view into market composition by geography or location. Using Dstillery's digital audiences and insights, DMaps brings digital targeting tactics to other forms of media, including out-of-home, TV, radio and direct mail.

Using a privacy-compliant combination of consumer behavioral data - including web, brand, location, mobile and contextual activities – DMaps brings a new level of scale and resolution to geospatial insights for brands. The tool's versatile and multi-faceted capabilities apply Dstillery's industry leading audiences and data science to a variety of use cases, including ad sales support, media delivery and marketing research. *www.dstillery.com*

Hyperion's blockchain-based distributed mapping system

Hyperion, an open blockchain-based mapping architecture, has ambitious plans to fundamentally transform how maps are made - and how the global market for maps and map technology operates. Its unique technology, which enables a completely decentralized, self-governing global map that users anywhere can contribute to, edit or utilize for their own needs, and share the economic value, promises a radical change in the process of how maps are made and managed. At present, there are more than 2 million apps in circulation -

but almost every single one is based on either Google Maps architecture or major Chinese map services including Gaode, Baidu and Tencent. *www.hyn.space*

Gravity and Microsoft forge strategic partnership to digitize supply chains

Gravity Supply Chain has announced a partnership with Microsoft enabling it to accelerate the delivery of its Software-as-a-Service (SaaS) solutions. Gravity provides organizations with real-time, end-to-end visibility of the supply chain. It will leverage Microsoft's Azure cloud platform to continue the deployment of market-leading, differentiated SaaS solutions for its customers. *www.gravitysupplychain.com*

Aecom to develop BIM strategy for baltic railway network project

Aecom has been selected to develop the detailed BIM strategy for the Rail Baltica project, one of the biggest transport projects in Europe, which will integrate the Baltic states into the current European railway network. The initiative will link Poland, Lithuania, Latvia and Estonia and indirectly Finland. Aecom will take advantage of the benefits of a digital approach for the design, construction and operation of the infrastructure. *www.bimplus.co.uk*

Arunachal to get geospatial tech for managing natural resources

Surveyor General of India, Lt General Girish Kumar has assured to assist and extend all possible technical expertise in the field of geospatial domain to improve the developmental planning, monitoring and management of natural resources in Arunachal Pradesh.

Lt General Kumar expressed his keen interest in collaborating in geospatial technology with the State Remote Sensing Application Centre (SRSAC) for village level survey using spatial data module structure developed for mobile mapping application, mapping of five major river basins, currently taken up for the Brahmaputra basin under National Hydrology Project funded under World Bank assistance.

He also expressed his willingness to provide technical expertise for DEM generation with vertical as well as horizontal accuracy for flood modelling geo database of 1.2 K scale, flood forecasting, observation of water reservoir in real time, creation of Geoidal Model of 10 cm and establishment of Continuously Operating Reference Stations network sites in Arunachal Pradesh for government agencies that collect GPS data to improve precision and accuracy of positions, which are useful for supporting three dimensional positioning, metrology, space weather and geographical applications. Citing example of Geospatial Smart Village recently developed by China, Lt General Kumar said that accurate village-level information is not available from ground level to improve infrastructure planning, utilities management, etc. Therefore, he emphasised on using geospatial techniques to help the State government identify villages lacking in basic infrastructure and ensuring their all-round development at micro level. https://nenow.in

French Supervisory Authority issues 2 GDPR warnings

Exactly one month after the GDPR started applying, the French Supervisory Authority ("CNIL") issued a formal warning to two companies in relation to their processing of localization data for targeted advertising. The CNIL found that the consent on which both companies relied did not comply with the General Data Protection Regulation ("GDPR").The CNIL also concluded that one of the companies was keeping geolocation data for longer than necessary. *www.insideprivacy.com*

Esri MoU with World Bank

Esri has entered into a memorandum of understanding (MOU) with the World Bank. Under the agreement, Esri software geoenables the World Bank's Survey Solutions software, allowing staff to improve accuracy and quicken the kinds of data collection, analysis, and decision-making that countries need to address the most urgent development challenges.

