RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th/20th of every month at NDPSO

No: DL(E)-01/5079/20-22
Licensed to post without pre-payment U(E) 28/2020-22
Rs.150

www.mycoordinates.org

# Coordinates

ISSN 0973-2136

Volume XVI, Issue 1, January 2020

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

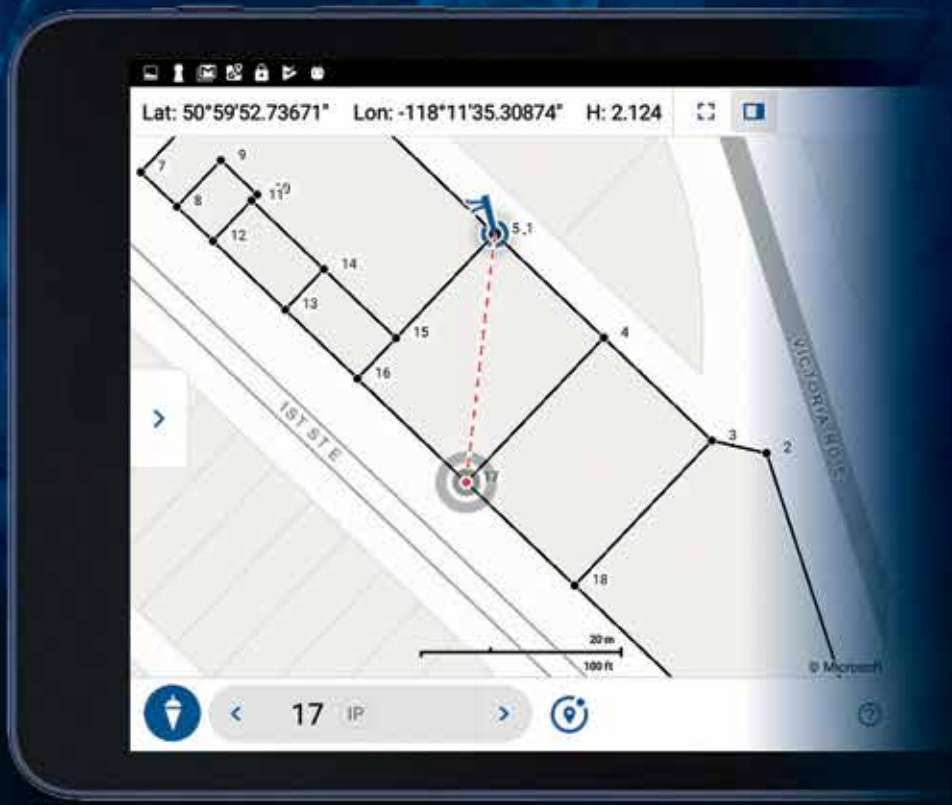
## GNSS Technology Trends

**Global experiences with PPPs for land registry services**

# DECADES OF INNOVATION
## NOW FOR ANDROID™

**MicroSurvey brings decades of innovation and expertise in survey field software creation to our next generation multi-platform FieldGenius application**

Be among the first to join our MicroSurvey Technology Innovation Group and help mold our FieldGenius for Android™ software. Learn about all the advantages at microsurvey.com/FGA



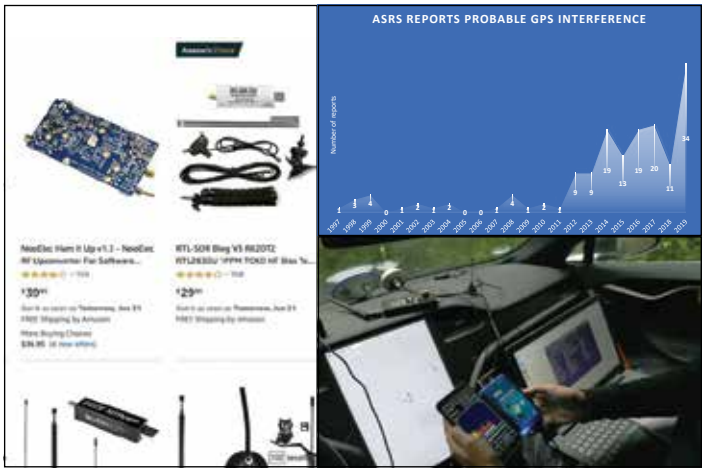

EARLY ADOPTER
MICROSURVEY SOFTWARE



PART OF HEXAGON

**Learn More**
microsurvey.com/FGA

MicroSurvey FIELDGenius For Android™




# In this issue

Coordinates Volume 16, Issue 1, January 2020

## Articles



## Columns



**This issue has been made possible by the support and good wishes of the following individuals and companies**
Graeme Hooper, Guy Buesnel, Jennifer Edis, Keith Clifford Bell, and Yoav Zangvil; CHC, GPSat Systems, Javad, Labsat, MicroSurvey, Vexcel, SBG System, and many others

**Mailing Address**
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
**Phones** +91 11 42153861, 98102 33422, 98107 24567

**Email**
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
[subscriptions] iwant@mycoordinates.org
**Web** www.mycoordinates.org



**Annual subscription** (12 issues)
[India] Rs.1,800 [Overseas] US$100

**Printed and published** by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
**Published** at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.
**Printed** at Thomson Press (India) Ltd, Mathura Road, Faridabad, India

**Editor** Bal Krishna
**Owner** Coordinates Media Pvt Ltd (CMPL)

**This issue of Coordinates is of 48 pages, including cover.**

# The sky is red

As the summer sets in Australia,

The country especially New South Wales,

Is engulfed with bushfires.

Some reports suggest

27 death so far and many lost their homes,

Millions of hectares of land burned,

Half a billion animal affected,

Potentially millions of them died,

One third of koalas killed,

Even some species might face extinction.

Being caused not only due to heat and drought

But some are charged for purposefully starting the bushfires.

As summer in Australia yet to peak, and prolonged drought is merciless

It eventually brings the needle back to the core issue

Climate change!

**Bal Krishna, Editor**
**bal@mycoordinates.org**

# The challenges for resilient PNT in 2020

Assessing the evolving PNT threat landscape and the implications for Resilient Navigation during the next twelve months

**Guy Buesnel**
Spirent's PNT Security Technologist

In October, the International Civil Aviation Organization (ICAO) for the first time identified GNSS disruption as an 'urgent safety priority', responding to concerns raised by a host of national and regional aviation bodies.

## A year in which disruption to GNSS reached new levels

In 2019 we saw massive worldwide disruption from GNSS jamming, spoofing and other vulnerabilities. The scale of the disruptions we observed was unprecedented and even though to some of us there had been many indicators that this sort of disruption to systems and devices dependent on precise positioning and timing data from space based PNT was becoming very likely many of the events still took much of the GNSS user community by surprise.

If anyone still doubts the seriousness of the risks presented by GPS and GNSS vulnerabilities, the stark reality of the events we experienced 2019 should put those doubts to rest.

Across the world we've seen flights grounded, shipping disrupted, drones lost, weather balloons downed, and vehicles of all kinds mysteriously lose their bearings. The causes range from state-sponsored electronic warfare and organised criminal activity to technical issues with the satellite systems and the receivers that rely on their signals.

## Increasing complexity of navigation and timing systems

The growing complexity of PNT systems in which GNSS is used as only one of the sensor inputs to a navigation or timing system means that the need to evaluate and test systems in real world situations has become greater than ever. We have seen impacts of GNSS jamming disrupting commercial aviation systems – where GNSS is just one of the sensors used – but as some of the reported occurrences show very clearly, where GNSS measurements disagree with measurements from other sensors, the consequence aren't always easily predictable or easy to assess. GNSS data may be shared with several onboard systems including ADS-B for collision avoidance and Enhanced ground proximity warning systems (GPS data used to provide terrain database information).

## ICAO flag GNSS interference as an 'urgent safety priority'

In October, the International Civil Aviation Organization (ICAO) for the first time identified GNSS disruption as an 'urgent safety priority', responding to concerns raised by a host of national and regional aviation bodies.

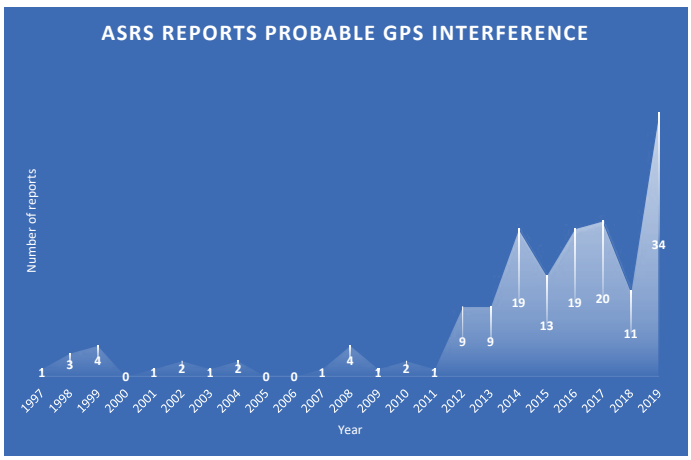
A horrifying near-miss incident at Friedman Memorial Airport in Hailey, Idaho, was one of the catalysts for ICAO's action. A write-up of the incident in NASA's June Callback newsletter notes that there was 'widespread jamming' and 'an abundance of smoke' in the area as 'Aircraft X' approached the airport. The pilot had reported a GPS outage prior to its descent, but said the problems had cleared up, so the local controller cleared the aircraft for a GPS-based approach.

Shortly thereafter, a controller some 250 miles away in Salt Lake City happened to notice that Aircraft X was straying off course. What's more, the plane was at 10,700 feet altitude and nearing a 10,900 feet mountain.

Thinking quickly, the controller contacted the local control tower in Hailey, which directed the aircraft back onto a safe flight path. The report concludes that "Had [the Radar Controller] not noticed, […] the flight crew and the passengers would be dead, I have no doubt".

## Pilot reports of GPS disruption are on the increase

This was an isolated incident, but data shows that GNSS interference poses a rapidly-growing threat to aviation. I spent some time in 2019 analysing pilot reports related to GPS that were filed with NASA's Aviation Safety Reporting System (ASRS) every year since 1997. I reviewed each of the incidents looking for events which where GPS interference was a probable factor. This is most likely a very conservative assessment – but the overall trend in events is striking and shows an unwanted increase in potentially disruptive incidents. The evidence is clear.




**Graph source: Spirent**

## GPS Spoofing incidents on the rise

As well as the ongoing problems in the Black Sea during 2019, for several months, commercial ships on the Huangpu River in Shanghai have been intermittently broadcasting inaccurate data about their location and movements. Some ships appear to traverse the river very quickly from side to side, while others have been creating elegant 'crop circles' of position data that bear no resemblance to the ships' actual locations.

Another spoofing incident reportedly occurred at the Geneva Motor Show in March 2019, and is said to have impacted the in-vehicle navigation systems of several vehicles on the exhibition floor, including models from a number of high profile vehicle manufacturers.

According to the automotive blog Jalopnik, the vehicles' navigation systems all suddenly started displaying the year as 2036, and their location as Buckingham, England. In some cases, even manual attempts to reset the date and location failed.

## Integrity is becoming even more important than pure GNSS performance

As GNSS signals are used in ever more applications, the last few years have seen the pursuit of accuracy and precision above all else. Multi-sensor positioning systems and precision timing receivers have made sub-centimetre positioning and nanosecond-level timing a reality – fuelling advances in autonomous vehicles, smart infrastructure and next-generation mobile networks.

Given the scale of GNSS interference and spoofing events we've observed worldwide in 2019 , the integrity (trustworthiness) of GNSS is becoming even more important to users than the fundamental measures of GNSS receiver performance. Without it, systems and devices of all kinds will continue to be compromised by escalating levels of interference that show no sign of stopping.

## Test challenges

As many applications move towards multi-sensor solutions for timing and navigation – e.g., autonomous ground vehicles, drones, autonomous shipping , aviation systems in both commercial and military domains, the overall test landscape is becoming much more complicated – testing a GNSS sensor in isolation will not be sufficient (although thorough testing of the GNSS sensor is still necessary)- Hardware in the Loop testing of systems and sensors is now a vital additional test component. Some of the main components of a programme to develop Assured PNT solutions for specific application domains should include:-

- Evaluating the performance and resilience of PNT dependent systems and devices
- Benchmark performance testing of systems and devices
- Bespoke testing carried out in fully equipped laboratories or on-site
- Scientific investigation– specific problem investigation/solving with domain experts
- Analysis/interpretation/opinion of quantitative test evidence
- Anticipation of technology advancements and threat developments
- Often overlooked when considering test challenges – especially those associated with system resilience and integrity, is the need for open and responsible sharing of threat intelligence. This is something that's definitely needed in the commercial PNT sector. Initiatives such as the US Coastguard's GPS Problem Reports Status https://navcen.uscg.gov/?Do=GPSReportStatus and NASA's ASRS reporting system https://asrs.arc.nasa.gov/ show how valuable this sharing of information can be and it will help lead to community driven support improving security within the GNSS industry.

## Stay up to date with GNSS vulnerabilities

Threats to GPS/GNSS are evolving all the time. To stay up to date with the latest news, events and incidents, join the growing community in the GNSS Vulnerabilities LinkedIn Group.

# The consequences of vulnerabilities within autonomous navigation are alarming

Autonomous navigation is entering new environments where the stakes have never been higher

**Jennifer Edis**
Brand Marketing Manager
Racelogic

When it comes to the trends and challenges facing autonomous navigation, there is one distinct factor that unites its application across transportation, robots, agriculture, space, marine, UAVs and drones, and that is an unprecedented rate of change.

The ancient Greek philosopher, Heraclitus, told us that *'change is the only constant in life'*, while renowned theoretical physicist, Stephen Hawking, told us that *'intelligence is the ability to adapt to change'*. So, if we are to be guided in the future by the wise minds of the past, we must accept that change is going to continue to drive the trends in autonomous navigation, and that intelligent thinking is going to be required to overcome the challenges.

**New environments and demand for accuracy:** The impeded performance of autonomous navigation within GNSS denied environments is no longer an acceptable limitation for modern technology. The ability to efficiently deliver accurate and reliable autonomous navigation in all conditions will need to become the industry norm. From advances in mass-market urban autonomous vehicles to biomedical autonomous robots within the human body, autonomous navigation is entering new environments where the stakes have never been higher.

**Investment and collaboration:** It is almost impossible to name an industry or company that does not include economic pressures within the list of challenges it is currently facing. When operating in a technological sector where keeping pace with advancements is not negotiable, finding creative solutions to the economic squeeze on an R&D budget is essential. From an accountancy perspective, the choice between in-house development or collaboration is relatively simple. The opportunity to minimise risk in expenditure through collaboration is a highly attractive solution.

However, collaboration is not without its own challenges and organisations that are fierce competitors are now finding themselves in partnerships in a bid to stay ahead of, ironically, the competition. The technical partnership between BMW and Daimler is a prime example of this within the automotive industry which has seen a boom in collaborations in recent years as brands race to bring commercially viable autonomous vehicles to the road.

Several organisations are hedging their bets by combining in-house development and collaboration including some that are native to sectors far removed from autonomous navigation. Online retailer Amazon has directed significant spend

Testing complete autonomy using controlled and geo-fenced test areas with no human presence already provides an achievable and affordable solution but having the technology and cost-effective solutions to migrate this to *'autonomy anywhere'* scenarios is not likely to happen in the near future

towards finding viable solutions to the problems posed by last-mile delivery which has led them to autonomous delivery robots whilst additionally embarking in an autonomous vehicle collaboration with Toyota and investing in autonomous tech developer Aurora Innovation.

As autonomous navigation continues to mature, the technology options will narrow, and collaboration potentially followed by consolidation is likely to become the norm.

**Regulation, legislation and ethics:** The rate of change referred to in relation to autonomous navigation is reflective of the fast pace being set by technological advances and applications. However, when rate of change pertains to regulatory and legislative change, the pace can usually be described as pedestrian at best. Add to this the complexities of driving coordinated change at both micro and macro levels and there is clearly trouble ahead as this disparity in pace increases.

The ethics of autonomous navigation are still very much a work in progress when it comes to applying technologies to the real world, where human life depends on the decisions being made by the AI driving the navigation. The question remains, are users as well as bystanders going to be willing to accept the outcome of actions dictated by a software code?

It is widely accepted that self-driving technology has the potential to dramatically reduce death and injuries on roads but defining *'how safe is safe enough?'* during testing and commercial roll-out remains vague. Currently there is disparity between the many companies that are developing autonomous vehicles with differences showing between the approaches of traditional automotive manufacturers compared to new entrants to the sector. Uber recently unveiled its Safety Case Framework which outlines how the company has updated its approach to safety following a fatal crash in March 2018 involving one of its self-driving vehicles. Updating what an individual company defines is acceptably safe throughout the live testing programme contrasts with the approach of many traditional car brands who are looking to keep their autonomous profile blemish free following turbulent years of safety recalls and environmental issues.

The role of ethics surrounding autonomy has the potential to drive substantial changes to society and the merger of ethics and engineering is set to continue throughout 2020.

**Security, jamming and spoofing:** GNSS jamming and spoofing has been a hot topic throughout 2019, from Pokémon Go enthusiasts using cheap SDRs (Software Defined Radios) to catch rare Pokémon, to the US Department of Transportation's Maritime Administration suspecting Iran of operating GPS jammers in the Persian Gulf to intentionally cause ships and aircraft to stray in to Iranian waters or airspace.

