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

No: DL(E)-01/5079/17-19
Licensed to post without pre-payment U(E) 28/2017-19
Rs.150

www.mycoordinates.org

Coordinates

ISSN 0973-2136

Volume XV, Issue 11, November 2019

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

"Advantages of multi-GNSS are that one can obtain more accurate and more robust parameter solutions"

– Prof. Peter Teunissen

Remote Sensing for air pollution control

VEXCEL
IMAGING

Harness pure power.

The UltraMap photogrammetric software suite offers a highly-automated and intuitive workflow for outstanding results. Process large datasets in the shortest time possible and deliver best data quality!

Discover more on
www.vexcel-imaging.com

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

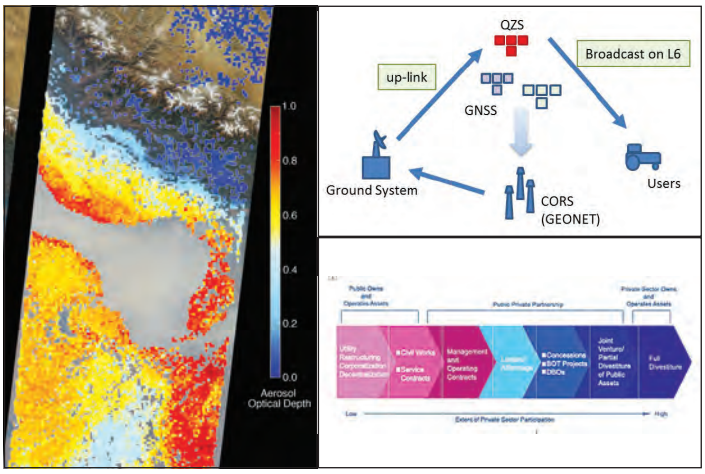
Be among the first to join our MicroSurvey Technology Innovation Group and help mold our FieldGenius for Android™ software. Learn about all the advantages at microsurvey.com/FGA

EARLY ADOPTER
MICROSURVEY SOFTWARE

PART OF HEXAGON

Learn More
microsurvey.com/FGA

MicroSurvey FIELDGenius For Android™



In this issue

Coordinates Volume 15, Issue 11, November 2019

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies
A K Jain, Keith Clifford Bell, Peter Teunissen and Rui Hirokawa and; CHC, EOS Positioning, Javad, Labsat, MicroSurvey, Pentax, SBG System, Vexcel 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

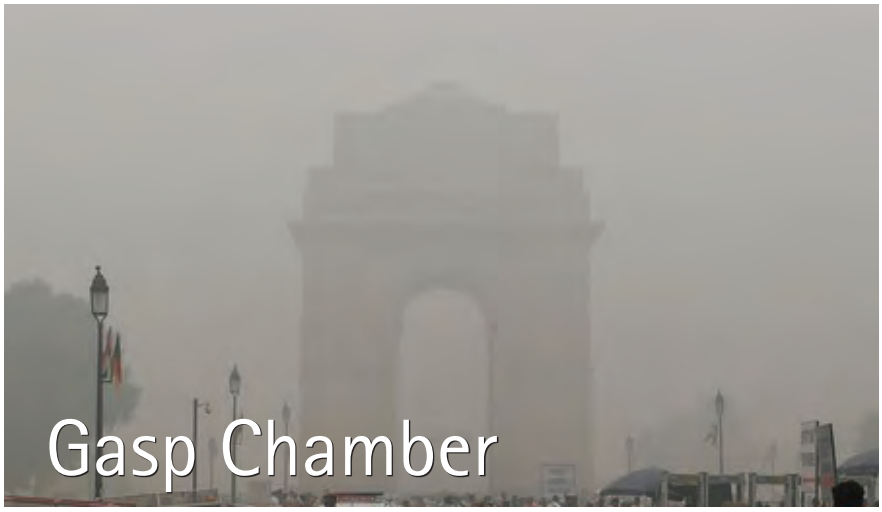
Email
[information] talktous@mycoordinates.org
[editorial] bal@mycoordinates.org
[advertising] sam@mycoordinates.org
[subscriptions] iwant@mycoordinates.org
Web www.mycoordinates.org

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 52 pages, including cover.