The World Bank's Survey Solutions is a computer-assisted personal interviewing (CAPI) software that helps build capacity for data collection and analysis in developing nations. Survey Solutions does this by offering national statistical agencies and other institutions involved in data collection a cost-effective and sustainable solution for conducting surveys. *go.esri.com/officialstatisticsprogram* .

B-Nest and Esri India collaborate to provide GIS Platform

B-Nest, a venture of Bhopal Smart City Development Corporation Limited announced a strategic partnership with Esri India. The partnership will provide a platform for startups incubated by B-Nest to leverage Esri ArcGIS technology . As a part of this initiative, Esri India would provide startups with free access to ArcGIS mapping platform, software development tools and APIs, ready-to-use content and technical mentorship. *https://m.dailyhunt.in*

Ultra-small GNSS active antenna module by Antenova

Antenova Ltd, is now shipping its latest module for tiny positioning devices – the RADIONOVA M20047-1. This is an active antenna module for GNSS applications in the 1559-1609 MHz satellite bands using GPS, GLONASS, GALILEO or BeiDou.

The M20047-1 antenna module comprises an SMD antenna with built-in active components: an LNA filter and SAW to boost antenna performance - so designers will not need to add these - all contained in a compact FR4 part with low power consumption, measuring just 7.0mm x 7.0mm x 0.9mm, and weighing less than 2g.

The on-board LNA and filter act to boost the signal to the GNSS processor in environments where there is a restricted view of the sky or where line-of-sight to the horizon is difficult. Antenova has also added an external matching feature to compensate for any de-tuning of the antenna caused by proximity to other components, such as a plastic case or a battery.

eSIM OTA test solution verification supports ERA-GLONASS

All new vehicles in the Euroasian Economic Union (EAEU) must be equipped with the ERA-GLONASS emergency calling system. Certification for these eCall systems is based on the Russian GOST R System specifications, where GOST 33470 covers the test methods for wireless communication modules of in-vehicle emergency call devices and systems. The newly added Chapter 9 will make SIM OTA testing mandatory from January 2019.

Anritsu and Comprion are now able to offer a test solution for the remote provisioning and management of the Embedded UICC (eUICC) in IVS (In Vehicle System) Devices which operates in accordance with GSMA SGP.02 v.3.1 and confirmation of its compliance to the corresponding standards (GOSTs) and regulations. eSIM allows the profile (a combination of a file structure, data and applications which allows access to a specific mobile network infrastructure) to be changed via an OTA environment. This is particularly attractive to the automotive market as it is physically hard to change a SIM card already deployed within the IVS of a vehicle. *www.anritsu.com*

Russia grants Kazakhstan access to military satellite signal

Kazakhstan now has access to a frequency of Russia's Glonass global navigation system used by the military to guide high-precision weaponry.The frequency has also been used by India since 2010 and Algeria since this year. *www.spacewar.com*

Another pair of Chinese navigation satellites successfully launched

A Chinese Long March 3B rocket launched two satellites to become the eighth and ninth spacecraft added to the country's Beidou navigation system so far this year. With this launch, China's Beidou program has added nine new satellites this year, including three previous Long March 3B flights with pairs of Beidou spacecraft going to Medium Earth Orbit, plus a Long March 3A launch earlier this month with a single payload heading for an inclined geosynchronous orbit. *https://spaceflightnow.com*

Pentagon restricts fitness and GPS trackers for deployed personnel

The Pentagon is banning the use of GPS on mobile devices in war zones and other sensitive locations, saying that fitness trackers and smartphone apps pose a "significant risk" to U.S. military personnel. The move bars deployed service members from using the devices in "operational areas" unless commanders have granted an exception.

The restrictions were issued some six months after the location and movements of U.S. troops were included in a usage map published by the Strava fitness tracking company. The global map reflected more than 1 billion paths that the Strava app tracked — but patterns and locations of U.S. service members could be gleaned from zooming in on sensitive or secured areas. Other services have similar usage maps, and the data they collect might be available to other app users or online.

"These geolocation capabilities can expose personal information, locations, routines, and numbers of DoD personnel," according to Deputy Defense Secretary Patrick M. Shanahan, "and potentially create unintended security consequences and increased risk to the joint force and mission."