The consequences of vulnerabilities within autonomous navigation are alarming and it is understandable that the development of constellation authentication systems, such as Galileo's OS-NMA (Open Service Navigation Message Authentication), and research focused on commercial applications of using dual-polarised antennas are being well received.

As with IT security, combating jamming and spoofing is a constant game of cat and mouse between those developing security systems and those intent on defeating them. However, the reality is far from a game (even when spoofing Pokémon!) and 2020 will need to ensure that GNSS technology remains an incontrovertible service to autonomous navigation.

**Human factors:** 2020 will be the year that human evolution will need to align itself with the autonomous revolution and the importance of the human factor should not be underestimated. Autonomous technology is not being designed or operated in a vacuum of humankind. Therefore, any system can only be as successful as its inherent human error and bias (unconscious or otherwise), and its aptitude for seamless human interaction.

The human factor also encompasses the changes to skills, education and knowledge required to both continue the advanced development of technologies and for society to prepare itself for the rapidly changing employment landscape. The most in-demand specialties in the job market today did not exist ten or even five years ago and the pace of change is set to accelerate.

**Testing solutions:** The common thread that ties together all other trends and challenges facing autonomous navigation is the need for testing solutions. New environments, new and collaborative technologies, changing regulations, security threats and human factors will all require testing solutions that can deliver irrefutable results without causing delays to competitive delivery schedules.

Testing autonomous vehicles has both degrees of difficulty and cost which must be weighed up against the returns required to maintain a feasible business model. As companies move towards testing Level 3 and above autonomous technologies, the challenges posed by testing and validation become considerable.

Using a test track to test Level 3 'eyes off' vehicles is achievable with current technology, but the budget required to set up the physical testing parameters, run the programme for sufficient time and mileage, and then repeat for permutations in weather and driving conditions is vast.

Testing complete autonomy using controlled and geo-fenced test areas with no human presence already provides an achievable and affordable solution but having the technology and cost-effective solutions to migrate this to *'autonomy anywhere'* scenarios is not likely to happen in the near future.

Smart investment in testing solutions that are as complex and specialised as the technologies they are charged with scrutinising, is something that should be a priority for all in 2020. Many companies are betting their future on developing and testing autonomous vehicles and although it is unlikely that we will see the outcome of the wager in 2020, we might witness a change to the odds of success.

# Do we need GNSS alternatives, OR, should we protect what we already have?

## GNSS SIL Certification – RF spectrum control is essential

**Graeme Hooper**
Managing Director
GPSat Systems Australia

In the real estate market they say it's all about location, well, it's the same in satellite navigation but for many different reasons. Precise location of objects using GNSS has been and will continue to be, the primary focus of the industry. However future trends for the 2020s onwards, will see "location" extended into the more peripheral challenged areas of precisely geolocating Radio Frequency Interference (RFI) spectrum threats. By example, the substantial reduction in aircraft hijacking is attributed to the broadscale introduction of X-Ray screening machines at airports, similar philosophies adopting more advanced radio technologies deployed terrestrially, we can also substantially improve protection for our precious GNSS satellite signals.

GNSS an incredibly effective global utility, but it's vulnerable to either deliberate or accidental Radio Frequency Interference (RFI) jamming of it's terrestrial signals. Jamming and/or spoofing (J&S) effects have the potential to severely cripple/ interrupt important mission critical GNSS safety of life operations, such as GBAS at airports, marine AIS or autonomous machines used in modern industrial applications.

For these mission critical applications, there are three key strategies available for increasing GNSS senor resilience in these J&S threats environments, these being;

1. *Avoidance:* Defence, hardening the navigation sensor by utilising CRPA antenna technologies, enhanced signal processing (Mcode, adaptive RF digital front ends), etc.
2. *Augmentation,* aiding the navigation process through the integrated use of a dissimilar sensors such as IMUs, Radar, Lidar, etc.

And/Or,

3. *Engagement*: instigating a process of "offence" by utilising tailored technologies to deal with the J&S RFI signals directly. In a GNSS environmental context, this translates to accurately and timely geolocating the RFI emission point/s and then take the required interdictory actions to eliminate the problem entirely.

All above strategies have an important place in modern GNSS enabled mission critical autonomous operations. However, history has taught many times that "*avoidance and augmentation*" are NOT enduring strategies alone. Only entirely effective solution for permanently dealing with persistent spectrum interference issues is active "*engagement*". Many great leaders have quipped, "*the BEST defence is a GOOD offence".*

For GNSS a good offence is direct interdictory responses, extending to many options, including law enforcement officers apprehending offending criminals, airport staff rectifying errant hanger GNSS signal re-radiators, mine workers rectifying faulty machinery, and/ or military kinetic explosive combat responses. It's only through instantaneous precision geolocation determination of threatening RFI source transmission points, coupled with prompt direct interdiction responses can resilient GNSS PNT can ever be meaningfully achieved.

Do we need GNSS alternatives, OR, should we protect what we already have? Australia's decade long response through several Australian Research Council (ARC), Defence and GPSat System investments adopts the "do more for GNSS protection and engagement philosophies".

For automation projects requiring "mission critical" safety and integrity level (SIL) certifications, GNSS technology signal vulnerabilities presents several challenges for achieving formal operational regulatory approvals. Systematic failures due signal atmospheric disturbances, multipath and/ or terrestrial RFI, effective control must be extended to ALL aspects, including the GNSS RF environment.

Industrial Safety Standards such as Aviation DO-178C and IEC61508, or specific industry derived standards (eg., rail EN50126, automotive ISO26262, etc) all require "*vulnerability to undesired EM signals*" to be appropriately address during safety requirements (SRS) establishment. Numerous references within IEC61508 relate to "*Increase of interference immunity*" (Part 7 - A.11.3) and "*Measures against Physical Environment*" (Part 7-A.14). Requirements Specification Part 7-B.2 requires the *"competent GNSS expert"* to address ALL vulnerabilities, and then, implement effective mitigation processes to ensure SIL systems are *"complete, free*

*from mistakes, free from contradiction and simple to verify"*. Comprehensively devoid of ANY inherent systematic failure modes impacting ongoing safety. In summary, it's essential that future automation GNSS professionals extend their responsibilities beyond exclusive USER PNT product/ services boundaries to also include meaningful spectrum policing and control. Rapidly and precisely geolocating RFI J&S threats, and then, promptly implementing appropriate interdiction responses. Even the more sophisticated GNSS "avoidance" technologies are neither adequate nor appropriate to meet entire GNSS SIL certification mandates alone.

Is it possible to effectively regionally police the terrestrial RF spectrum in the GNSS bands, quickly detecting, characterising and precisely geolocate RFI threats to GNSS operations.? Yes absolutely, providing the right equipment and technologies are carefully fashioned to meet the unique nature of GPS RF signals arriving from space at very low levels, well below the ambient/ background noise.

Military radar and astronomy sciences for many decades have dealt with very weak RF signals arriving from any direction. Employing phased array antenna receiver reception combinations for directional signal amplification, and then, precisely determining Direction of Arrival (DOA). Digital advanced spectrum cleansing/ whitening signal processing techniques for subtracting "known RF sources" (eg, GNSS signals, 4G harmonics etc.) improving RFI sensitivity are essential ingredients for any future regional spectrum GNSS policing system.

To complete essential ingredient list, GNSS engineers need to invert their Time Difference Of Arrival (TDOA) skills away from "multiple satellite RF sources into single reception antenna" thinking, to embrace, "single RFI source into multiple spatially distributed reception antenna" thinking. Using a network of remote synchronised monitoring stations (multiple RF antennas & receivers) all working cooperatively receiving RFI source transmission signals at different locations. Each remote monitoring station's DOA and TDOA contributions can then be used centrally for very rapid and accurate RFI signal geolocation and Area of Influence (AOI) determinations.

Does AOA phased array, TDOA and advanced spectrum cleansing processes work for effective regional GNSS spectrum policing? Absolutely! Through a dedicated team of engineers (several PhDs) from GPSat Systems, UniAdelaide, and UniNSW effectively combining each's expertise in RF electronics design, geodetic spatial sciences, defence radar phased array engineering, weak RF signal numerical processing and numerous others technologies, have all carefully been blended into the very unique GRIFFIN project. Having successfully completing past (2017) Australian Defence testing and demonstrations, GRIFFIN is now undergoing defence initial production, with deliveries anticipated Q2 2020.

For future 2020 and onwards GNSS trends, systems like GRIFFIN and issues associated with spectrum protection are sure to gain both greater industry focus and adoption, particularly in SIL related applications.

# The case for automotive GNSS cyber security measures

Since the backbone of automotive position, navigation, time and velocity is dependent on real and secure GNSS data, the spoofing threat is considered dangerous for the safety of using ADAS and driverless-based cars

**Yoav Zangvil**
CTO & Co-Founder
Regulus Cyber

As the use of ADAS and Autonomous Driving technology grows in automotive, so does the dependency on navigation and safety technologies that accommodate it. One of the core technologies used for navigation is GNSS – Global Navigation Satellite System.

GNSS plays a critical role in next-generation positioning systems as the only source of absolute position, navigation, and time.

GNSS is a general term to describe the different satellite technologies providing positioning, navigation, velocity and timing (PNT, or PVT). These satellite networks include GPS, BeiDou, Galileo and GLONASS among others. All of these satellite networks are commonly used across multiple commercial applications.

Automotive and road applications are the largest users of GNSS technology, adding to about 50% of GNSS cumulative revenue, according to the European GNSS Agency.

## GNSS – Safety-critical automotive positioning, and the spoofing problem

Spoofing is the action of replicating GNSS signals. A spoofer can fool a receiver into thinking that it is elsewhere in either time or location. The generating and transmitting of falsified GNSS signals at a slightly stronger level than the authentic signals causes the targeted GNSS receiver to accept the fabricated signals. Furthermore, the arrival of cheap Software Defined Radios (SDR), costing as little as $300, combined with the availability of open source code has made spoofing far more accessible to anyone.

Since the backbone of automotive position, navigation, time and velocity is dependent on real and secure GNSS data, the spoofing threat is considered dangerous for the safety of using ADAS and driverless-based cars. In automotive, positioning and time information is increasingly used for safety-critical features. GNSS is now the main input for safety-critical automotive positioning and is used in safety critical systems like speed control – thus GNSS resiliency is becoming an aspect of functional safety in cars. GNSS is now an important part of both ADAS systems available today, and the level 2 – 5 autonomous vehicles. GNSS also determines the exact timing of actions and communications (V2V & V2X and other functions), thus is critical beyond the single car – for the network, fleet and infrastructure supporting the vehicles.

In our ongoing independent tests of several current cars, from leading manufacturers, using advanced ADAS capabilities – disturbing vulnerabilities of the different GNSS systems have been found. By using a simple off-the-shelf software defined radio, Regulus' researchers were able to remotely affect different aspects of the driving experience including navigation, mapping, power calculations, speed control (including autonomous acceleration and deceleration) and even the car's suspension system.

## The cost of ignoring GNSS vulnerability

### The Fiat Chrysler\Harman Cybersecurity lawsuit

During the summer of 2015, Wired Reporter Andy Greenberg was driving a Jeep Cherokee while being hacked by Chris Valasek and Charlie Miller, two cybersecurity experts. This exposed a cybersecurity vulnerability across multiple vehicles, leading to 1.4 million cars being recalled.

Almost 4 years later, in January 2019, Fiat Chrysler Automobiles and HARMAN (a Samsung Electronics subsidiary) are at the center of the biggest (est. $440M) automotive cybersecurity lawsuit in history. Both companies are charged with knowing about a cybersecurity vulnerability within their cars, and still releasing them to the public. The US court system sent a clear message to the automotive industry: a car should never be sold without proper cybersecurity.

## Spoofing incident at Geneva Motor Show

On March 14, 2019, a GNSS spoofing attack was performed inside Geneva Motor Show. According to the report, companies affected include AUDI, Peugeot, Renault, Rolls-Royce, Volkswagen, Mercedes-Benz, and BMW.

CHCNAV

# Enable GNSS Survey
## *Anytime, Anywhere!*

# i90
## IMU-RTK GNSS


**Dramatically increase RTK availability and reliability**

**Compensate pole-tilt to boost survey and stakeout speed by up to 20%**

WWW.CHCNAV.COM

This was the largest scale GNSS spoofing attack on cars ever recorded.

## The risk of not being prepared

These two recent occurrences were a big wake-up call for automakers worldwide. The mass spoofing of vehicles demonstrates the vulnerability that exists, regardless of car, model, etc. As we have seen in the recent developments in the Fiat Chrysler/Harman (Samsung) lawsuit, regarding known automotive cyber vulnerabilities, these incidents put the automakers in substantial legal liability requiring them to implement solutions for their GNSS vulnerabilities so that drivers and passengers know they are safe from GNSS hacking**.**

## An example of dangerous spoofing – Autonomous vehicle spoofing experiments

In the first week of June, Regulus Cyber experts test-drive the Tesla Model 3 using Navigate on Autopilot (NOA). An active guidance feature for its Enhanced Autopilot platform, it's meant to make following the route to a destination easier, which includes suggesting and making lane changes and taking interchange exits, all with driver supervision. While it initially required drivers to confirm lane changes using the turn signals before the car moved into an adjacent lane, current versions of Navigate on Autopilot allow drivers to waive the confirmation requirement if they choose, meaning the car can activate the turn signal and start turning on its own.

Tesla Model S was also tested, and during the spoofing experiment, it showed different results such as wrong navigation cues, incorrect battery power warnings (when calculating the distance) and changes to the suspension. However, the spoofing did not affect the actual driving as it does not have the NOA feature available. The Model S test revealed that there is a link between the car's navigation and air suspension systems. This resulted in the height of the car changing unexpectedly while moving because the suspension system "thought" it was driving through various locations during the test, either on smooth roadways, when the car was lowered for greater aerodynamics, or "off-road" streets, which would activate the car elevating its undercarriage to avoid any obstacles on the road.

Tesla model 3 was successfully spoofed in several attack scenarios. The navigate on autopilot feature is highly dependent on GNSS reliability and spoofing resulted in multiple high-risk scenarios for the driver and car passengers. Tesla Model 3 spoofing during navigating on autopilot led to extreme deceleration and acceleration, rapid lane changing suggestions, unnecessary signaling, multiple attempts to exit the highway at incorrect locations and extreme driving instability. This test proves beyond doubt the crucial dependence on GNSS for any level 2+ autonomous navigation and the high threat spoofing poses to drivers and passengers utilizing these features.

## Equipment used for spoofing and hacking

Jammer – ADALAM PLUTO configurable SDR manufactured by Analog Devices ($150).

Spoofer – Blade RF SDR manufactured by nuand ($400) with external PPS sync connected to a laptop
*The equipment used was purchased online and easily accessible to anyone.

## Important terms regarding Tesla mentioned in this research

Cruise – a mode in which the driver designated a certain maximum speed and the car maintains it.

Autopilot – In addition to the cruise, the mode that can only be activated when the car's cameras are recognizing lane markings. During this mode, the car is responsible for 3 additional activities – maintaining a safe distance from the car in front, adjusting speed according to road conditions, and maintain the middle of the lane. The driver has to hold the wheel momentarily every few seconds.

Navigate on autopilot (NOA) – Tesla's semi-autonomous mode, this can only be activated if the car is driving on a road that has 2 lanes in each direction PLUS the car has a clear destination. This mode includes all the features of cruise and autopilot with the addition of 2 new additional activities – changing lanes to maintain maximum speed to pass slow vehicles (the car does require the driver to agree to lane change with blinker) and autonomously exiting highways at the relevant interchange. Exiting highway feature is engaged on its own and does not require driver confirmation, the car automatically engaged the blinker and changes lanes and physically turns off the high into the exit up to a distance of 250m before requiring the driver to regain control.

During the Tesla 3 experiment, the spoofing antenna was mounted on the roof. This was done to simulate an outside attack and see if the car is capable of isolating against the spoofing. This is the typical case in which an external attacker would try to influence the car. This was also done to prevent the spoofing from affecting any nearby cars or other GNSS receivers.

The spoofer can easily use an off the shelf high-gain directional antenna to get a range of up to a mile. If they add an amplifier, a range of a few miles is very much possible. It has already been proven that spoofing can even occur across dozens of miles, for example in the Black Sea spoofing attack in June 2017.

Regulus Cyber initially discovered the Tesla vulnerability during its ongoing study of the threat that easily accessible spoofing technology poses to GNSS (global navigation satellite systems, also known as GPS) receivers.

The researchers found that spoofing attacks on the Tesla GNSS (GPS) receiver could easily be carried out wirelessly and remotely.

Tesla emphasizes that “in both of these scenarios until truly driverless cars are validated and approved by regulators, drivers are responsible for and must remain ready to take manual control of their car at all times.”

It appears the Tesla Navigate On Autopilot (NOA) has no reliance on GPS for the actual physical driving decisions. It relies on its own visual sensors, just like a human driver.

There is one exception. The feature “Navigate on Autopilot” (NOA) uses GPS and Google map data, because the point of that feature is to follow a route. The car is only using GPS and map data to determine what lanes it should be in and what exits to take. Actual control of the car is still the job of the onboard sensors. That means that spoofing it basically manipulating the car’s autonomous turning decision, which means an attacker can remotely engage the car to turn while driving with NOA engaged.