The new Pentagon policy allows commanding officers to evaluate whether troops should be allowed to use geolocation technology if they deem it doesn't pose a threat — or if a mission requires the use of GPS apps. It also encouraged commanders of troops not in deployed areas to consider applying the ban. *www.npr.org*

First global GNSS-Reflectometry ocean wind data service

The first global GNSS-Reflectometry ocean wind data service has been launched by Surrey Satellite Technology Ltd (SSTL) together with partner the National Oceanography Centre (NOC), and with support from the European Space Agency. The data service is free and is hosted on the website www.merrbys.co.uk where users can access measurements of wind taken by a specially designed GNSS receiver hosted on SSTL's TechDemoSat-1 satellite, which collects GNSS signals, such as GPS, reflected off the surface of the ocean. TechDemoSat-1 is also collecting GNSS reflections off land and polar regions, opening the door for new applications of this technology, such as soil moisture and ice measurements. TechDemoSat-1 was launched in 2014 and carried 8 payloads from different UK organisations. *www.sstl.co.uk*

Glonass-K1 launch next year

Launch of a new satellite "GLONASS-K1" will be held next year. According to preliminary data, as previously reported, it will occur in March 2019, delaying the start for exactly three months. *https://ktelegram.com*

'Can't keep soldiers away from social media, smartphones', says army chief of India

Soldiers cannot be prevented from using smartphones and social media but there has to be discipline, Army Chief General Bipin Rawat said recently. He said he had been advised to keep soldiers away from smartphones, but that was not possible, so best to allow it.

"We have received advice that we should advise our soldiers to stay away from social media. Can you deny a soldier from the possession of a smartphone?" General Rawat questioned.

"If you can't prevent usage of smartphone, best to allow it, but important to have means of imposing discipline," he added.

General Rawat also said in modern day warfare, information warfare was important and artificial intelligence (AI) was being talked about. "If we have to leverage AI to our advantage we must engage through social media as a lot of what we wish to gain as part of AI will come via social media," said the army chief, according to ANI.

Hexagon partners with Clevest

Hexagon's Safety & Infrastructure division and Clevest have partnered to offer Clevest's workforce automation products alongside Hexagon's utility GIS and outage management systems for integrated office-to-field solutions. The partnership expands the network engineering and operations offerings for utilities and telecommunications companies and smart cities in North America. Clevest provides software that connects the mobile workforce to office operations, optimizing field activities or processes and improving outage response, restoration times, worker productivity and safety. *hexagon.com*

U.S. Navy to meet civil navigation standards on multiple aircraft

Rockwell Collins is helping multiple U.S. Navy and U.S. Marine Corps aircraft obtain safety-critical Required Navigation Performance Area Navigation (RNP-RNAV) capabilities through a contract issued by the Naval Air Systems Command (NAVAIR) Air Combat Electronics program office (PMA-209).

Under the agreement, Rockwell Collins will supply its Mission Flight Management Software (MFMS-1000) and Localizer Performance with Vertical Guidance (LPV) Calculator (LPVC-1000) applications, which will enable these aircraft to meet RNP-RNAV requirements and obtain global airspace access and perform GPS approach procedures. These procedures improve airspace utilization and reduce congestion, delays and fuel burn while improving safety by providing more precise aircraft navigation. *www.rockwellcollins.com*

Expanding the reach and capabilities of autonomous vessels

Iridium Communications Inc. have announced the signing of a Letter of Intent with smart shipping pioneer Rolls-Royce Marine (RRM), in support of their autonomous vessel development program. Through this arrangement, RRM and Iridium will work together to explore incorporating Iridium's next-generation L-band satellite broadband service, Iridium CertusSM, into the RRM suite of Ship Intelligence solutions. By doing so, RRM will have a resilient and reliable broadband capability that can serve as a standalone option or high throughput backup, while expanding the reach of autonomous vessels to all the world's waterways.

RRM's solutions deliver multifaceted enhancements to ships, enabling remote diagnostics, operations and performance monitoring capabilities. Among many offerings, these solutions provide remote access to onshore operators and control centers, delivering real-time connectivity and automation. By automating processes such as navigation, crew are able to focus on more valuable areas of vessel operations helping to streamline overall functionality, ushering in a new digital era of shipping. *www.IridiumNEXT.com* .