Sensor fusion used the GNSS data together with the camera data to make the mistake of turning off the highway. Tesla’s computer used the GPS position to understand where it is. It uses the camera to identify lanes/exits and the radar to avoid collisions and keep the distance from other cars. Tesla does not use LiDAR and even if it did, it wouldn’t matter. The experiment shows that utilizing GNSS for autonomous navigation makes spoofing a wireless threat that manipulates the car’s path.

## Tesla Model 3 experiment description

The test was designed to reveal how the semi-autonomous Model 3 would react to a spoofing attack, the Regulus Cyber test began with the car driving normally and the Navigate on Autopilot (NOA) activated, maintaining a constant speed and position in the middle of the lane.

The test started with normal driving, having Navigate on autopilot engaged, driving on a main high way at 95 KPH. The navigation destination was a nearby town requiring the car to autonomously exit an interchange in 2.5 km.

Using a small 1 meter (3 feet) range antenna mounted on the roof, the researchers transmitted fake satellite coordinates that got picked up by the Model 3 receivers. These coordinates were a location on the highway, 150 meters before the exit.

The exact moment that the car was spoofed to the new location, it passed a dotted white line on it's right hand side, leading to a small road into an emergency pit stop.

Although the car was a few miles away from the planned exit when the spoofing attack began, the car reacted as if the exit was just 500 feet away— slowing down from 60 MPH to 24 KPH, activating the right turn signal, and making a right turn off the main road into the emergency pit stop. During the sudden turn the driver was with his hands on his lap since he was not prepared for this turn to happen so fast and by the time he grabbed the wheel and regained manual control, it was too late to attempt to maneuver back to the highway safely.

The testing is designed to assess the impact of spoofing with low-cost, open source hardware and software, the same kind of technology that is accessible to anyone via e-commerce websites and open source projects online. The very same hardware teenagers use to cheat PokemonGo or Uber drivers to fake their commute. This dangerous technology is everywhere.

Taking control of Tesla's GPS with off-the-shelf tools took less than one minute. The researchers were able to remotely affect various aspects of the driving experience, including navigation, mapping, power calculations, and the suspension system. Under attack, the GNSS system displayed incorrect positions on the maps, making it impossible to plot an accurate route to the destination.

## Tesla response

Prior to the Model 3 road test, Regulus Cyber provided its Model S research results to the Tesla Vulnerability Reporting Team, which responded with the following points at that time:

"Any product or service that uses the public GPS broadcast system can be affected by GPS spoofing, which is why this kind of attack is considered a federal crime. Even though this research doesn't demonstrate any Tesla-specific vulnerabilities, that hasn't stopped us from taking steps to introduce safeguards in the future which we believe will make our products more secure against these kinds of attacks.

The effect of GPS spoofing on Tesla cars is minimal and does not pose a safety risk, given that it would at most slightly raise or lower the vehicle's air suspension system, which is not unsafe to do during regular driving or potentially route a driver to an incorrect location during manual driving.

While these researchers did not test the effects of GPS spoofing when Autopilot or Navigate on Autopilot was in use, we know that drivers using those features must still be responsible for the car at all times and can easily override Autopilot and Navigate on Autopilot at any time by using the steering wheel or brakes, and should always be prepared to do so."

"This is a distressing answer by a car manufacturer that is the self-proclaimed leader in the autonomous vehicle race," Yoav Zangvil, Regulus Cyber CTO and co-founder comments. "As drivers and safety/security experts, we're not comforted by vague hints towards future safeguards and statements that dismiss the threats of GPS attacks." He offers the following counterp oints in response:

Attacks against any GPS system are indeed considered a crime because their effects are dangerous, as we've shown, yet the same devices we used to simulate the attacks are legally accessible to any person, online via e-commerce sites

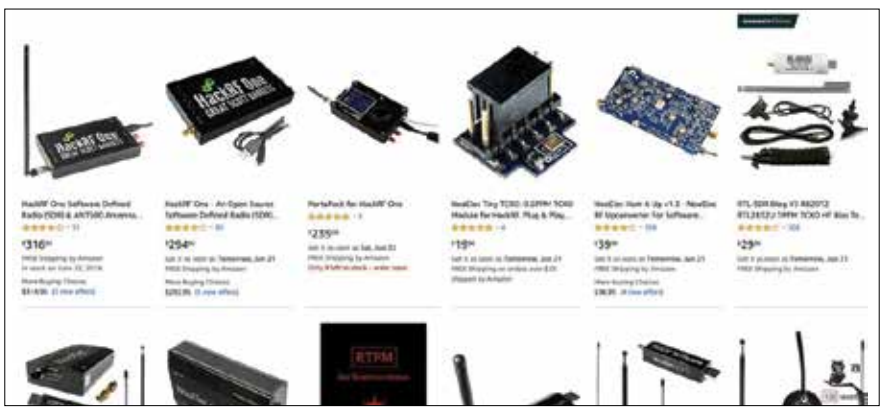
Taking steps to "introduce safeguards for the future" indicates that spoofing is, in fact, a major issue for Tesla, which relies heavily on GNSS

In the case of cars, a spoofing attack is confusing in the best case, and a threat to safety in more severe scenarios

The more GPS data is leveraged in automated driver assistance systems, the stronger and more unpredictable the effects of spoofing becomes

The fact that spoofing causes unforeseen results like unintentional acceleration and deceleration, as we've shown, clearly demonstrates that GNSS spoofing raises a safety issue that must be addressed.

In addition, the spoofing attack made the car engage in a physical maneuver off the



**Software Defined Radios sold on Amazon (20.06.19)**

road, providing a dire glimpse into the troubled future of autonomous cars that would have to rely on unsecure GNSS for navigation and decision-making

Given that the trust of the public still has to be earned as the automotive industry moves towards autonomy, the leading players are accountable for a responsible deployment of new technology

As Tesla clearly stated, drivers are responsible for overriding autopilot under a spoofing attack, so it appears its auto pilot system can't be trusted to function safely under a spoofing attack.

Because every GNSS/GPS broadcast system can be affected by GNSS/GPS spoofing, the issue is everyone's problem and shouldn't be ignored; furthermore, governments and regulators that have a mandate to protect the public's safety must engage in proactive measures to ensure only safe GNSS receivers are used in cars

According to Tesla, they'll soon be releasing completely autonomous cars utilizing GNSS, which means that, in theory, an attacker could remotely control the car's route planning and navigation, however, we're obligated to ask what steps they're taking to address this threat, and whether new safeguards will be implemented in its next generation of entirely autonomous cars.

Although the researchers tested only the Model S and Model 3, they concluded that the "disturbing vulnerability" of Tesla's GNSS system is most likely an industry-wide issue, since "the most common GNSS chipsets used are all vulnerable to our testing – you can learn more about it in the Regulus Cyber resiliency report.

## Spoofing detection and mitigation

One of the key concepts to negate the harmful effects of spoofing is detection. If a GNSS receiver is capable of telling whether the signals received are real or false, this provides the first line of defense against spoofing. The receiver could stop transmitting fake data into the car's navigation sensor fusion, hence preventing false information from corrupting the system.

The next step in GNSS cybersecurity is mitigation. This means the GNSS receiver can differentiate between real and fake signals, and lock-on to the real signals coming from satellites, even under a spoofing attack.

Regulus has been developing the Pyramid GNSS technology enabling the detection and mitigation of spoofing. The Regulus Pyramid GNSS technology is diverse, aiming at the different GNSS product levels – from a resilient, stand-alone Pyramid GNSS Receiver, fortified to defend against spoofing attacks, to a software solution compatible with the most common commercial GNSS receivers on the market, and even GNSS chip level detection and mitigation.

# The lasting impact...
# Remebring Prof David Last

**Prof David Last BSc(Eng) PhD DSc CEng FIET FRIN**
**03-03-1940 to 25-11-2019**

Professor David Last died suddenly in a light aircraft crash near Puffin Island off the coast of Anglesey on 25th November 2019.

Professor David Last held a Personal Chair and was Head of the Radio-Navigation Group at the University of Wales, Bangor until retirement in March 2005 when he became a Professor Emeritus.

He was born in Manchester in 1940 and educated at The Manchester Grammar School. He was awarded the degree of BSc(Eng) by the University of Bristol in 1961, PhD by the University of Sheffield in 1966 and DSc by the University of Wales in 1995.

From 2005-2008, Professor Last was President of the Royal Institute of Navigation. He is a Past-President of the International Loran Association, a Fellow of the Institution of Engineering and Technology and a Chartered Engineer. He has published more than 400 technical and policy papers on navigation and communications systems, including the Global Positioning System (GPS), Loran C and enhanced Loran (eLoran), Galileo and other Global Navigation Satellite Systems, Maritime Differential GPS, Argos, Decca Navigator, and Omega. He acts as a consultant on radio-navigation and communications to companies and to governmental and international organisations and is active as an Expert Witness, especially in forensic matters concerning GPS. He is an instrument-rated pilot and user of terrestrial and satellite navigation systems.

In 2010 he was awarded the Harold Spencer-Jones Gold Medal of the Royal Institute of Navigation and in 2015 the Necho Award of the International Association of Institutes of Navigation.

**We have lost David Last. But his contribution to the domain of GNSS shall remain invaluable. Coordinates have been fortunate to have interacted with him on several occasions on range of topics. As we fondly remember him, following are excerpts of some of the insights that Prof Last shared with us...**

## On eLoran...

eLoran comes up against a profound prejudice: GNSS replaced an earlier generation of terrestrial radio navigation aids. Recommending a terrestrial system to overcome the vulnerability of a satellite system is to swim against a powerful tide!

Galileo combined with eLoran would provide a robust technology; they can even share chips. The obstacles are not technical or financial, but political. Look: Europe has invested more than 10B Euros in Galileo; the last thing they want to hear about is its vulnerability! Norway – which had the best legacy Loran set-up in Europe – blew up its towers, filming their collapse as entertainment on Youtube. Absurd! The US Congress, in contrast, is now well aware of the weaknesses of GPS and has fostered an eLoran system. China, Russia, South Korea and Saudi Arabia have similar ground-based navigation stations. Europe is lagging some 20 years behind; the disappearance of Galileo in July came as a shock! Moreover, the provision of a US Loran system for 20 years would cost the equivalent of a single GPS satellite! Satellite navigation is much more attractive to industry and creates lots of jobs. Maybe Loran is just too cheap to survive; that's frustrating! *Coordinates September 2019*

## On multi-GNSS scenario...

The advantages to countries or regions of providing their own GNSS are political, not technical. Indeed, so many satellites are now transmitting in the same narrow radio bands that the additional ones are raising the noise level with which they all have to cope!

But many countries are unwilling to have their critical national infrastructure or military capabilities dependent on a satellite system controlled by a foreign state that will always put its own interests first. *Coordinates July 2018*

## On the direction of satellite navigation...

Satellite navigation was one of the outstanding innovative technologies of the late twentieth century, arguably the

most successful, being widely adopted with remarkably few downsides, either social or environmental. Through the first decade of the twenty-first century the technology was refined: devices became much smaller, much cheaper, more powerful, and gained superior accuracy, integrity, availability and continuity. But by now we are 45 years on from the meeting at which the principal parameters of GPS were settled.

Satellite navigation has become a very mature technology in which major change is unlikely. Thus its direction will be more about an increase in the numbers of systems, satellites and receivers, all based on essentially the same old technology. But I do expect to see the cost of satellite systems and launchers continuing to fall. *Coordinates July 2018*

## On Brexit...

Brexit has already led to a conflict between the UK and the rest of the EU concerning future UK access to the Public Regulated Service (PRS), the military-grade part of Galileo. According to the EU, only member states have the right to access the PRS. The UK, requiring either PRS or an equivalent for military purposes has countered by stating that it will consider developing its own independent GNSS. Studies of this option are currently under way.

The row is complicated by the substantial role that UK companies, or the UK parts of multi-national companies, have played and are continuing to play in the development of Galileo. Brexit could end that cooperation, leaving unanswered questions concerning the intellectual property involved. It could also throw into uncertainty the position of the European Space Agency (ESA) which is not part of the EU but acts for it in certain ways.

It remains to be seen whether this conflict is genuine or part of the manoeuvring between the UK and the EU over the terms of Brexit and the future relationship between the two. Divorces can be messy affairs! *Coordinates July 2018*

## Vulnerablists Vs Autonomists

Two yawning divides: the first between those who believe in rival satellite systems, centrally organised, and those for whom systems are now just components of GNSS with the receiver makers determining the mix. The second divide, between the Vulnerablists and the Autonomists, is turning into a sort of Global Warming of the navigation world, with proponents and deniers locking horns! *Coordinates March 2015*

## Satellite Navigation– Truths & Myths

…Then, quietly, a revolution started in the world of navigation. The first phase of the revolution brought lower cost, smaller, higher performance navigation equipment. Amateur sailors and aviators got technology more powerful than professional equipment, and very much cheaper: Decca Navigator and Loran-C sets for yachts, for example (Fig 1 & 2). The second phase of this revolution was driven by GPS. Navigators, the early adopters of satellite navigation, were rapidly followed by surveyors, geodesists, desert travellers – people with at least loose connections to navigation. But then came, farmers,motorists, truckers, people seeking not so much the high peaks of the great outdoors as the delivery bay at McDonalds! Soon, these nonnavigators outnumbered the navigators.Global navigation systems stopped being primarily about navigation; they became simply public utilities. And now we are entering a third phase of this revolution, where the utility that is Global Satellite Navigation becomes universal and largely invisible. The trigger for this phase was the US government's requirement that cell-phone networks should automatically identify the locations of users who call the emergency 911 number. Many networks chose Assisted-GPS (A-GPS) technology, near instantaneous location measurements using a GPS receiver inside the handset, assisted by data passed to it over the cellular system (Fig3). This works, and the networks can now locate their users. Your phone can tell you where you are, download a map for you, guide you to your destination; it can locate the nearest police station, or hospital, pubs for young men and toilets for elderly gentlemen. It can give you tourist information, tell you of traffic problems ahead. Phones can track your children or your girlfriend, or your boyfriend! Of course, think of the Internet and spam: as you walk down a street, your phone will soon try to entice you into sleazy bars, dubious cinemas, or houses of ill repute! Worldwide, there will be soon be hundreds of millions of new users of global satellite navigation systems, GNSS. Most of them will neither know nor care that they are using a satellite navigation system. Our sophisticated navigation technology will simply have become a location sub-system of a low-cost consumer product....

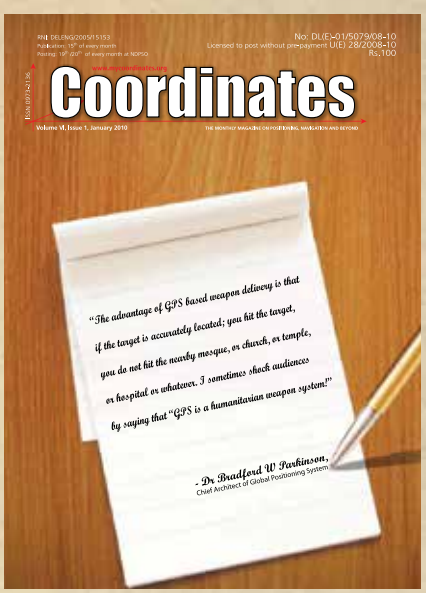
...It could get much worse when people really try to stop satellite navigation. Many European countries now plan to charge road users. Motorists hate the idea, just as they hate radar speed traps. A jammer in a motorist's car could disable GPS road user charging across a city – and at the same time disable GPS for the rest of the population. Who would track it down? How long would that take? That is the potential problem.

...These are indeed safety critical areas, and governments have responsibilities for them. But there is no sense here of governments recognising the role satellite navigation is now playing in their economies. What about telecommunications timing, mobile phone users and their emergency calls? The UK and other countries are saying that these millions of new users (perhaps 96% of the market) are not critical and do not really need satellite navigation. If there is a GPS problem, they can just go back to doing what they did before. But they no longer can!

...Why is Europe is producing a GPS look-alike? Like GPS, Galileo will be a Global Navigation Satellite System. It is broadly similar to GPS, using the same principles and radio frequency bands, so our receivers will pick up both. But they are very different in certain important respects. *Coordinates February 2007*

# In Coordinates

## 10 years before...




mycoordinates.org/vol-6-issue-1-January -10

## GPS is a humanitarian weapon system

**says Dr Bradford W Parkinson, Chief Architect of Global Positioning System**
**Do you think the apprehensions about GPS 'failure' are justified?**

First of all, I think the notion that GPS would suddenly not work is fairly far-fetched. I have dug into that a great deal. What is more apt to happen is that for some reason or another we may have premature failure of the satellites and hence we may not have as dense a population of them.

We would call that a brown out. I do have some concerns about that, but I don't think under any circumstances it is going to disappear. I am very anxious to see the first IIF be launched and I am anxious to see USAF JPO make progress on GPS III. I will be visiting the manufacturer here to get an assessment of that. I still serve on an Independent Review Team for the Department of Defence on GPS, and we help evaluate risks.

## Do we fail on delivery of geospatial projects?

**Prof P Misra**
Consultant, Land information technologies

The paper draws attention to some of the major difficulties in bringing a geospatial project to a successful end. The difficulties (call them as challenges) will be quite formidable as they emanate from areas which can be called:

- Multidisciplinary
- Multi-organizational
- Multi-locational

These will always be a part of a geospatial project. A judicious use of project – management techniques, as mentioned above may be useful.

## Tracking system for goods

**Koichi Chino, Dinesh Manandhar and Prof Ryosuke Shibasaki**
Center for Spatial Information Science, The University of Tokyo, Japan

We have proposed basic concepts of how to realize the Secure and Safety Tracking System (especially for food, food material) between different countries. The problems to be solved are cleared as follows:

- The certainty of tracking route from producer to consumer through logistic and Value added re-seller over country to country.
- The cleanness of tracking route from export country to import country and the checkpoints as immigration, customs, means of transportation.
- The certification of tracking route and the satisfaction of authorized agency certification

## On GPS/GNSS signals multipath modeling

**Slobodan Nedic**
Consultant in Communication and Navigation Systems & Technologies. Nedics Associates

This article presented some considerationsregarding a due extension and enhancement of the traditional modeling of multipath in Urban- Canyons and other dynamical environments containing Doppler shifts on reflected signal components that are generally different from the LoS Doppler. An extended model has been derived and some simple illustrative scenarios have been evaluated. The impact of the code group delays on GPS/GNSS receiver tracking loops has been discussed in qualitative terms.

# Total Solution
# Bridge to RTK

- Direct up to 300 feet
- Remote (Robotic) up to 150 feet

JAVAD

www.javad.com

Front

# Your Own Complete RTK & Optical

Setup TRIUMPH-3 on top of J-Mate.
Set up TRIUMPH-LS on top of the Zebra rod.

TRIUMPH-3 is the RTK base station and TRIUMPH-LS the RTK rover.
J-Mate is the optical base station and the Zebra rod is the optical rover.

Now RTK and optical solutions are available simultaneously and can verify each other's solutions. They also can cover each other, when one is not available.

RTK has six engines. We treat the J-Mate solution as the seventh engine of the system.

This is the first time that Back sight calibration is done so simple and with one point. There are obvious benefits of simultaneous availability of RTK and optical solutions.

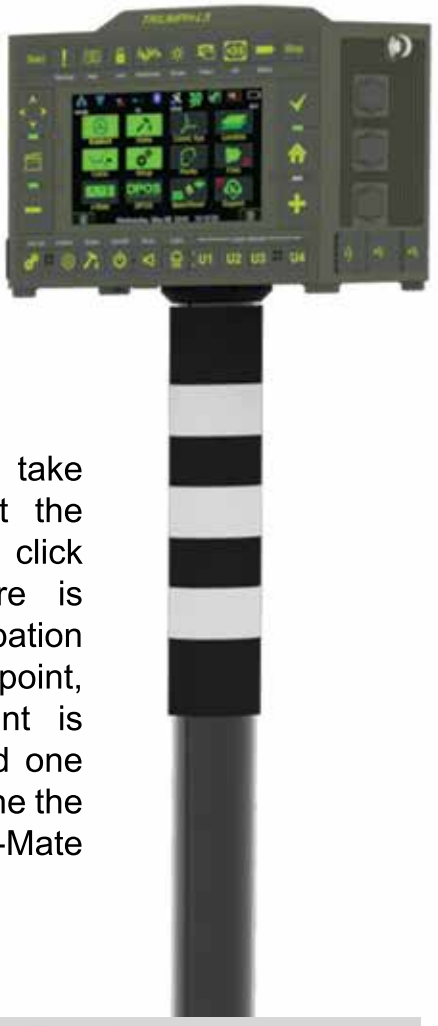
The system is self-sufficient for all jobs. No need to pay RTN service providers for RTK base stations and no need to pay communication service providers. The communications are done via integrated and included Bluetooth, UHF, and Wi-Fi embedded in the system.

Another major advantage is that because your own RTK base station is not far from your rover, RTK solutions will be provided much faster and more reliably.

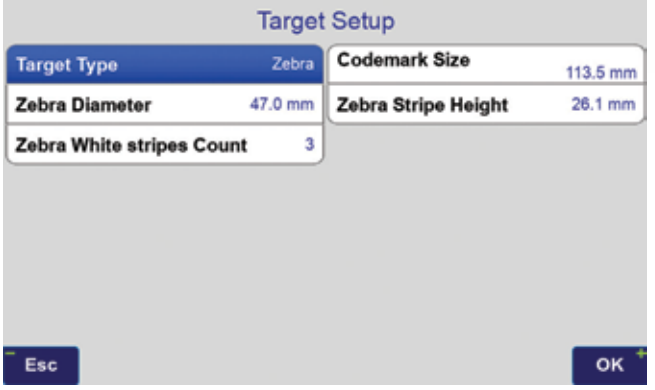
At TRIUMPH-LS = 2.13 kg (4.40 lb), TRIUMPH-3 = 1.26 Kg (2.20 lb), and J-Mate = 2.17 kg (4.41 lb), The total package of 5.6 kg (11.02 lb), weighs less than one conventional optical total station alone.

J-Mate does have complete geodetically encoded scanning (3 points per second) and robotic features too.


# Take Backsight with a Single Shot

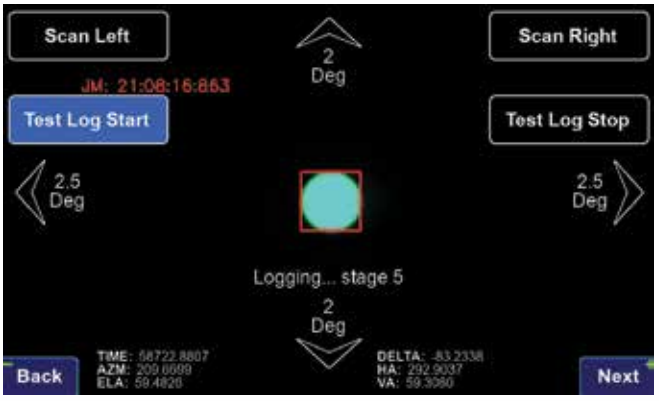



To calibrate the J-Mate, take few seconds of RTK at the Backsight point, and click “Backsight” button. There is no need to locate Occupation Point and the Backsight point, because Occupation point is the RTK Base station and one point is enough to determine the azimuth to calibrate the J-Mate angular encoders.

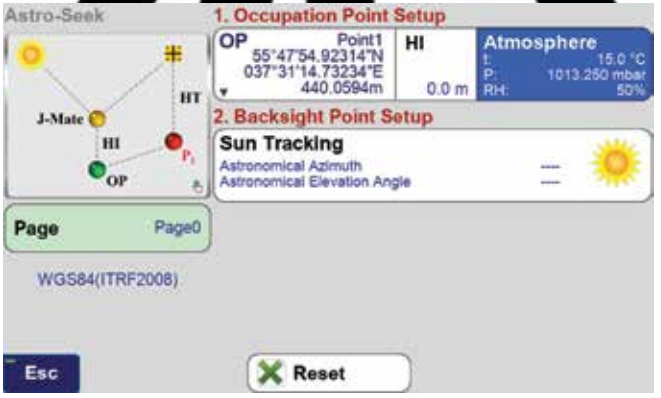



# Backsight with Auto SunSeek

Click a button and after a few seconds Backsight will be calibrated with the Sun AUTOMATICALLY.
Don’t forget the Sun filter.








See details at www.javad.com

# Light Weight, Low Cost

## Costs ½ , Weighs ½ and works much better than conventional total stations and RTK systems.

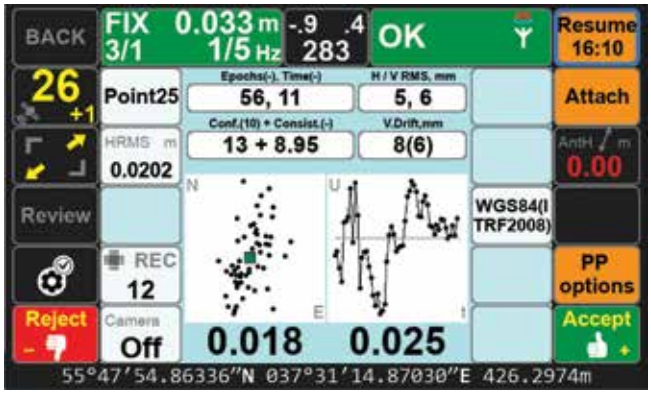
Complete RTK Base & Rover.
Complete optical system.
Complete controller and software.
Free updates.
Robotic & Scanner...
...all under $40K

And it all fits in a small carrying bag.

# Six RTK Engines Auto VERIFY


**Smart assignment of satellite signals to different engines.**

This vigorous, automated approach to verifying the fixed ambiguities determined by TRIUMPH-LS gives the user confidence in his results and saves considerable time compared to the methods required to obtain minimal confidence in the fixed ambiguity solutions of other RTK rovers and data collectors on the market today. The methods required by other systems are not nearly so automated, often requiring the user to manually reset the single engine of his rover, storing another point representing the original point and then manually comparing the two by inverse, all to achieve a single check on the accuracy of the fixed ambiguities. Acquiring more confidence requires manually storing and manually evaluating more points. Conversely, J-Field automatically performs this test, resetting the multiple engines, multiple times (as defined by user), provides an instant graphic display of the test results, and produces one single point upon completion.




# J-Field, the Embedded Controller

J-Field is the embedded application program of TRIUMPH-LS. It has the following unique features for each point surveyed:

- Six parallel RTK engines to maximize solution availability.
- Automatic Engines Resets, verification and validation strategy.
- Several graphical and numerical confidence reports and documentation.
- Voice-to-text conversion for hands free operation and documentation.
- Lift & Tilt and automatic shots for hands free operation.
- Visual Stakeout (Virtual Reality).
- “DPOS it” or “Reverse Shift it” features. The most advanced RTK verification.
- Photogrammetry and angle measurements with embedded cameras.
- Automatic or manual photo documentation.
- Automatic screen shots documentation.
- Audio files for documentation.
- Automatic tilt correction.
- Scanner feature.
- Find objects by their shape, by laser or optical.
- Comprehensive HTML and PDF reports.
- Comprehensive codes, tags and drawing tools.
- Status of all GNSS signals and their quality.
- Over 3,000 Coordinate Systems.
- Automatic and free software update via Internet.


# TRIUMPH-3

The new TRIUMPH-3 receiver inherits the best features of our famous TRIUMPH-1M.

Based on our new third generation TRIUMPH chip enclosed in a rugged magnesium alloy housing.


The TRIUMPH-3 receiver can operate as a portable base station for Real-time Kinematic (RTK) applications or as a receiver for post-processing, and as a scientific station collecting information for individual studies, such as ionosphere monitoring and the like.

It includes options for all of the software and hardware features required to perform a wide variety of tasks.

- UHF/Spread Spectrum Radio
- 4G/LTE module
- Wi-Fi 5 GHz and 2.4 GHz (802.11 a, b, g, n, d, e, i)
- Dual-mode Bluetooth and Bluetooth LE
- Full-duplex 10BASE-T/100Base-TX Ethernet port
- High Speed USB 2.0 Host (480 Mbps)
- High Speed USB 2.0 Device (480 Mbps)
- High Capacity microSD Card (microSDHC) up to 128GB Class 10;
- “Lift & Tilt”
- J-Mobile interface


**Ideal as a base station**

# Global experiences with public private partnerships for land registry services: A critical review

The purpose of this paper is to provide an overview of experiences globally with LRS PPPs and privatization proposals. Readers may recall that in the first part of the paper published in November issue the emphasis was on understanding privatization and Public Private Partnerships. In the second part published in the last issue, the author shared some of the global experiences from Canada, United Kingdom and Malaysia. In this concluding part the author shares the experiences from the Philippines, New Zealand and Australia

**Dr. Keith Clifford Bell**
RFD, FIEAust, FISV,
F.ASCE, LS, CPEng, NER
The World Bank Office
Bangkok, Thailand

## Philippines

The Philippines is a Torrens system jurisdiction, adopted from the version used in Massachusetts, USA, during the American colonial period. The responsibility for land registry in the Philippines is Land Registration Authority (LRA), under the Department of Justice. The LRA's operations are highly decentralized with 16 Regional Registries of Deeds (RD), together with the 162 RDs, as well as the central office in Quezon City, Manila.

The county's land titling system was entirely manual and transactions could take years to process, unless informal fees were paid. At least half of legally occupied land is not registered. There is a high proportion of fake and fraudulent titles in the system. Most RDs were in poor dilapidated condition and lacked security. All records were held in largely disorganized storage roos lacking security. There was weak capacity and no IT infrastructure. To do a land transaction it was always necessary to visit the local RD covering the municipality, province or district where the parcel was located.

In the Philippines, the land titling system was entirely manual and transactions could take years to process, unless informal fees were paid. At least half of legally occupied land is not registered. There is a high proportion of fake and fraudulent titles in the system. Most RDs were in poor dilapidated condition and lacked security

In 2003, the Philippines launched the Land Titling Computerization Project (LTCP) to restore confidence in the country's registry and titling systems and raise its level of service to the public. To proceed with computerization, and in the difficult fiscal situation of the country, which was a developing country, the only way forward was to see private sector financing. The government decided to pursue a PPP with private sector joint venture consortium partner, the Land Registration Systems, Inc. (LARES). LARES is the project company formed by the STRADEC consortium that was awarded the contract for the LTCP under a Build-Own-Operate Transfer (BOOT) arrangement, as provided by Republic

Act No. 1778 and its Implementing Rules and Regulations. As such, LTCP is being implemented at no cost to the government. It is wholly funded by the private investors without any government guarantee.

It is noteworthy that none of the consortium members had experience with land registration or automation. The initial lease was for ten years without guarantee of renewal. Early into the project, the private partner struggled, lacking competence and there were also issues on the government side. The project stalled for around two years and worked through an arbitration process. When it restarted around 2005-06, there were changes to the consortium partnership and the proposed backing by the International Finance Corporation did not proceed. Importantly a technical partner was brought on board - IL&FS Technologies India, part of IL&FS Group, one of the largest infrastructure and finance conglomerates in India. It is also notable that the BOOT agreement morphed into a BOO structure and the original ten-year concession period, seem to have been forgotten.

Governance has been a constant concern throughout project implementation. A further key issue has been charging government agencies at both national and local level for data. Notably, many of these government agencies contribute data free of charge to the LRA, and prior to the project received free access to land records.

Nonetheless significant progress has been made. As at August 2017 total of 159 RDs have been fully computerized. A further innovation is called "Anywhere-to-Anywhere (A2A)," under which the public can apply for certified true copies of land titles, located in all other parts of the country, by going to any of LRA's Registry of Deeds offices nationwide.[78]

In sum, the BOO PPP could be judged as successful in the Philippines, where it has almost achieved full national computerization. Private finance was the only viable option for the government. However, implementation has not been smooth and it is largely assessed that government has lost ownership of land titling data through the BOO modality.

Under the original BOOT modality, full operations, including all data would have returned to government. There was no real opposition to the PPP. The general public was largely unaware and there was no significant professional opposition. There have been no staff cuts, so staff opposition was negligible. It is unknown as to whether the private consortium has yet recouped its outlays at this time, and once it has, as to whether any royalties will be returned to government. [79]

## New Zealand

Much can be learned from the experiences in New Zealand – lessons that Australia seems to have ignored. Land Information New Zealand (LINZ) was formed in 1996 following the restructure of the then Department of Survey and Land Information (DOSLI). DOSLI was restructured into Land Information New Zealand (LINZ) and Terralink NZ Ltd on 1 July 1, 1996. LINZ was vested with core government land related regulatory and purchase functions. Terralink NZ Ltd (then a State-Owned Enterprise and now fully divested from government and is a private company) was vested with the commercial activities. (NB. At the same time the responsibility for hydrographic services was transferred from the Royal New Zealand Navy to LINZ.)

In establishing LINZ, the government considered a PPP for land registration and an offer from Unisys was received and rejected. The specific reasons for rejection are not available. [80]

New Zealand gave further consideration to a LINZ PPP a few years later, and in 2013, as part of its decision-making process, LINZ hired ConsultingWhere Limited and ACIL Allen to review the suitability of the Ontario LRS PPP for New Zealand. The review would seem to provide a balanced assessment of the Ontario-Teranet PPP operation:

*"It can be argued that the public private partnership and subsequent contractual arrangement have been a success. It enabled the development of a fully functioning electronic land registration system by the late nineties. The land registration process is now virtually all electronic, all records have been converted and there is an effective electronic land registration system readily accessible to the property business and the citizen. Financially, a long-term sustainable model has been established which yields profits for Teranet and revenue and royalties for the Government of Ontario. The latter has been able to benefit from the increased value of the business even after it sold all of its stake in it. Meanwhile, the public interest is able to maintain regulatory control whilst retaining ownership of the data.*

*On the down side, the conversion of records to POLARIS took longer and cost far more than originally estimated. The arrangement is monopolistic to the detriment of other commercial interests and competition especially in respect of the value-added services. Ontario is now locked into a very long-term agreement with Teranet which could lead to complacency and a lack of incentive to evolve the ELRS in line with technological and other changes and increasing user expectations. "* [81]

However, the consultant concluded with a risk analysis with very strong warnings:

*"The dangers inherent in the type of arrangements operating in Ontario if there are not strong controls and effective governance in place, particularly where agreements run for decades, are that: · The service provider will exploit their monopoly position to the detriment of any potential competitors for value added services; · Public ownership of the data does not guarantee access to the data if it is via a service provider that has little incentive to promote its use by others; · The rights of smaller players in the data deriving originally from them may get lost in the rush to establish an ELRS; · There will be little incentive for technological advance on the basis of, 'if it ain't broke don't fix it' or more aptly, 'if it ain't broke don't spend money on it'; · There will little incentive to upgrade the data and no migration path in*

As can be seen, LINZ did not pursue PPP for land registration services, following its careful consideration of the independent review – the risks far outweighed likely benefits. This would seem to be in stark contrast to both NSW and SA which did not take reviews of the nature commissioned by New Zealand and did little in terms of risk analysis, at least with such information made publicly available

*place for this to take place; · There is a lack of transparency in financial reporting."* [82]

As can be seen, LINZ did not pursue PPP for land registration services, following its careful consideration of the independent review – the risks far outweighed likely benefits. This would seem to be in stark contrast to both NSW and SA which did not take reviews of the nature commissioned by New Zealand and did little in terms of risk analysis, at least with such information made publicly available.