ROK eLoran Contract Award

The Korea Research Institute of Ships and Oceans Engineering (KRISO) has awarded UrsaNav, through its agent, Dong Kang M-Tech, a contract to supply an eLoran Transmitter Test Bed Systemin the Republic of Korea. This contract represents the first phase in a broader program to upgrade Korea's Loran-C stations to be the foundation of a sovereign Enhanced Loran (eLoran) Positioning, Navigation, and Timing (PNT) service.

The Republic of Korea recognizes the challenges associated with relying solely on space-based signals, the relative ease with which those signals can be jammed or spoofed, and the necessity to provide Trusted Time and Trusted Position to its citizens and critical national infrastructure. *www.ursanav.com*.

Hemisphere GNSS acquires Outback Guidance Business

Hemisphere GNSS, Inc. has announced the signing of a definitive agreement to purchase all of the assets of the Outback Guidance (Outback) business from AgJunction, Inc. along with a new technology licensing agreement. This acquisition aligns well with Hemisphere's continued push into the global agriculture market. In addition to the included IP licenses for business into the dealer channel, a second license was signed to allow agriculture steering solutions sales into OEM VAR (value-added reseller), and all other segments of the agriculture supply chain. *www.outbackguidance.com/*

Eos, LaserTech and Esri Introduce Laser Mapping Workflow

Eos Positioning Systems, Inc.® (Eos) has announced its release of the world's first laser offset solution within the Esri® Collector for ArcGIS® workflow.

When combined with Laser Technology, Inc.'s (LTI) laser rangefinders, the solution will allow field crews to capture centimeter-accurate 3D locations of hard-to-reach assets and in GNSS-impaired environments. The solution has been in the works for months, as demand has grown for hard-to-reach, high-accuracy mapping within the Collector workflow. *eos-gnss.com*.

GPS III Satellite shipped to Cape Canaveral for launch

On August 20, Lockheed Martin shipped the U.S. Air Force's first GPS III space vehicle (GPS III SV01)to Cape Canaveral for its expected launch in December. GPS III will be the most powerful and resilient GPS satellite ever put on orbit. Developed with an entirely new design, for U.S. and allied forces it will have three times greater accuracy and up to eight times improved anti-jamming capabilities over the previous GPS II satellite design block, which makes up today's GPS constellation. *www.lockheedmartin.com/gps*.

Geneq introduces Net20 Pro GNSS CORS reference receiver

Geneq Inc. has introduced the Net20 Pro, a robust system designed for Continuously Operating Reference Station networks. The Net20 Pro's efficiency and flexibility will provide high-quality data for users interested in the proximity and reliability of a reference station while eliminating real-time kinematic (RTK) corrections service charges. The Net20 Pro uses multifrequency, 555-channel technologies in a rugged casing to deliver accurate and effective positioning data even in a harsh environment. The receiver can be configured for correction data reception in client mode to calculate a fixed RTK position and to monitor the antenna position while continuing to work as a GNSS reference server.

Airgain offers 6-in-1 and 5-in-1 antennas with GNSS, LTE, Wi-Fi

Airgain Inc. has released its Multimax FV 6-in-1 and 5-in-1 antennas. The compact Multimax FV family is available in a range of configurations, supporting multi-constellation GNSS. The antennas also support up to dual MIMO LTE (including Band 14 for the FirstNet public safety network), 3×3 MIMO Wi-Fi or 2×2 MIMO Wi-Fi.

The new products include high-gain antennas that deliver a larger cellular footprint alongside high rejection GNSS technology with coverage for multiple satellite systems including GPS, GLONASS, Galileo and BeiDou.

NovAtel launches new TerraStar-C PRO Multi-Constellation correction service

NovAtel Inc. has launched its new TerraStar-C PRO correction service with multi-constellation support, including the GPS, GLONASS, Galileo and BeiDou constellations. Combined with NovAtel's OEM7 positioning technology, TerraStar-C PRO cuts initial convergence times by nearly 60 percent and offers 40 percent better horizontal accuracy than the current TerraStar-C service.