LINZ is currently working on Advanced Survey and Title Services (ASaTS), a project for updating and expanding the range of services offered by the Landonline system for property transactions. This is the next generation of New Zealand's Landonline system, first introduced in 2000.

*"LINZ plans to use an 'as a service' model for Advanced Survey and Titles Services (ASaTS). This means that instead of paying a vendor to build a system that we then own, we'll select a vendor that can deliver a suitable system that we pay to use – a bit like renting. We are now working through procurement processes to find a vendor to deliver this."* [83]

LINZ has not reported the expected costs as the government has deemed it to be "commercially sensitive".

The project schedule for ASaTS (below), is a multi-year effort based on rigorous research and business planning:

- *2013 Indicative Business Case – approved by Cabinet November 2013 and identified a preferred investment option.*
- *2014 Request for Information (RFI) March – May 2014- sought market information to implement the preferred option for providing survey and titles services in the future.*
- *2014-2015 Detailed Business Case on the preferred option, approved by Cabinet November 2015.*
- *2016 Cabinet approval for 'as a service' approach to deliver ASaTS. LINZ begins procurement process to select a vendor.*
- *LINZ anticipates having ASaTS in place by 2021.* [84]

In sum, New Zealand seems by all accounts seems to have undertaken due diligence, including obtaining independent expert advice, throughout its evolution from DOSLI to LINZ and has now adopted a strategic, low-risk approach for its primary business system provided by the private sector.

### New South Wales

In April 2017, the NSW government announced the awarding of a 35-year lease of the state's land registry, under Land and Property Information (LPI), to a consortium comprising Australia's Hastings Funds Management and pension fund First State Super. Under the deal, described as a "purchase", the consortium has agreed to pay A$2.6 billion to run New South Wales state's land registry. The consortium is made up of 80 percent Australian institutional investors, including First State Super, investment funds from Hastings Funds Management and a 20 percent stake held by the Royal Bank of Scotland Group. The consortium has received the relevant regulatory approvals to proceed. The PPP operated Land Registry will be answerable to the state's Registrar General. The government has the power to resume control of the Land Registry if required. This author is not aware of the specific conditions required to resume control by government including any payments, notification periods, dispute arbitration and so forth.

The primary driver for the PPP, which the NSW described as a "sale" is to fund infrastructure across New South Wales, as population growth and a housing boom, particularly in Sydney, "stretched public services" such as transport. However, the former Premier has also advised that a significant proportion of the proceeds would finance a major new sports stadium. NSW has also continued to report much of its justification being based on much-lauded "successes" of the Ontario LRS PPP.

A former NSW Registrar-General, Kevin Nettle, who has also worked in international development assistance for land registries, advised [85]:

*"I had hoped to see what the stated justification was for the change but the case is lacking any support. Many of the registries in the case studies were so undeveloped that something drastic had to be done and PPPs were a good solution. However, NSW was not in that situation, either from a technological or a customer service viewpoint. It was the first registry to computerise and I was invited to the Canadian Registrar's Conference in 1987 to present on our achievements and went to Ontario to see what they were attempting with Teranet at that time. We were way ahead of them. In NSW, all the hard work of data conversion was done long ago and services are online. National Australia Bank became our first online customer in the 1980s.*

*Some of the justification relates to creating a more customer focussed organisation. But again, back in my time the NSW registry won the Australian Quality Award for Service Quality competing against the private sector. That service quality must still exist as all the professional bodies, Law Society, Institution of Surveyors etc. opposed the sale of the registry.*

*So, the government has foregone an annual dividend of 150 million and rising in return for a one-off payment of 2.6 billion much of which will go to fund a football stadium. Maybe this is short term political thinking or just political ideology. If there is any justification it can only be in the redevelopment of the computer systems. Many of these are now some 20 years old and no doubt are old from a computer viewpoint and could be redeveloped. Whether that needed to be done by the private sector is a moot point as the registry had always been able to manage it previously helped by the fact that it was an executive agency. Landgate, which bought the NSW system in 2000, is currently redeveloping through Advara. Maybe they are now hoping to sell that back to NSW."*

Critical concerns were raised by professions including lawyers and surveyors, which are well summarized by a former President of the Law Society of NSW:

- The land registry is a natural monopoly and critical infrastructure upon which the security of business and commerce are based.
- Lack of an independent assessment of the deal, and whether the expected upfront payment is suitable compensation for forgoing the annual revenue.
- Likely requirement for home buyers to pay title insurance, as occurs in the US. Title insurance on the purchase of a A$1.4m property is currently about A$990. Based on 213,000 land transfers lodged in NSW in 2016, it amounts to around A$210 million in insurance premiums or tens-of-billions of dollars over the 35-year term of the lease.
- Failure to consider why similar PPP proposals were rejected in other jurisdictions around the world.[86]

In sum, NSW had an efficient, well-capacitated land services agency, LPI, with modern technology prior to entering the PPP. The government saw an opportunity, for realizing significant immediate funds from the private partner to fund infrastructure and it was fixed on this path. The NSW PPP is held to be a great success by both the Victorian and SA governments

Significantly the lack of an independent objective assessment could be considered to be a breach of duty of care and due diligence. In late 2014, the NSW Productivity Commission's report on the provision of public infrastructure, explicitly warned that the government's financial incentives for privatization of public assets ("asset recycling"):

*"...could act to encourage privatization in circumstances that are not fully justified and encourage the selection of new projects that do not have demonstrable net benefits".*

The NSW PPP raises many concerns:

- NSW's primary justification for the PPP, was short-term funding needs to invest in infrastructure. NSW's LR was modern, advanced in use of digital technologies, provide good service delivery, was secure, met the required obligations to state and federal police for Law Enforcement Agency Network (LEAN) agreement, had the confidence and trust of the banking sector, professions, private business and the general public.
- The real return to the state through the PPP versus what would have been realized over 35 years was not provided for public scrutiny. Media has reported "insider" views that the sale was a bargain and the real upfront payment should have been A$3-4 billion. LPI, which enjoys a 70 per cent profit margin, generated $190 million in revenue in 2015-16. Fees for regulated products will rise by CPI each year. Leaked government sales pitch documents stressed the billions of dollars profit that would be made by the private investor. [87]
- The government chose to ignore widespread public opposition to the PPP and proceed. This suggests that the government had no intention to change its mindset and was never open to considering alternatives or the wishes of the electorate. Both the former and current Premiers presented the Ontario success in their respective pitches the NSW PPP.

In sum, NSW had an efficient, well-capacitated land services agency, LPI, with modern technology prior to entering the PPP. The government saw an opportunity, for realizing significant immediate funds from the private partner to fund infrastructure and it was fixed on this path. The NSW PPP is held to be a great success by both the Victorian and SA governments. Both SA, and now also Victoria, utilize the NSW PPP establishment as justification for proceeding down similar paths for their respective jurisdictions.

What enabled the NSW LRS PPP to proceed? The government which doesn't control the Upper House of Parliament, secured the vote of Reverend Fred Nile, Christian Democrat, to get the requisite legislative bill passed. [88]

### South Australia

The SA government announced its intention to "commercialize" a range of transactional land services and functions in the 2016-17 State Budget.

On August 10, 2017, the SA Premier announced that Land Services SA has been appointed as the exclusive service provider for South Australia's transactional land services, which cover land registration and valuation for a period of 40 years. The Government will receive A$1.605 billion in an upfront payment. The Government also will receive an ongoing annual royalty stream. The Land Services SA consortium comprises Macquarie Infrastructure and Real Assets and the Public Sector Pension Investment Board of Canada. The deal is comparable with that signed in NSW in April 2017. Notably, the NSW PPP does not cover valuation services.

Although the commercial details of the contract are confidential, what is known includes:

- The contract includes a commitment by Land Services SA to establish an Innovation Hub in Adelaide, provide A$35 million in ICT investment in South Australia and to work with local digital start-ups.
- Land Services SA will accelerate innovation and investment in transactional land services and functions as it will be investing in major ICT systems and bringing new product offerings to market.
- Under the commercial contract, the government retains key legal, policy and regulatory functions and responsibilities while the private sector takes over processing of transactions for the next 40 years.
- Government will continue to set prescribed fees and charges for land services
- Land Services SA will have exclusive rights to commercialize related data, subject to Government approvals.

Land Services SA will adopt the existing Lands Titles Office information technology systems. Some existing staff will be expected to be hired by Land Services SA, which implies an early loss of expertise, and long-term risk of any early recovery of the land functions if the contract had to be terminated.

In addition to the upfront payment and annual royalties for the period of the PPP, the government perceives the key benefits included:

- Reduction of future operating costs to government and drive innovation in customer service.
- Promotion of investment in systems and reduce risks to government in future ICT upgrades.

The SA government has been very specific of the statutory responsibilities that will reside with, and be oversighted by the government which include:

- Continuing to guarantee indefeasibility of property title, supported by the statutory assurance fund;
- No change to Torrens Title or other legal status of land;
- The Government retaining key legal, policy and regulatory functions and responsibilities with the statutory positions of the Registrar-General, Valuer-General and the Surveyor-General continuing;
- The Government will continue to set regulated fees and charges with no changes other than the standard annual increases applied;
- The Government retaining ownership of titling and valuation data and associated intellectual property;
- Stringent service delivery standards, data security and privacy protections –with penalties, up to termination of the contract, for breaches.

Key opposition to the PPP included [89]:

- The Law Society of South Australia and the Property Council raised the key risks compromising data security, eroding services, as well as increasing consumer costs;
- The Public Service Association (PSA) and Australian Institute of Conveyancers have also raised concern about the likely need for title insurance, risk of compromising privacy, failure to publicly disclose protections and risk mitigations due to "commercial in confidence";
- The government's move to PPP was more about a short-term cash injection.

The PSA established a very informative website "The Secret Selloff" which provides a very comprehensive coverage of media reports of government "asset recycling" proposals, including LPI, which is informative and inciteful.[90]

What has not received adequate exposure is the real return to government over the 40-year period taking into account the upfront payment, annual royalties adjusted for changes in prices due to inflation or other external effects and so forth. Assessing the nominal rate of return in real terms, which keeps the purchasing power of a given level of capital constant over time. Adjusting the nominal return to compensate for factors such as inflation allows you to determine how much of your nominal return is actually real return. Was there a net social benefit analysis?

In sum, SA had an efficient, well-capacitated land services agency with modern technology. The government saw an opportunity, for realizing significant immediate funds from the private partner and also ongoing technology innovation to support the state. Opposition to the PPP was largely ignored by the government. The funds realized from the upfront payment became available for other government financing priorities. This is most definitely a case of the devil being in the detail.

### Western Australia

Landgate, formerly the Department of Land Information (DLI) (and earlier the Department of Land Administration, DOLA) is the statutory authority responsible for land registration services, property and land information in Western Australia. In Landgate's creation as a statutory authority, it adopted a hybrid model with both public and private characteristics. The compromise provided the financial flexibility, but the government's greater oversight made the model more palatable to officials. The state continued to regulate prices for core services such as registration and valuation, and the new authority would still provide discounted services for other government offices - paid for by a state budget allocation. But the new agency could also develop and sell commercial products and services, and it would be

responsible for funding its own operations and investments by using fee based revenue and commercial profits - enabling it to build any new IT systems it could afford.

Significantly, the legislation establishing Landgate required it to generate a "fair commercial return", with a portion of the agency's profits, agreed upon each year with the minister, to be returned to the state government. The legislation enabled Landgate to engage in a wide range of business activities, such as providing consulting services, developing and marketing software or other intellectual property, forming companies, partnerships, or joint ventures and also commercializing land information.

When Landgate commenced in 2007, Western Australia faced the biggest land boom in the state's history with the volume of transactions increased by 35%. With manual processes and limited staff, the registration of even a simple transaction took up to six weeks at the height of the boom.

In order to deliver land, mapping and geospatial services and provide context to the State's property interests, Landgate coordinates access to location information held across WA government departments through the Western Australian Land Information System (WALIS). Landgate operates an open data platform called the Shared Location Information Platform (SLIP).

The immediate-past CEO of Landgate, Mike Bradford reported to the 2016 GovInnovate conference:

*".....the agency saw the writing on the wall in 2010, as the advance of electronic property trading gathered pace, and other states began to sell their own registries to the private sector in anticipation of the market shake-up.*

*Since then, NSW has announced its intention to sell off part of Land and Property Information, and SA is formally scoping its options for its own Lands Titles Office. Victoria's then-Liberal government threatened to do the same in 2014 before it lost office.*

*'We are seeing privatization of land registries starting to occur largely because the governments in each of those jurisdictions don't believe that the government-owned operator has the capability or capacity to deal with the industry transformation we see coming'...*

*But instead of sitting and waiting to be dismantled, Landgate launched into a five-year, IT-based revolution."*

Since 2010, Landgate has undergone radical transformation as an alternative to moving to a PPP. [91] The outcomes have seen a drastically smaller, vastly automated organization, as well as establishing Advara. A privatized Landgate subsidiary that was awarded the A$140 million IT contract for Landgate in December 2016, without bids being sought from competing providers. Landgate said it received an exemption from the requirements of the State Government's competition policy from the Public Sector Commission (PSC) before handing out the contract.

The IT system for online title management, which is owned by Landgate, and for which Advara has the contract, was developed by partner Adecco. In addition to its IT contract to Landgate, Advara will continue to partner in bids on PPPs for other land titles registries. Advara was a technical adviser to the consortium that successfully bid on the A$2.6 billion PPP for NSW's land registry services.

Advara is 78 per cent-owned by the Western Australian government, through Landgate, and 22 per cent by Swiss outsourcing giant Adecco, which paid A$2 million for its stake in the company in August, 2016. In July 2017, it was announced that the Landgate CEO, Mike Bradford, had stepped down and had been being appointed Advara's CEO. Bradford was seconded to act as Advara chief executive in February 2017, having sought permission from the PSC for the transfer shortly after the IT contract was awarded. [92] One can easily speculate on governance issues concerning Advara, but that is beyond the scope of this paper.

There are many lessons to be learned from the Landgate experience, which to date has avoided going down the LRS PPP:

*"The statutory-authority model adopted in Western Australia had both advantages and drawbacks. Despite operating increasingly like a private company, Landgate still had to adhere to public-sector policies on human resources and financial management—for instance, not investing some of its cash reserves because doing so would add to the state's already high net debt. Being a statutory authority meant Landgate faced financial pressures for efficiency but could think beyond the bottom line. Despite certain limitations, the broad commercial powers accorded to Landgate in its enabling legislation gave it far more flexibility and space to innovate than government department."* [93]

In sum, Landgate was faced with many challenges including efficiency, technology upgrade investment, financial return to government and so forth. The government adopted the modality of a

Landgate was faced with many challenges including efficiency, technology upgrade investment, financial return to government and so forth. The government adopted the modality of a statutory authority to operate the LRS and source its IT from by a private sector partner Advara

statutory authority to operate the LRS and source its IT from by a private sector partner Advara. Having said that, it is arguably ironic that Advara, majority-owned by the WA government is actively lobbying and pursuing business in other jurisdictions for land registry PPP and privatization.

Subsequently, since the original version of this paper was produced, Western Australia proceeded to enter into a forty-year lease for Landgate for A$1.4 billion with Land Services WA, a consortium comprised of Macquarie Infrastructure and Real Assets, and superannuation funds Sunsuper and HESTA.[94]

### Other cases

There are extensive other PPP case studies that could have covered in this report, but time and space precluded their inclusion. However, these further examples are all developing countries, and whilst all are interesting with pros and cons, they are of less relevance to the Australian context.

These further cases include:

- Nigeria – states of Ondo and Kaduna.
- Cabo Verde, a former Portuguese colony, is an archipelago approximately 570 kilometers west of Senegal, West Africa.
- Honduras
- Jamaica – another PPP with Teranet as the private partner
- India – Maharashtra State.

## Part C: Lessons and conclusions

### Safeguards

There are always risks associated with any decision to partner with the private sector in delivering land registration services. What may work in Jurisdiction A, may not work in Jurisdiction B due to one or more local factors that may not have been fully considered.

There would seem to be a consensus across most of the case studies that among critical safeguards that any government should have in place, there are always two key functions that must be under government control:

- setting fees
- ownership of data.

Other safeguards may include the retention of key statutory officer functions within government including Surveyor-General, Registrar-General and Valuer-General – where such positions, or their respective equivalents exist.

However, such critical oversights must be monitored and the role of the jurisdictional Auditor-General would seem to be critical. Of course, governments must act on the advice received.