NovAtel's TerraStar-C PRO offers a robust multi-constellation solution that provides greater positioning accuracy, availability, and reliability than ever before, according to the company. With the growing number of operational GNSS satellites, TerraStar-C PRO offers considerable benefits in challenging signal conditions such as multipath, shading, interference, and scintillation. High rate TerraStar-C PRO corrections provide re-convergence in less than 60 seconds following brief GNSS signal interruptions.

Quectel Releases GSM/GPRS/GNSS/Wi-Fi Module

Quectel Wireless Solutions has announced the release of MC90, a quad-band GSM/GPRS/GNSS/Wi-Fi module. The new module supports hybrid positioning technologies including GNSS, Cell ID and Wi-Fi aided positioning, and enables position tracking in both indoor and outdoor environments.

Quectel MC90 integrates multi-GNSS systems, including GPS, GLONASS, Galileo and QZSS, which greatly improves the positioning accuracy and ensures that the module can track position even in areas with weak satellite signals, according to the company. This makes MC90 especially suitable for urban areas with high-rise buildings and complex environments.

TS-1701/02 GNSS / GPS Timing System

TS-1701/02 1U or 2U GNSS receiver system with configurable ports that can use GPS, Galileo, Beidou, and GLONASS allows user to select one or a combination of up to three of these sources. The system can also be used as a Stratum 1 NTP Server to provide accurate time to NTP clients or continuously and smoothly Synchronize time with any system in the network whether NTP or other protocols.

FreeFlight SBAS/GNSS receiver chosen for USAF helicopter fleet

A FreeFlight Systems SBAS/GNSS receiver has been selected to provide ADS-B position source information as a part of an upcoming ADS-B modification and compliance program for the United States Air Force HH-60G helicopter fleet. Strategic Enterprise Solutions Corp. (SESC) of Warner Robins, Georgia, was awarded the modification program, which includes installation of the 1203C SBAS/GNSS receiver and the AN/APX-119 Mode S Extended Squitter transponder with Mode 5 capability to provide a complete ADS-B Out solution for more than 100 helicopters.

CHC Navigation completes acquisition of AMW

Shanghai-based Shanghai Huace Satellite Navigation Technology Ltd. ("CHC Navigation") has announced it has acquired the business assets and personnel of AMW Machine Control Inc. The business will now be conducted by AMW Machine Control Solutions Inc. ("AMW Solutions"), a subsidiary of CHC Navigation.

AMW Solutions business has over 30 years of advanced machine guidance, machine control and GNSS knowhow. With innovative topo and machine control software solutions known as GRADE, DIRT, DITCH, PIPE, LANDFILL and ROAD, AMW Solutions offers the industry's most cost-effective solutions designed for equipment operators. AMW Solutions offerings will be based upon turnkey, wireless CHC Navigation Android industrial tablets and industry-leading CHC Navigation RTK GNSS receivers. AMW Solutions has also appointed Phil Gabriel as President. *www.chcnav.com*

High-end wideband I/Q data recorder from Rohde & Schwarz

The solution consists of an R&S FSW signal and spectrum analyzer, the new R&S IQW wideband I/Q data recorder and an R&S SMW200A vector signal generator from Rohde & Schwarz.

The R&S IQW records the signal spectrum of a wideband RF signal or the spectra of multiple narrowband signals in a frequency band, with a bandwidth up to 512 MHz. This makes it ideal for realistic component tests with radar signals, for deployments using a variety of RF test scenarios in the automotive sector, and for tests employing GNSS signals, for example.

To obtain signals as realistic as possible for simulations, the R&S IQW high-end I/Q data recorder samples signal spectra at a rate up to 640 Msample/s and a large bit depth – 16 bits each for I and Q data. Removable 6.4 Tbyte SSD memory packs are used for storage. *www.rohde-schwarz.com*

Galileo update

British government to fund study on Galileo alternative

The British government has announced on Aug. 29 that it will spend more than $100 million to study whether the country should develop its own satellite navigation system as an alternative to Europe's Galileo.