From the perspective of law and order, it is important that law enforcement agencies have access to land registry information to help them in issues of monitoring and investigation of matters such as money laundering.

The rights of citizens to privacy and confidentiality should be protected and private partners should be prohibited from either commercializing such data or passing it to others except for official government purposes.

State lands (often called Crown or public) lands should also not be compromised by PPP lease.

Finally, where jurisdictional governments guarantee title, that should not be comprised.

Clearly, these thoughts on safeguards to mitigate risks, are brief. Identifying safeguards is one thing, ensuring compliance is another, and may prove to be challenging, especially if it is necessary to terminate the contract and for government to resume the land registry services operation.

### Updates

Since the original version of this paper was prepared, the Land Registry of the Australian State of Victoria, was leased for an initial forty-year concession in August 2018 for A$2.86 billion to Australia's First State Super.[95] Notably, Australia's First State Super also secured the concession for the Australian State of new South Wales land registry services in August 2017 for A$2.6 billion. .Despite public outcry, and the significant opacity on making publicly available the real financial return or otherwise, using the usual economic and financial analyses based on net present value determinations, the government stuck to its policy decision to proceed. It is significant that this is the normal path for governments wishing to move down this path. Subsequently, the Australian State of Western Australia also entered into a forty-year concession for its land registry (Landgate) in September 2019 for A$1.4 billion. [96] There is no such thing as "readiness" for land registry PPP or full privatization, rather it is almost always a policy decision to yield a quick windfall to produce better government budgetary figures and in some cases to fund election promises. Nonetheless, it is the prerogative of governments to make such decisions.

It is especially profound, that Professor John Quiggan's [97] submission to the Victorian Upper House Enquiry advised:

"Broadly speaking the activities most suited to the private sector are those characterized by competitive markets, limited need for regulatory oversight, a wide range of products with constant innovation and significant opportunities for gains in operating efficiency. Conversely, the activities most suited to the public sector are natural monopolies operating in stable environments and requiring close regulation." [98]

Quiggan further advised that:

*".. a land titles registry service represents a 'natural monopoly' and is best operated by the public sector."* [99]

Prudently, Australia's watchdog, the Australian Competition and Consumer Commission (the ACCC) told the

*"Committee that a private operator in the land titles register with 'existing upstream or downstream interests in related markets' requires government to enact appropriate and effective regulatory arrangements to ensure competition issues are addressed.'* [100]

## Concluding remarks

There is a lot to learn from those LRS PPPs which are reported to be successfully operating, especially from Ontario and Manitoba and the respective justifications for going down the PPP path. On the other hand, there is a lot to be learned from jurisdictions that are reported to have rejected the LRS PPP or privatization approaches. Why have similar arguments prevailed in some jurisdictions but failed in others? Understanding the political economy is essential.

Jurisdictions including Nova Scotia, New Zealand and the UK have looked at the Teranet Ontario experience and rejected it. On the other hand, Manitoba and Jamaica contracted Teranet to be the private sector partner. It seems to be very much the case that NSW and SA governments have cherry-picked the Ontario-Teranet experiences to support their respective PPP decisions and the Victorian government is now following suit. What differs in each of the Australian cases from those of Ontario, Manitoba and even Jamaica, is that the Australian state government registries are well-capacitated, have good technology, are computerized, provide high-levels of service and are highly regarded, support law enforcement agencies and so forth. The justifications in each jurisdiction are to "recycle an asset" to provide immediate cash injection to the governments. In contrast, Ontario and Manitoba lacked good capacity, were not modern and struggled to meet local demands. These are clearly very different drivers and would for all purposes suggest the need for ASD including PPP.

If government has a LRS sale or private partnership arrangement firmly in its sights, there may be little that can be done to change the political will – and even harder if the government has a strong majority. Such governments, with sights set on a fast fat cash injection to jurisdictional coffers, are unlikely to be swayed by arguments such as:

- Guaranteeing integrity of the property boundary system
- Ensuring that registration services continue to be delivered by suitably qualified and experienced persons
- The need for registrations services to be able to evolve because of innovation and advancements in technology
- Recognising and maximising the value of the registration services
- History of the jurisdictional titles office.

Arguably, for both proponents and opponents, it is better to focus on more substantive factors such as:

- Real return of any deal using net present value methodology computed over the lease period
- Governance, transparency and accountability
- Roles of statutory officers
- Law enforcement access to information specially to investigate money laundering
- Risks and mitigations of LRS being delivered from off-shore locations and being subject to the obligations of foreign laws
- Government agency access to information including public (crown) lands records
- PPP contractual remedies
- Fees
- Impacts on Financial Institutions requirements.

It seems that in most jurisdictions key government watchdogs and information privacy commissioners have raised strong concerns and are likely to be ignored if the government has a strong majority. There is a role for Auditor-Generals in reviewing risks, accountabilities, due process and business cases.

Continued pursuit of fiscal reform to reduce deficits and balance budgets by "recycling assets" is a finite strategy. Once all the government's viable assets, i.e. those that may be attractive to private investors – are either under PPP or privatized, what's next?

Finally, it is useful to especially look at decisions taken by the governments such as New Zealand which carefully looked at roles for the private sector and have made decisions that work for their respective jurisdictions. New Zealand undertook extensive due diligence into its decision to enter into a PPP for its IT-related requirements for land registration services. Significantly the due diligence was objective, technically sound and financially prudent, rather than political. The New Zealand approach is definitely one that should be studied by any government considering going down the PPP path for land registry services.

Malaysia would seem to be an example of government stepping in to provide a course correction to the PPP approach, and then resuming, with close monitoring. There may be roles for the private sector in land registry services and with due diligence they can be successfully established to deliver benefits.

Although this paper has confined itself to land registry services, it would be relatively simple to draw parallels to the New Zealand experience in considering going down a PPP path for geospatial information services such as a national geodetic network of Continuously Operating Reference Stations (CORS) and

> Although the decision to contract with a private sector partner may be taken for primarily political reasons, and there may be significant negative public sentiment, nonetheless, the public interest and the rights of citizens, should always be protected by adequate safeguards, which are monitored and transparent. The ability of the government to ensure the safeguards may not be easy.

even for production and maintenance of fundamental geospatial data sets for the national spatial data infrastructure. For both, the government should always retain the strong regulatory oversight roles to ensure the authoritative requirements of NSDI are retained.

Although the decision to contract with a private sector partner may be taken for primarily political reasons, and there may be significant negative public sentiment, nonetheless, the public interest and the rights of citizens, should always be protected by adequate safeguards, which are monitored and transparent. The ability of the government to ensure the safeguards may not be easy.

## Endnotes

78 http://www.philstar.com/business-usual/2017/08/14/1728525/easy-access-land-titles-a2a-computerized-process

79 This overview was largely prepared by the author's own notes and records from engagement in reviewing the original project back in 2003 up until 2015. The author also has a copy of the original BOOT contract obtained when advising IFC of its possible membership of the LARES consortium.

80 Email exchange dated May 20, 2017 with Neil Pullar, former DOSLI and Terralink staff, FAO specialist and now land administration consultant.

81 ConsultingWhere Limited & ACIL Allen, 2014, Annex B, Section 8, p.21.

82 Ibid, pp.23-24.

83 LINZ website, status as at April 19, 2017. http://www.linz.govt.nz/about-linz/our-organisation/our-whakapapa

84 ibid

85 Private email from Kevin Nettle to the author, June 28, 2017.

86 Margaret Hole (2017). https://www.macrobusiness.com.au/2017/04/nsw-land-registry-everything-thats-wrong-privatisation/

87 http://www.smh.com.au/nsw/leaked-nsw-treasury-document-reveals-billions-to-be-made-by-land-title-registry-operators-20170201-gu2wed.html

88 http://www.smh.com.au/business/consumer-affairs/baird-governments-privatisation-of-nsw-land-titles-registry-to-lift-costs-for-home-buyers-20161011-gs086i.html

89 https://www.macrobusiness.com.au/2017/06/sa-joins-reckless-land-registry-privatisation/

90 http://www.secretselloff.com.au/media/

91 https://www.itnews.com.au/news/how-was-land-registry-used-tech-to-save-itself-from-privatisation-441668

92 Advara is 78 per cent-owned by Landgate and 22 per cent by Swiss outsourcing giant Adecco, which paid $2 million for its stake in the company in August.

93 Daniels, 2017.

94 https://www.abc.net.au/news/2019-09-10/wa-property-database-landgate-sale-to-fund-child-abuse-redress/11498056

95 https://realassets.ipe.com/news/first-state-super-wins-land-registry-rights-in-aud286bn-deal/realassets.ipe.com/news/first-state-super-wins-land-registry-rights-in-aud286bn-deal/10026342.fullarticle

96 https://www.abc.net.au/news/2019-09-10/wa-property-database-landgate-sale-to-fund-child-abuse-redress/11498056

97 Quiggan is a Vice-Chancellor's Senior Research Fellow and Australian Laureate Fellow in the School of Economics at the University of Queensland.

98 https://www.parliament.vic.gov.au/images/stories/committees/SCEP/Land_Titles/EPC_58-12_Text_WEB.pdf Professor John Quiggan, Submission, no. 50, p. 4.

99 ibid.

100 Australian Competition and Consumer Commission (ACCC), Submission, no. 60, pp. 1-2.

## References (selected)


Canadian Center for Policy Alternatives, (2015), Privatization Nation: The Canada-wide Failure of Privatization, Outsourcing and Public-Private Partnerships, Saskatchewan Office – CCPA, November 2015.

Canadian Council for Public- Private Partnerships, (2016), Overview of the Canadian Public Private Partnerships Market, CCPPP publication, Canada.

http://www.lavery.ca/en/publications/our-publications/2986-overview-of-the-canadian-public-private-partnerships-market.html

ConsultingWhere Limited and ACIL Allen for Land Information New Zealand (LINZ), (2013), Better Property Services: Assessing the Economic Value of a Better Property Services (BPS) Future, Final Report, November 30, 2013. Also, Annex B to Final Report: Case Study, Canada – Ontario, Version 1, November 2013, Wellington, New Zealand.

Chin, C., (2007), E-Tanah system lets many down, The Malaysian Bar, Used with Permission from "The Star", December 22, 2007, Penang, Malaysia.

http://www.malaysianbar.org.my/bar_news/berita_badan_peguam/e_tanah_system_lets_many_down.html

Daniels, A., (2017), The Way Forward: Public Private Partnerships in Land Administration, June 27, 2017, World Bank, Washington D.C., USA.

Delmon, J., (2010), Understanding Options for Public-Private Partnerships in Infrastructure: Sorting out the forest from the trees: BOT, DBFO, DCMF, concession, lease…, World Bank, January 2010, Washington D.C, USA.

http://documents.worldbank.org/curated/en/999661468323693635/Understanding-options-for-public-private-partnerships-in-infrastructure-sorting-out-the-forest-from-the-trees-BOT-DBFO-DCMF-concession-lease

Department for Business Innovation Skills, (2014), Government Response: Introduction of a Land Registry service delivery company, July 2014, London, UK.

https://www.gov.uk/government/consultations/land-registry-new-service-delivery-company

Department for Business Innovation Skills, (2016), Consultation Document: Consultation on moving Land Registry operations to the private sector, March 24, 2016, London, UK.

https://www.gov.uk/government/consultations/land-registry-moving-operations-to-the-private-sector

FDA, (2016), FDA Response to BIS Consultation on Moving Land Registry Operations to the Private Sector, May 10 2016, London UK.

Gainer, M., (2017), Breaking New Ground: Pioneering Electronic Land Registration in Ontario, 1987–2010, Innovations for Successful Societies, January 2017, Princeton University, USA.

https://successfulsocieties.princeton.edu/sites/successfulsocieties/files/Canada%20Case%20Study%20With%20Logo%20JRG_1_30_2017.pdf

Gainer, M., (2017), Embracing Disruption: Transforming Western Australia's Land Agency 2007 - 2017, Innovations for Successful Societies, May 2017, Princeton University, USA.

Gowers, E., (1954), The Complete Plain Words, Her Majesty's Stationary Office, London.

G20, (2017), G20 Leaders' Declaration: Shaping an Interconnected World, July 2017, Hamburg, Germany.

http://www.consilium.europa.eu/en/press/press-releases/2017/07/08-g20-hamburg-communique/

Hall, D., (2015), Why Public Private Partnerships Don't Work: The Many Advantages of the Public Alternative, Public Services Research Institute, University of Greenwich, First published January 2014 and updated February 2015, UK.

http://www.world-psi.org/sites/default/files/rapport_eng_56pages_a4_lr.pdf

Hanifah, F.A., (2012) potential for Public-Private Partnership (PPP) for SDI in Malaysia, Exchange Forum: Public – Private Partnership for SDI, Geospatial World Forum April 26, 2012 | Amsterdam, The Netherlands.

https://geospatialworldforum.org/2012/gwf_PDF/Puan%20Fuziah.pdf20Fuziah.pdf

Legislative Assembly of Ontario, (2001), Committee Documents: Standing Committee on Public Accounts - 2001-Nov-01 - Special Report, Provincial Auditor, Thursday 1 November 2001, Consideration of section 3.03, project to automate the land registration system (Polaris).

http://www.ontla.on.ca/web/committee-proceedings/committee_transcripts_details.do?locale=en&BillID=&ParlCommID=2&Date=2001-11-01&Business=Special+Report%2C+Provincial+Auditor&DocumentID=19792

McCann, D. and L. Macfarlane, (2016), Future profits vs short term cash: what's at stake in the great British Sell-off, New Economics Foundation on with support from We Own It, May 2016, UK.

https://weownit.org.uk/sites/default/files/attachments/Future%20profits%20vs%20short%20term%20cash%20-%20What%27s%20at%20stake%20in%20the%20Great%20British%20sell%20off.pdf

Mok, O., (2013), Penang PAC investigates faulty e-Tanah system, Malay Mail Online, September 25, 2013, Malaysia.

http://www.themalaymailonline.com/malaysia/article/penang-pac-investigates-faulty-e-tanah-system

Office of the Auditor General of Ontario, (2014), Annual Report, Fall 2014.

http://www.auditor.on.ca/en/content/annualreports/arreports/en14/2014AR_en_web.pdf

Price Waterhouse Coopers, (2012), Public Private partnerships in Malaysia, September 12, 2012.

https://www.slideshare.net/syafa_187/ppp-projectsinmalaysia

Regier, A. (2013), First a ripple, then a wave, Canadian Centre for Policy Alternatives (CCPA), Fast Facts, February 28, 2013.

http://www.policyalternatives.ca/publications/commentary/fast-facts-firstripple-then-wave

Tan, J. (2013). "The Pitfalls of Water Privatization: Failure and Reform in Malaysia", pp. 2552–2563], World Development, Volume 47, July 2013.

Thiessen, G., (2001), Canada's Economic Future: What Have We Learned from the 1990s? Remarks by the Former Governor of the Bank of Canada (1994-2001), Canadian Club of Toronto, January 22, 2001, Toronto, Ontario.

U.S. Department of the Treasury Office of Economic Policy, (2016), An Economic Framework for Comparing Public-Private Partnerships and Conventional Procurement, May 2016, United States Government, Washington D.C, USA.

https://www.treasury.gov/resource-center/economic-policy/Documents/1_PPP%20paper_FINAL%2005%2017%2016.pdf

Victoria State Government, (2004), Surveying Act 2004, No. 47 of 2004, Melbourne, Australia.

## Madagascar embarks on multi-sectoral nutrition mapping

Nearly one in two children under five years old suffer from chronic malnutrition in Madagascar, according to the 2018 Global Nutrition Report. Malnutrition is more prevalent in some parts of the country due to economic disparities, lack of resources and increased poverty.

To combat this issue, the Government of Madagascar has long been committed to a multi-sectoral approach at the highest level since its early adherence to the SUN Movement in February 2012. For the first time, nutrition has been included in the 'Plan Emergence', a strategic document of the General Policy of the State that will soon be released. The National Office of Nutrition (ONN) is responsible for monitoring the inclusive implementation of the National Nutrition Policy (PNN) and its Nutrition Action Plan (PNAN).

Within this framework, the ONN made a request for technical assistance on the UNNNAM III (Nutrition Action Plan III – 2017-2021) to help ensure that its implementation is on track, looking to the UN Network Secretariat. Madagascar joined a list of 25 other countries, which have undertaken the Nutrition Stakeholder and Action Mapping exercise to gage the coverage levels of nutrition actions on the path to scale up. Additionally, this was the first time that Japan financed a UNN-supported mapping exercise.

The mapping will bring an accountability framework putting beneficiaries at the center of programs and actions. It is also catalyzing capacity building at the sub-national level with the participation and training of more than 50 M&E regional assistants.

The multi-sectoral approach of the mapping included 27 actions that engage sectors including health, agriculture, WASH and social protection. The national mapping team included technical focal points from the ONN, Ministry of Agriculture, Ministry of Health, National Institute for Geography and Hydrography, National Statistics Institute as well as UN colleagues from the United Nations Children's Fund (UNICEF) and the World Food Programme (WFP). This not only ensures ownership of the exercise but also helps to institutionalize the mapping within government institutions.

The first phase took place over 6 days, in late August 2019, including all stakeholders involved in the field of nutrition in Madagascar. More than 100 participants attended the launching workshop, where technical and financial partners undertook a prioritization exercise to identify which nutrition actions would be mapped.