In a statement, the government announced it would use £92 million ($119 million) from a £3 billion "Brexit readiness fund" to perform an 18-month study on the feasibility of developing the alternative navigation system.

The study is prompted by ongoing negotiations between the United Kingdom and the European Union about the role the country will have in the Galileo system once the U.K. exits the E.U. next year.

British officials say they're concerned that, after Brexit, British companies may no longer be able to participate in the system's development while the British military could be locked out of Galileo's military-specific services without some kind of agreement.

"Our position on Galileo has been consistent and clear," said Greg Clark, the U.K. government's business secretary, in the statement. "We have repeatedly highlighted the specialist expertise we bring to the project and the risks in time delays and cost increases that the European Commission is taking by excluding U.K. industry. "

"The danger space poses as a new front for warfare is one of my personal priorities, and it is absolutely right that we waste no time in going it alone if we need an independent satellite system to combat those emerging threats," said Gavin Williamson, U.K. defense secretary, in the statement. He also noted the government was working on its first defense space strategy for release later this year.

The study, to be led by the U.K. Space Agency, will offer a "detailed technical assessment and schedule" for a British navigation satellite system. That system will offer both civilian and military signals, and be compatible with the U.S. Global Positioning System.

British government officials have hinted for months that the country could seek to develop its own satellite navigation system if it's unable to work out an agreement with the E.U. on continued participation in Galileo.

In the statement, Graham Turnock, head of the U.K. Space Agency, argued that the study will have benefits for the British space industry regardless of any future decision on an independent satellite navigation system.

"Even if the decision was taken not to create a U.K. independent satellite system and the U.K. remained a full member of Galileo post-Brexit, this work would support U.K. jobs and expertise in areas including spacecraft and antenna design, satellite control systems, cryptography and cyber security," he said. "It will also support the U.K.'s growing space sector." *https://spacenews.com/british-government-to-fund-study-on-galileo-alternative*

TRIMBLE NEWS

RTX Correction Technology Now Delivers Two Centimeter Accuracy

Trimble recently announced today its Trimble RTX™ GNSS corrections technology that can now achieve horizontal accuracies of better than two centimeters. Start-up times, commonly referred to as convergence, have also improved. Users can now achieve full accuracy in less than 15 minutes, and as fast as one minute in select areas where RTX Fast network infrastructure is available. This performance is achievable using Trimble's premier correction service, CenterPoint® RTX, delivering RTK-level accuracy outside traditional Virtual Reference Station (VRS) networks, considered the gold standard for high-accuracy corrections. Trimble RTX provides unprecedented performance from a satellite-delivered correction source. In addition, corrections are available via an Internet or cellular connection, making it one of the most versatile services available today.

Offering a suite of correction services, Trimble RTX provides users the flexibility to choose the level of accuracy to suit their application needs from meter to centimeter level. It is an ideal correction solution for a variety of applications including agriculture, survey, mapping, construction, automotive and any location-based service that could benefit from greater precision.

R10 GNSS System for Land Surveyors

Trimble has announced the launch of a new model of its premium GNSS receiver, the Trimble® R10 Model 2 GNSS System. Designed to help surveyors in a wide range of industries work more effectively and productively, it enables reliable, fast and accurate collection of survey data in the field.

The new enhancements include the latest and most advanced custom Trimble survey GNSS ASIC with an industry-leading 672 GNSS channels for unrivaled GNSS constellation tracking, including GPS, GLONASS, BeiDou, Galileo, QZSS, IRNSS as well as the full range of SBAS. The Trimble R10 Model 2 tracks and processes all of today's available GNSS signals and is designed to support planned GNSS signals and systems that may be launched in the future. *www.trimble.com*.

Ordnance Survey underpins UK driverless car testing

Ordnance Survey (OS) is one of 11 partners in OmniCAV, a £3.9m project to develop a world-first Artificial Intelligence-based simulation model for testing autonomous car safety. The simulation environment will feature a 32km circuit of Oxfordshire roads, covering rural, urban, main roads and intersections. The simulation will be used to create and run different scenarios for the safe testing of CAVs, and will support certification bodies, insurers and manufacturers.