The mapping team spent three days building capacity for the supervision of data collection and data capture. One of the days focused on the mapping module, using the District Health Information (DHIS2) software for customization, data collection, data entry and basic analysis. During this period, the team proposed a preliminary long list of nutrition actions, target groups, implementation mechanisms and geographical levels that was validated during the workshop.

The mapping exercise itself will take roughly four months to be completed, including the data collection phase, data cleaning, analysis and dissemination of results. This will make it possible to reframe and deliver the package of priority interventions with a proven impact by targeting the geographical areas not previously covered. The goal is to identify existing gaps among the different demographics to boost coverage for hard-to-reach populations. *https://reliefweb.int*

## Punjab, India launches Web-GIS for ease of doing business

Punjab Small Industries and Export Corporation (PSIEC) has launched Estate Management System (EMS) and Web-GIS to improve transparency and promote ease of doing business in the state. Through EMS, applicants/ allottees will be able to apply for allotment of industrial/ commercial/ residential plots, pay dues online and also avail post-allotment services with respect to their plots.

All the PSIEC allotees will be given access to an online dashboard which, will be used for managing all aspects of their industrial plot. Post-allotment services shall be made available online, including, applying water/sewage connection, permission to mortgage, registration of lease deed/conveyance deed, issuance of no dues certificate, conversion from lease to freehold etc. *www.hindustantimes.com*

## GeoDB democratizing Big Data with Blockchain-based data sharing ecosystem

GeoDB is a decentralized peer-to-peer data sharing ecosystem that boasts over 12 million users from 150 countries. They are on the forefront of addressing some of the major issues in the big data industry. The company has successfully raised over $3 million (USD) from several closed private investment rounds as well as a crowd sale held on crowdcube, the leading crowdfunding platform in the UK.

GeoDB has established several strategic partnerships with third party applications whose users will share data while being rewarded via its ecosystem. With over 12 million users the company is confident that they will become one of the largest company by amount of token holders already in 2020. This would make GeoDB one of the first crypto/ blockchain projects to achieve mass user adoption, which has been a major challenge for most blockchain based projects.

Apart from merely boasting about having a large user base, it also launched their in-house GeoCash application about 5 months ago and during this time, over 1000 wallets were created and more than 15 million locations where uploaded to the platform. *https://geodb.com/en/*

## Sponsorship for RSU2-based Robotics Team

Delta Prime Robotics has received a $4,000 sponsorship from Hallowell-based software company Blue Marble Geographics®. The sponsorship covers most of the team's registration with its parent-organization FIRST Robotics®, which includes the cost of two regular season competitions and equipment such as basic robot chassis.*bluemarblegeo.com*

## Advanced Navigation raises $13M for global expansion, R&D

Australian-based Advanced Navigation, which develops artificial intelligence-based navigation technologies for robotics and self-driving vehicles, this week announced it has raised $13 million in a Series A funding round.

The round was led by Main Sequence Ventures' CSIRO Innovation Fund, along with Brick & Mortar Ventures and In-Q-Tel. The company said the funding will be used to support global expansion for the business and accelerate research and development programs for "transformative new robotics, navigation and sensor technologies." *www.advancednavigation.com*

## China to launch Beidou-3 satellites in 2020

China will launch in 2020 the last two satellites of its Beidou-3 mapping system, an alternative to the US GPS, authorities have announced. China has launched 10 Beidou satellites into space during 2019. *www.outlookindia.com*

## Third Glonass-K Satelite launch to take place in March 2020

The launch of the third Glonass-K navigation satellite from Plesetsk Space Center is planned for late March this year, a source in the space industry told Sputnik. At the moment, the Russian GLONASS navigation system consists of 28 satellites, including 22 operational devices in orbit. To ensure the global coverage of the navigation system, 24 operational satellites are needed. *www.urdupoint.com*

## Measuring the volcano's shape with high precision GNSS

HVO operates a 67-station GNSS network spread out across the island but concentrated near persistent deforming features like rift zones. These high-precision GNSS stations give scientists a 24/7 record (called a time-series) of the precise position of the antenna every second through time.

To get a more complete view of the deforming volcano, HVO also conducts yearly campaign surveys on Mauna Loa and Kilauea. During these surveys, HVO staff place temporary GPS receivers and antennas on benchmarks and leave the equipment in place for a couple of days at each site. Benchmarks are permanent brass disks that have been drilled into the ground. The benchmark typically has a cross inside a triangle that serves as a reference point for centering of the antenna.

During each survey, we return to these benchmarks to collect data and determine how the point has moved. Data collected allow us to calculate both a horizontal and vertical location, similar to latitude, longitude, and altitude and thus to evaluate the change from prior surveys. Campaign GPS surveys have been conducted on both Mauna Loa and Kilauea since the mid-1990s providing extraordinary time-series records of volcano deformation. Along with Mauna Loa and Kilauea, Hualalai and Haleakala volcanoes are surveyed periodically (approximately every three to five years) as part of our volcano monitoring program. This past October, HVO surveyed the western flank of Mauna Loa to add to the picture of volcano deformation provided by the continuous network.

Measuring the changing shape of the volcano helps us refine models of what is happening beneath the surface, for example, the inflation of a magma reservoir. A combination of improved technology and new data processing techniques is providing our best data yet in the history of satellite-based geodesy at HVO. *https://volcanoes.usgs.gov*

## Robust receiver in development for critical infrastructure

The European GNSS Agency (GSA) awarded a contract for the development of the Galileo-based TIming Receiver for CriticAl INfrastructure Robustness (GIANO) to Thales Alenia Space, for resistance against interference, jamming and spoofing. The timing receiver for professional applications addresses the needs of the energy generation and distribution grid, telecommunications, financial operators and other users in the critical infrastructure community.

The GIANO receiver will leverage Galileo and European Geostationary Overlay Service (EGNOS)-driven tools to improve resilience of the receiver against interference, jamming and spoofing and increase the accuracy and reliability of the time transfer service. The timing platform prototype will integrate innovative technologies, including professional products from Thales Alenia Space, paving the way for future Galileo-based timing receivers that offer improved resilience and accuracy at a reasonable cost.

Since the inclusion of a timing receiver in a certified time distribution system implies the certification of the receiver itself, a continuous self-calibration approach is being studied to allow monitoring the internal delays along the full signal path by injecting a reference signal at the antenna. To ensure the integrity of the RF path from the antenna down to the receiver (which is important for certification purposes), the delay measurements would allow compensating fluctuations in the delay along the signal path due to environmental changes.

## India's NAVIC GNSS capability declared an allied system by U.S. Congress

The U.S. Congress has formally acknowledged India's NAVIC global navigation satellite system (GNSS) to be an "allied system" in its finalized 2020 National Defense Authorization Act (NDAA), the legislative bill that outlines the U.S. Department of Defense's budget, policies, and priorities for the coming fiscal year.

The acknowledgement of NAVIC by the U.S. Congress will mean that the GNSS system will be on a par with Japan's GNSS Quasi-Zenith Satellite System (QZSS) and Europe's Galileo GNSS. This will allow U.S. military and government users to utilise NAVIC along with the U.S. Global Positioning System (GPS), QZSS, and Galileo. Presumably, it will also allow similar privileges for India's military and government to formally utilise GPS.

Navigation with Indian Constellation (NAVIC – is also a Hindi word for sailor or navigator), has cost the Indian Space Research Organisation (ISRO) U.S.$220 million for the orbital section and about U.S.$45 million for the ground segment. The NAVIC system provides two services: the Restricted Service reserved for Indian government and military users for now; and the Standard Positioning Service for civilian and commercial users in India and within NAVIC's coverage area beyond, including the Middle East.

NAVIC's coverage area ranges from much of the Middle East and East Africa through much of South- and Northeast Asia (except for Japan) and Northwest Australia. The Restricted Service signal provides position accuracy of better than 10 meters while the Standard Positioning Service signal will provide position accuracy of better than 20 meters throughout the coverage area.

NAVIC comprises a constellation of seven Indian Regional Navigation Satellite System (IRNSS) satellites located in Geostationary orbit at 36,000 kilometres altitude. *https://spacewatch.global*

## China completes core of Beidou global satellite navigation system

Two Chinese Beidou navigation satellites successfully launched recently, completing the core of China's independent positioning and timing network ahead of the start of global service next year. The satellites launched are orbiting Earth at an average altitude of 13,500 miles (21,800 kilometers), with an inclination of 55 degrees, according to tracking data published by the U.S. military.

The successful launch means all 24 third-generation, or BDS-3, Medium Earth Orbit satellites for China's Beidou navigation network have been sent into space since 2017, according the Chinese state-run Xinhua news agency. The BDS-3 spacecraft are the latest generation of China's Beidou navigation satellites intended for worldwide service, following earlier missions designed for technology demonstrations or intermediate regional service. *https://spaceflightnow.com*

## SK Telecom, Samsung set sail with 5G autonomous navigation platform

SK Telecom and Samsung Heavy Industries set sail with their 5G-based autonomous navigation platform, which will allow ships to move and set destinations on their own. Samsung provided 3.3m craft for the trial, which SK Telecom equipped with LIDAR at a shipyard covered by its 5G network. The companies then set the ship's destination from a control center located 250km away in Daejeon City.

The ship's safe arrival at the set destination was confirmed using an SKT real-time video monitoring platform. SK Telecom said it successfully recognized and avoided obstacles. They were also able to remotely control and monitor the ship from the control center through using the telco's 5G network. Eventually, SK Telecom and Samsung hope to develop a "5G smart yard" that will improve the safety of ships when sailing in particularly treacherous environments such as narrow waters and near shore. *www.rcrwireless.com*

## Combating counterfeit activity in aerospace with Blockchain

Honeywell is working with iTRACE and SecureMarking to bring transparency and increased security to the e-commerce market of aerospace products via blockchain technology. This first-of-its-kind process in the aerospace market will greatly simplify the complex regulatory and supply-chain landscape in the industry. Under the new process, the moment a part comes off the Honeywell assembly line, the identification plate receives a two-factor authentication marking. First, iTRACE's 2DMI data matrix is laser-etched onto the identification plate. Next, an invisible, high-security ink, provided by Honeywell's Performance Materials and Technologies (PMT) business and SecureMarking, a third-party authentication company, is applied.

Finally, the iTRACE mobile app scans the 2D matrix and activates the digital authenticity record for the part. This data, along with the part's birth information, is recorded on Honeywell's digital blockchain ledger. Because the two-factor authentication always follows the part from the time of installation until it is taken out of service, the results of this process are a reduction in counterfeit parts and a more dependable supply chain for manufacturers. This anti-counterfeit blockchain technology will have a far-reaching impact in aerospace, where parts change ownership an average of four times throughout their life cycle. *www.honeywell.com*

## Mitsubishi Corporation and NTT new investors in HERE Technologies

HERE Technologies announced that Mitsubishi Corporation (MC) and Nippon Telegraph and Telephone Corporation (NTT) of Japan are to jointly acquire a 30% ownership stake in the company. The companies are co-investing in HERE via their newly established, jointly owned holding company COCO Tech Holding B.V. in the Netherlands.

## Platform for next-generation autonomous electric vehicles

Southern California-based automaker and high-tech incubator Karma Group has announced during the NVIDIA GPU Technology Conference in China that it will leverage the NVIDIA DRIVE AGX Xavier and Pegasus AI computing platforms for future autonomous electric vehicle capabilities.

Karma Group's path forward as a technology-focused innovator combines its two vehicle platforms and two core technologies with five intelligent ecosystems. Karma's vehicle platforms consist of its family of Revero vehicles and Project e-Klipse, its all-electric global platform starting in 2021. Its two core technologies include both full electric vehicles (BEVs) and extended range vehicles (EREVS). These platforms and technologies are supported by five intelligent ecosystems: Karma Skateboard, Cockpit, CarNet, Drive and Cloud. Karma's ecosystems and electric vehicle architecture can be scaled across different vehicle models and types, powered by cutting-edge technologies including artificial intelligence, autonomous driving and advanced connectivity.

Karma will leverage both NVIDIA DRIVE AGX Xavier and DRIVE AGX Pegasus AI computing platforms for its autonomous driving systems. At the core of the DRIVE AGX platform is the auto-grade NVIDIA Xavier system-on-a-chip, the first processor developed for autonomous driving. It incorporates six different types of processors for running redundant and diverse algorithms for AI, sensor processing, mapping and driving. *www.karmaautomotive.com*

## XAG launches farm robots and smart agriculture management system

To establish an integrated smart agricultural system, XAG has released R80 Agricultural Utility Vehicle (XAUV™), AutoPilot Console (XAPC™) and Smart Agriculture System (XSAS™) at SAC 2020. This complements XAG's existing drone-based solutions and automates every production process from planting, seeding, management to harvest.

XAUV™ R80 is an autonomous, multifunctional farm robot which allows third-party payloads and adapts to both plain fields and sloped terrains. While inheriting XAG's technical advantages in centimetre-level RTK navigation and variable-rate application, XAUV™ R80 can support 80L payload capacity and embark different agricultural devices, such as JetSprayer™ and XIoT™, for orchard spraying, open field weeding, crop monitoring and farm transportation. *www.xa.com*

## Intel acquires Israel-based startup Habana Labs

Intel Corp has bought Israel-based artificial intelligence (AI) firm Habana Labs for about $2 billion, the chipmaker said, seeking to expand its AI portfolio to bolster its data-center business. Intel expects the fast-growing AI chip market to exceed $25 billion by 2024, with its own AI-driven revenues this year seen rising 20% from 2018 to more than $3.5 billion. The deal follows a string of AI-related acquisitions by Intel in recent years, including Movidius, Nervana, Altera and Mobileye. *https://newsroom.intel.com*

## Airbus-built CHEOPS satellite successfully launched on Soyuz

The Airbus-built CHEOPS satellite has been successfully launched on a Soyuz rocket from the European spaceport in Kourou, French Guiana.

CHEOPS is the first exoplanetary mission of the European Space Agency (ESA). It is also the first satellite built by Airbus in Spain for ESA. CHEOPS will characterise exoplanets of nearby stars, observing known planets in the size range between Earth and Neptune and precisely measuring their radii to determine their density and understand what they are made of. The satellite uses proven technologies to pave the way for bigger and more ambitious missions – with the aim of verifying if any exoplanet may be capable of supporting life. *www.airbus.com*

## Building capacity in remote sensing in Syria

The Food and Agriculture of the United Nations (FAO) Representation in the Syrian Arab Republic teamed up with the National Agricultural Policy Center (NAPC) and the General Organization of Remote Sensing (GORS) to conduct technical training session on the use of remote sensing technology to evaluate the effect of irrigation on agricultural production.

The collaboration between the partners concluded with an advanced session for selected experts who have attended previous training on remote sensing and its methodology and tools. The purpose of the session was for experts to become skilled in monitoring water productivity using data derived from FAO's Water Productivity Open-access portal (WaPOR). *https://reliefweb.int*

## China launches microsatellite for Ethiopia

China launched a remote-sensing microsatellite for Ethiopia, the African country's first satellite, in order to help the nation's research into climate change. The wide-range multispectral remote-sensing microsatellite donated to Ethiopia by China was sent into space together with eight other satellites by a Long March-4B carrier rocket from the Taiyuan Satellite Launch Center in north China's Shanxi Province.

The satellite, weighing about 65 kg and with a design life of two years, can obtain remote-sensing data for agriculture, forestry, water conservation, as well as disaster prevention and mitigation, according to the China National Space Administration.

Solomon Belay Tessema, director-general of the Ethiopian Space Science and Technology Institute, said the government policies of Ethiopia focus on transforming agriculture into modern industry. The satellite data can be used for the analysis of agriculture, climate change, the environment, drought and natural disasters. *www.xinhuanet.com*

## BRICS nations working on framework deal to build RS satellites

Space agencies of the BRICS group of nations have been negotiating a framework agreement to formalise the cooperation on building a 'virtual constellation of remote-sensing satellites', a senior minister in India, said.

According to Union Minister of State, Jitendra Singh, technical aspects with respect to identifying the satellites and the ground stations for the initial virtual constellation were discussed by the space agencies. The purpose of the proposed virtual constellation is to get access to satellite remote-sensing data, which could be used by the individual BRICS nations for various purposes, including natural resources management and disaster management, said the Minister.

Isro has set up five Space Technology Cells (STCs) at the Indian Institutes of Technologies (IITs) in Mumbai, Kanpur, Kharagpur and Chennai, Indian Institute of Science (IISc), Bengaluru and the Joint Research Programme with Savitribai Phule Pune University (SPPU, Pune), to carry out research activities in space technology and applications. *www.business-standard.com*

## China launches new optical remote sensing satellite

China recently sent a new optical remote sensing satellite into space from the Taiyuan Satellite Launch Center in northern China's Shanxi Province.

The Jilin-1 Gaofen 02B satellite, which belongs to the Jilin-1 satellite family, was launched by Kuaizhou-1A (KZ-1A) and entered the planned orbit successfully. The satellite was independently developed by the Chang Guang Satellite Technology Co., Ltd., featuring high resolution, wide width and high-speed data transmission. The satellite will form a network with the 14 previously launched Jilin-1 satellites, providing remote sensing data and services for agriculture, forestry, resources and environment. Xinhua News Agency

## China Natural Resources Aerial Geophysical and Remote Sensing Center Projrct

Luokung Technology Corp., China, has announced eMapgo Technologies (Beijing) Co., Ltd. ("EMG") successfully bid for the Beidou high-precision digital map integration construction and application project, which was initiated by the Chinese Aero Natural Resources Survey and Remote Sensing Center.

As the only contractor of the project, EMG dedicates its professional technologies and leading advantages in digital map navigation to assisting the Chinese Aero Natural Resources Survey and Remote Sensing Center to build the high-precision digital map database in sub-meter level, lane-level navigation application platform and to develop thousands of lane-level navigation application terminals.

This project will provide high-precision digital map demonstration services in internet of vehicles, internet travel, logistics and transportation, automatic driving, and urban transportation. The project is a national-level demonstration project for Beidou in high-precision positioning and intelligent travel application. *www.luokung.com*

## White Paper promotes European GNSS for safe, reliable UAVs

The European GNSS Agency has published an online White Paper on European Global Navigation Satellite Systems, asserting that use of Galileo and its corrections via the European Navigation Overlay Service (EGNOS) are essential for the safe and reliable navigation of drones.

The report further states that GNSS receivers are implemented on almost all new commercial drones as standard. Market statistics cited in the report predict that European drone service revenues will nearly double from EUR 32 million in 2018 to approximately EUR 60 million by 2020, eventually rising to EUR 150 million by 2023.

With increasing demand for beyond visual line of sight (BVLOS) operations, GNSS with augmentations is the most obvious choice of technology for navigation — although not the only one, according to the authors. Galileo-enabled receivers are borne by more than 30% of the receivers used for drone applications, while many also implement EGNOS corrections to increase accuracy. *www.gsa.europa.eu*

## NASA starts using FLARM for drone UTM

National Aeronautics and Space Administration (NASA) Langley Research Center has started using FLARM traffic awareness and collision avoidance technology in its Pathfinder drone unmanned traffic management (UTM) project. Its goal is to take separate UTM projects and combine them into a single autonomous concept to enable vehicles to fly and communicate with other autonomous vehicles in the airspace. "Pathfinder was conceived as a way to perform a graduation exercise for a lot of the UTM projects we developed over the years," said Lou Glaab, assistant branch head for the Aeronautic Systems Engineering Branch in Langley's Engineering Directorate and Pathfinder project manager. Part of that graduation exercise is the Independent Configurable Architecture for Reliable Operations of Unmanned Systems (ICAROUS). *https://flarm.com*

## SkyWatch to build advanced autonomous space systems

SkyWatch has announced that the company was selected by the Canadian Space Agency (CSA) to complete Phase I of the Artificial Intelligence and Big Data Analytics for Advanced Autonomous Space Systems challenge in July 2019. During this phase of the project, it will work closely with the CSA to develop and deliver a system concept that aims to demonstrate the technical feasibility and commercial potential of applying artificial intelligence and big data analytics to the data from multiple space missions collected by the CSA.

The purpose of the Artificial Intelligence and Big Data Analytics for Advanced Autonomous Space Systems challenge is to apply artificial intelligence and big data analytics to bring tangible advancements in the operation and utilization of space assets in support of government operations, public safety, public health and discovery. *www.skywatch.com*

## Autonomous drone tech in Madrid warehouse

IAG Cargo has announced that it has successfully trialled autonomous drone technology within its warehouse facility in Madrid. Designed around the automation of freight checks, the technology will help improve efficiency and reliability of its operations.

Conducted using technology developed by drone software start-up FlytBase, the trials come after IAG Cargo found it was spending an average of 6,500 hours each year recording the barcodes and location data of freight across their individual warehouses. Due to the drones' use of the 3D space, degree of autonomy, and continuous advancement in intelligent automation software, IAG Cargo identified a viable solution to increase accuracy within the warehouse.

## Lockheed Martin and Canadian UAVs to improve unmanned BVLOS operations

The ability to fly unmanned aerial vehicles (UAVs) beyond the visual line of sight (BVLOS) significantly improves their effectiveness and potential. The increased range of BVLOS operations requires real-time airspace situational awareness for the UAV pilot and support crew to ensure safe, repeatable operations.

Canadian UAVs and Lockheed Martin Canada CDL Systems have signed a memorandum of understanding to provide an unmanned traffic management solution to meet this challenge. This solution will build a complete airspace picture necessary to conduct unmanned operations beyond visual line of sight in Canada and beyond.

Lockheed Martin Canada CDL Systems will provide integration support for the vehicle control station software called VCSi, a universal Ground Control System based on more than 1.5 million flight hours in military and commercial flight operations. Canadian UAVs will integrate their low-cost, ground-based radar, Sparrowhawk, into VCSi to provide users with a complete airspace picture of manned and unmanned aviation tracking with collision avoidance. *https://canadianuavs.com*

## Drone-based aerial intelligence platform for mine planning

Kespry announces that Midsouth Aggregates, part of North America's largest aggregate materials producer CRH, is using the Kespry drone-based aerial intelligence platform for inventory management and mine planning.

With granite and limestone reserves located throughout Alabama, Georgia and Tennessee, Midsouth Aggregates produces a variety of aggregate products destined for the concrete, asphalt, block, and precast industries, as well as base course material, fill products and general construction aggregates. The company also supplies concrete and asphalt sand, general construction sand and gravel. *www.kespry.com*

## MicroSurvey inCAD 2020 released

MicroSurvey announces the release of inCAD 2020. It adds the MicroSurvey feature set to the latest Autodesk® software – including AutoCAD® 2020, AutoCAD Map 3D™ 2020, and AutoCAD Civil 3D™ 2020 – providing users with complete survey drafting and calculation workflows, including COGO, point tools for gridline-based projects, traverse input and adjustment, misclosure reporting, common data collector support, 3D surface representation and computation, corridor design, and much more.

These utilities are perpetually licensed and are designed to complement the professional land surveyor and their desire for maximum efficiency. With two product tiers, inCAD allows the avid professional to choose precisely the features and price point they need to produce the quality deliverables they want.

## Zenith16 – The new GeoMax GNSS receiver

GeoMax is pleased to announce the release of the Zenith16 – the new GNSS receiver. Equipped with NovAtel`s latest cutting-edge technology and multi-constellation measurement engine this antenna provides highest reliability and a seamless integration into the GeoMax workflow meeting the toughest MIL standards.

## GMV's avionics system greenlighted for microlauncher use

After a long field-testing campaign the GMV-developed avionics system for PLD Spaces' MIURA 1 launch vehicle has successfully passed its Qualification Acceptance Review (QAR), clearing it for fitting in this suborbital launch vehicle, one of the essential prelaunch conditions.

Since 2017 GMV has been working on the design, development and qualification of a complete avionics system for the space probe MIURA 1. This system takes in all vital avionics items for a classic launcher, such as the power subsystem; data management subsystem; guidance, navigation and control (GNC) system; onboard software; payload management; telemetry plus the autonomous tracking technology and the termination system.

Key features of the avionics system designed and developed by GMV in collaboration with PLD are its modularity and scalability. Other fundamental aspects are its use of COTS parts and the availability of advanced technology that guarantees the required performance at an affordable cost. *www.gmv.com*

## Septentrio and Analog Devices collaboration

Septentrio recently announced a collaboration with Analog Devices, Inc. The two companies are combining Analog Devices' high-quality IMUs with Septentrio's multi-frequency, multi-constellation GNSS receivers. The resulting high-performance GNSS/INS systems deliver centimeter-accurate positioning together with 3D orientation (heading, pitch and roll), ideal for applications such as automotive ADAS and industrial automation. *septentrio.com*

## Trimble extends the reach of GNSS with LTI Laser Rangefinders

Trimble has announced its Trimble® TerraFlex™ field software now supports remote feature capture with Laser Technology, Inc. (LTI) TruPulse® 200 series and 360° series laser rangefinders. The solution enables easy, accurate and safe capture of Geographic Information System (GIS) features in locations that are physically inaccessible, hazardous and in challenging Global Navigation Satellite System (GNSS) environments. *www.trimble.com*

## Fugro to provide hydrographic surveying services to NOAA

Fugro has been awarded a five-year Indefinite Delivery Indefinite Quantity (IDIQ) contract by the National Oceanic and Atmospheric Administration (NOAA) to provide hydrographic surveying services in the U.S. The contract was issued by NOAA's National Ocean

Service, Office of Coast Survey, to support the creation and maintenance of nautical charts. *www.dredgemag.com*

## New GeoSLAM solution for stockpile volume analysis

GeoSLAM Volumes is an end-to-end way to calculate stockpile mass, instantly turning stockpile point cloud data into actionable 3D information for quick decision making. This is achieved using the company's handheld Zeb Horizon SLAM (simultaneous localisation and mapping) scanner, which can be utilised on foot or with an UAV.

The solution can capture and calculate complex data, such as the weight and bulk of stockpiles, up to ten times faster than traditional tools. It enables volume calculations to be calculated as frequently as required at all stages of the supply chain without disruption to site activity or compromising employee safety.

Designed for use in mines and quarries, but also suitable for use in a range of sectors such as agriculture, recycling centres or ports, its fully-mobile technology is adaptable for untrained staff to use in any environment. In addition, the technology does not require GPS, opening up hazardous or hard to reach areas that are ordinarily off-limits using traditional surveying methods. *https://geoslam.com*

## gisAMPS for real-time project mapping

gisAMPS is a comprehensive tool for an end to end tracking of all the land and infrastructure data. It is one of the many software solutions created by the couple owned company geoAMPS.

It enables a quick view of the status tracts within a project. Its color-coded maps and graphs help analyze project features easily by overlaying multiple layers. Another amazing feature is that the Geospatial visualization feature can also be integrated with it.

With gisAMPS mapping, organizations receive a visual overview of the project data to aid in route planning, cost analysis, environmental assessments, and overall project management. *www.geoamps.com*

## Esri enters into licensing agreement with EC

Esri has entered into a four-year general master agreement (GMA) with the European Commission. The agreement will enable the EC and selected Executive Agencies to use Esri software and deploy the full suite of its ArcGIS products in an open, scalable, and standards-based GIS architecture.

Implemented and deployed by Esri's European distributors, the GMA also provides terms and conditions which several other EU institutions, agencies, and bodies can leverage to have access to Esri products. *www.esri.com*

## SimActive introduces new LiDAR workflow

SimActive Inc. has announced a new LiDAR workflow integrated in its Correlator3D™ product. The capability allows to import a point cloud in the software and to perform registration with an image dataset. Using LiDAR as control eliminates the need for traditional ground control points (GCPs) when processing the photos. The registration occurs during aerial triangulation, leading to a precise alignment of imagery with the LiDAR data. *www.simactive.com*

## RoboSense launches lidar solution for Robo Taxis outside of China

RoboSense has developed a complete lidar perception solution for Robo Taxi (RS-Fusion-P5) in markets outside China, launched last month.

The company is positioning the RS-Fusion-P5 as an alternative to Waymo's LiDAR solution. RoboSense RS-Fusion-P5 uses an RS Ruby on top of the vehicle to ensure a sensing range with a radius of more than 200 meters. However, even if the vertical field of view (FOV) of RS-Ruby reaches the perfect angles from -25° to +15°, there is still a small blind zone around the vehicle body. Therefore, to cover the small blind zone, 4 RS-BPearl are embedded sideways around the vehicle to form a hemisphere FOV scanning area relative to the vehicle's perspective, to guarantee a complete 360° surrounding view.

The RS-Fusion-P5 solution fuses point clouds from RS-Ruby and RS-BPearl in real-time, and generates laser points of more than 4,600,000 pts per second. RS-Ruby achieves the anti-interference of multiple lidar using special laser encryption technology to filter interference signals. Meanwhile, it is not affected by the strongest direct-sunlight.

The embedded four RS-BPearl form a hemispherical FOV coverage of 90 ° * 360 °, which not only can precisely identify objects around the vehicle body such as pets, children, roadbeds as well as other details of the near-field ground area, but also detect the actual height information under particular scenarios such as bridge tunnels and culverts, further supporting autonomous vehicles for driving decision making and greatly improving car safety. *www.robosense.ai*

## SkyDrive launches test flights of first-ever cargo drone

SkyDrive Inc. has successfully launched test flights of a cargo drone which could revolutionize the way heavy goods are transported and speed up the movement of equipment in remote locations. The first operational testing took place earlier this month (December) in Toyota City, Japan. It was carried out to test the technology by moving heavy equipment in remote locations. Additional testing will be carried out later in the month. *www.skydrive.co.jp/*

## Terra Drone India partners with Geo-Plus

Terra Drone India, has announced that it is joining forces with Canada-based geomatics pioneer Geo-Plus. This partnership makes Terra Drone India an official reseller of Geo-Plus' innovative land surveying and civil engineering software and mapping solutions in the India market.

# SUBSCRIPTION FORM

YES! I want my Coordinates

I would like to subscribe for (tick one)

| ☐ 1 year | ☐ 2 years | ☐ 3 years |
|---|---|---|
| 12 issues | 24 issues | 36 issues |
| Rs.1800/US$100 | Rs.3000/US$170 | Rs.4300/US$240 |

SUPER saver

First name .....

Last name .....

Designation .....

Organization .....

Address .....

.....

City ..... Pincode .....

State ..... Country .....

Phone .....

Fax .....

Email .....

I enclose cheque no. .....

drawn on .....

date ..... towards subscription

charges for Coordinates magazine

in favour of **'Coordinates Media Pvt. Ltd.'**

Sign ..... Date .....

Mail this form with payment to:

**Coordinates**
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.

If you'd like an invoice before sending your payment, you may either send us this completed subscription form or send us a request for an invoice at iwant@mycoordinates.org

## MARK YOUR CALENDAR

### March 2020

**Munich Satellite Navigation Summit**
16 - 18 March
Munich, Germany
**www.munich-satellite-navigation-summit.org**

**10th International Conference and Exhibition on Geospatial & Remote Sensing (IGRSM 2020)**
17 -18 March
Kuala Lumpur, Malaysia
**http://igrsm.org/igrsm2020**

**Geo Connect Asia 2020**
18 - 19 March
Singapore
**www.geoconnectasia.com**

**Geo Week**
March 23-25, Washington, DC,
**www.geoweek.com, www.lidarmap.org**

### April 2020

**United Nations/Mongolia Workshop on the Applications of GNSS**
13 - 17 April
Ulaanbaatar, Mongolia
**www.unoosa.org**

**SpaceTimeAI 2020**
20 - 22 April
London, UK
**www.ucl.ac.uk/civil-environmental-geomatic-engineering/**

### May 2020

**China Satellite Navigation Conference**
May 2020
Chengdu, China
**www.beidou.org**

**XPONENTIAL 2020**
4 - 7 May
Boston, USA
**www.xponential.org**

**GISTAM 2020**
7-9 May
Prague, Czech Republic
**www.gistam.org**

**FIG Working Week 2020**
10 -14 May
Amsterdam, the Netherlands
**www.fig.net**

**European Navigation Conference 2020**
11-14 May
Dresden, Germany
**www.dgon.de**

**GeoBusiness 2020**
20 - 21 May
London, UK
**www.geobusinessshow.com**

**ICCM 2020: International Conference on Cartography and Mapping**
21 - 22 May
London, UK
**https://waset.org**

### June2020

**International Conference on Localization and GNSS (ICL-GNSS 2020)**
2 - 4 June
Tampere University, Finland
**https://events.tuni.fi/icl-gnss2020**

**AEC Next Technology Expo + Conference**
June 3-5, Chicago
**www.aecnext.com**

**XXIVth ISPRS Congress**
14 - 20 June 2020
Nice, France
**www.isprs2020-nice.com**

**The 8th International Conference on Cartography and GIS (ICCGIS)**
15 - 20 June
Nessebar, Bulgaria
**https://iccgis2020.cartography-gis.com**

### July 2020

**GI Forum**
7 - 10 July
Salzburg, Austria
**www.gi-forum.org**

**Esri User Conference**
13 - 17 July
San Diego, USA
**www.esri.com**

### September 2020

**Commercial UAV Expo Americas**
September 15-17, Las Vegas,
**www.expouav.com**

**ION GNSS+ 2020**
21 - 25, September
St. Louis, Missouri, USA
**www.ion.org**

### October 2020

**INTERGEO 2020**
13 – 15 October
**Berlin, Germany**
**www.intergeo.de**

### November 2020

**Trimble Dimensions 2020**
2 - 4 November
Nashville, USA
**www.trimbledimensions.com**

### December 2020

**Amsterdam Drone Week & UAM Summit**
December 2-4
**www.amsterdamdroneweek.com**


**"The monthly magazine on Positioning, Navigation and Beyond"**

Download your copy of Coordinates at www.mycoordinates.org

# LabSat

## Compact yet powerful multi-constellation, multi-frequency GNSS testing solution.

### Wide Bandwidth

Up to 56MHz bandwidth and 6-bit sampling

### Multi-Frequency

Record and Replay in the upper and lower L Band

### Multi-Constellation

Record and Replay RF signals from all GNSS constellations

### Easy Configuration

HTML interface for convenient device set-up


**RELIABLE • REPEATABLE • CONSISTENT**

### SatGen Software

Create custom simulations using all signals

### Future Proof

Supports future full constellations such as L2C, L5 and L1C

### Field Testing

Portable with up to two hours battery runtime for field testing

### External Signals

Additional signals (RS232, CAN, Digital) synchronised to GNSS

Register now for your **FREE 14 DAY LabSat TRIAL** **labsat.co.uk**