OS will lead the capture, processing and serving of geospatial high-resolution mapping data. This will include 3D geometry and information about the roadside assets and their characteristics, so that data standards and requirements can be developed for the real-world deployment and operation of CAVs. *www.os.uk*

Mapping startup for autonomous vehicles, raises $20 million

Carmera, a New York-based mapping and data analytics startup, has now raised $20 million in a Series B funding round led by GV, formerly known as Google Ventures. Carmera previously raised $6.5 million.

Carmera has an interesting business model, and one that's likely attractive to investors looking for startups with a present-day revenue stream. The company describes itself as a street intelligence platform for autonomy. Its main product is the Carmera autonomous map, a high-definition map for autonomous vehicle customers like automakers, suppliers and robotaxis. *https://techcrunch.com*

Telenav and Sionic Mobile strategic alliance

Telenav®, Inc. and Sionic Mobile, have entered into a strategic alliance agreement to bring localized in-car digital commerce and offers to drivers. Telenav's LBS and mobile-advertising capabilities coupled with Sionic Mobile's in-vehicle payment and order-ahead technologies, allow automotive OEMs (Original Equipment Manufacturer) to bring a relevant, personalized commerce experience into the car to help drivers save time, money and effort on the road. *www.telenav.com.*

WaveSense launches the GPR Sensor for self-driving vehicles

WaveSense, Inc. has announced the commercialization of its patented military-proven ground-penetrating radar (GPR) that significantly improves navigation safety and precision on any road by keeping self-driving vehicles precisely in-lane. The company has several pilots underway with leading global players in the automotive and technology sectors and is currently closing a $3M seed round led by Rhapsody Venture Partners.

WaveSense's patented technology complements existing self-driving vehicle sensors - GPS/INS, radar, lidar, cameras - to keep vehicles precisely in-lane, especially in poor weather conditions including snow, rain and fog and where lane markings do not exist or are unclear and confusing. *www.wavesense.io*

HERE topples Google to become the world's leading location platform

HERE Technologies has surpassed Google to become the world's leading location platform, according to the latest ranking from Ovum.

Recently Ovum assessed 14 major location platform vendors, ranking them according to the mapping and technology they offer as well as the size of their reach across developer communities and industries. For the first time, HERE scored higher than Google in the overall ranking, boosted by advancements it has made in several areas.

Toyota and Uber Extend collaboration to automated vehicle technologies

Toyota Motor Corporation (TMC) and Uber Technologies, Inc. (Uber) thave announced that they have agreed to expand their collaboration with the aim of advancing and bringing to market autonomous ride-sharing as a mobility service at scale. To accomplish this, technology from each company will be integrated into purpose-built Toyota vehicles to be deployed on Uber's ride-sharing network. *www.toyota-global.com.*

TomTom Go Essential

TomTom has announced the launch of the TomTom GO Essential – a feature-packed, connected sat nav with hands-free calling, voice control, compatibility with Siri voice recognition software and Google Now™ service, fully interactive screen and a magnetic mount. Also included are Lifetime Europe Maps and Traffic updates, with a six-month trial of TomTom Speed Cameras, making it easy to stay up to date on new roads and helping the driver to avoid traffic and fines.

Robert Bosch Venture Capital invests in DeepMap

Robert Bosch Venture Capital GmbH (RBVC), the corporate venture capital company of the Bosch Group, has completed an investment in DeepMap Inc, a US start-up based in Palo Alto, California. DeepMap is a software company focused on solving the mapping and localization challenge for autonomous vehicles. "

DeepMap is taking a novel approach within the mapping industry and allows different companies to create custom HD maps, which contain different characteristics and data structures. *www.bosch-presse.de*

Trooper™ II – Slender LTE/Wi-Fi/Multi-GNSS Antenna

PCTEL, Inc. has announced at APCO 2018 the next generation of its Trooper™ antenna, the company's flagship multi-band platform for public safety fleets. It provides optimal wireless communications performance through the antenna's 4-port 4G LTE connections and 4x4 802.11ac Wi-Fi MIMO capability. It also incorporates PCTEL's newest high rejection multi-GNSS technology for high precision tracking and asset management. *www.pctel.com/*

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October 2018

Joint Geo Delft Conference
The 6th International FIG 3D Cadastre Workshop
The 3D GeoInfo Conference
1- 5 October
Delft, the Netherlands
www.tudelft.nl/geodelft2018

HxGN LOCAL CONVERGE
5 October 2018
Hyderabad, India
https://hxgnlocal.com

39th Asian Conference on Remote Sensing (ACRS 2018)
15 - 19 October
Kuala Lumpur, Malaysia
http://acrs2018.mrsa.gov

Intergeo 2018
17 - 18 October
Frankfurt, Germany
www.intergeo.de

November 2018

Trimble Dimensions 2018
5 - 7 November
Las Vegas, USA
www.trimbledimensions.com

CHINTERGEO2018
7 - 9 November
Chengdu, Sichuan Province
PR China
www.chintergeo.com

International Navigation Conference 2018
12 - 15 November
Bristol, UK
www.rin.org.uk

ITSNT 2018
13 - 16 November
Toulouse, France
www.itsnt.fr

Commercial UAV Show
14 - 15 November 2018
London, UK
www.terrapinn.com/exhibition/the-commercial-uav-show/

United Nations World Geospatial Information Congress
19 - 21 November
Deqing, China
www.unwgic2018.org

International Symposium on GNSS (ISGNSS 2018)
21 - 23 November
Bali, Indonesia
www.isgnss2018.com

The Pacific GIS and Remote Sensing User Conference
26 - 30 November 2018
SUVA, Fiji
www.picgisrs.org

The 16th IAIN World Congress 2018
28 November – 1 December
Chiba, Japan
https://iain2018.org

BeiDou Satellite Navigation Application Expo & Smart City Expo
30 November - 02 December
Nanjing, PR China
www.tleer.cn/enbdsexpo

January 2019

International LiDAR Mapping Forum (ILMF)
28 - 30 January
Denver, United States
www.lidarmap.org

March 2019

Munich Satellite Navigation Summit
25 - 27 March
Munich, Germany
www.munich-satellite-navigation-summit.org

Land and Poverty Conference 2019
25 - 29 March
Washington, DC, USA
www.worldbank.org

April 2019

European Navigation Conference 2019
9 - 12 April
Warsaw, Poland
http://enc2019.eu

FIG Working Week 2019
22 - 26 April
Hanoi, Vietnam
www.fig.net/fig2019

AUVSI Xponential 2019
29 April - 2 May
Chicago, United States
www.auvsi.org/events/xponential/auvsi-xponential-2019

June 2019

HxGN LIVE 2019
11 - 14 June
Las Vegas, USA
https://hxgnlive.com/2019

TransNav 2019
12 - 14 June
Gdynia, Poland
http://transnav.am.gdynia.pl

July 2019

Esri User Conference
8 - 12 July
San Diego, California
www.esri.com

August 2019

The South-East Asia Survey Congress(SEASC) 2019
15 - 19 August
Darwin, Australia
https://sssi.org.au


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Precise Aerial Imaging System
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W-1500N & W-2800
Windows CE Total Stations
Truly integrated systems
G6 Ti | Ni
GNSS Receivers
Precision Satellite Surveying with wireless communications
S-3180V
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LabSat3 WIDEBAND

The most powerful LabSat yet, the new LabSat 3 WIDEBAND captures and replays more GNSS signals at a much higher resolution than before.

Small, battery powered and with a removable solid state disk, **LabSat 3 WIDEBAND** allows you to quickly gather detailed, real world satellite data and replay these signals on your bench.

With three channels, a bandwidth of up to 56MHz and 6 bit sampling, **LabSat 3 WIDEBAND** can handle almost any combination of constellation and signal that exists today, with plenty of spare capacity for future planned signals.

LabSat 3 WIDEBAND can record and replay the following signals:

- GPS: L1 / L2 / L5
- GLONASS: L1 / L2 / L3
- BeiDou: B1 / B2 / B3
- QZSS: L1 / L2 / L5
- Galileo: E1 / E1a / E5a / E5b / E6
- SBAS: WAAS, EGNOS , GAGAN, MSAS, SDCM
- IRNSS

www.labsat.co.uk