Gasp Chamber

With air quality at dangerous level

This time around air pollution in Delhi

Led to health emergency.

Several desperate measures were taken,

Banned on construction activities,

Plying of vehicles with odd-even numbers on odd and even dates,

Schools closed for a few days,

Alas! not with desired results.

The Supreme Court of India intervenes,

Governments scramble for actions, politicians blame each other,

And the saga continues… year after year,

With each passing year, getting from bad to worse.

Poison is in the air,

Not only in Delhi but in the entire northern belt of India,

And hapless millions in the region inhale the same,

Helplessly.

Bal Krishna, Editor
bal@mycoordinates.org

"The general advantages of multi-GNSS are that one can obtain more accurate and more robust parameter solutions"

says Professor Peter Teunissen. He shares his views on a wide range of subjects related to GNSS in an interview with Coordinates magazine

Professor Peter Teunissen has recently received Johannes Kepler Award from ION for his influential and groundbreaking contributions to the algorithmic foundations of satellite navigation and sustained dedication to the global education of next generation of navigation engineers (https://www.ion.org/awards/2019- Kepler.cfm). He has been recognized by the national newspaper 'The Australian' as the world-best in the field of 'radar, positioning and navigation' (https://specialreports.theaustralian.com.au/1540291/top-of- the-world/)

He is currently a Professor of Satellite Navigation at Delft University of Technology, The Netherlands and Curtin University, Australia. Prof. Teunissen invented the Least Squares Ambiguity Decorrelation Adjustment (LAMBDA) method, the worldwide standard for ambiguity resolution, which revolutionized high precision GNSS positioning capabilities. His findings are particularly important for multi-GNSS processing, which require a proper understanding of individual system characteristics and their respective contributions to achieve navigation solutions of the highest precision and integrity. He holds several honorary professorships and fellowships of numerous international organizations, including Australia's prestigious Federation Fellowship of the Australian Research Council. He has published over 300 papers, seven books, is co-editor and author of the Handbook of Global Navigation Satellite Systems, and is a member of 13 editorial boards. He is a regular contributor to ION and ION programs. He is a Fellow of the ION, the RIN and the Royal Netherlands Academy of Sciences.

> One feature of the GLONASS FDMA model is that it guarantees, independent of the actual satellite channel number entries, the integer- estimability of the GLONASS ambiguities

Would you like to share your present research works and research priorities with our readers?

Recently I developed and introduced a new GLONASS FDMA model with my colleague Dr Amir Khodabandeh from the University of Melbourne. One feature of the model is that it guarantees, independent of the actual satellite channel number entries, the integer- estimability of the GLONASS ambiguities. This means that existing methods of integer ambiguity resolution can now be directly applied and that the GLONASS FDMA model can thus now be used and combined in a standard way with all other CDMA-based GNSS systems.

Next to the GNSS-modelling, we are also working on some of the more theoretical integrity challenges that exist. With the varying and challenging environments in which GNSS

often has to operate, there is a multitude of different threat models that need to be considered simultaneously. This therefore requires a multivariate and collaborative integrity approach to tackle the fundamental complexities that are brought forward by the high dimensionality and dynamics of the problem.

You have invented the Least Squares Ambiguity Decorrelation Adjustment (LAMBDA) method. Could you explain the significance of this invention?

GNSS receivers can measure fractions of the signal waveforms that they receive from each GNSS satellite with millimetre precision, but they cannot measure the total number of signal waveforms that exist in each of the distances between receiver and the satellites. The LAMBDA method is a statistically-based algorithm that helps the receiver to determine these whole number of waveforms. As a result of the combination of the very precisely GNSS- measured fractions of waveforms and the LAMBDA-determined whole number of waveforms, each of the distances from receiver to the satellites can be very precisely determined and thus used for a very-precise positioning and/or navigation of the receiver location.

This is a world of multi-GNSS systems. Having worked on joint use of new GNSSs and also in setting up multi-GNSS receiver test beds, what advantages do you see about this scenario especially in the precise positioning?

The general advantages of multi-GNSS are that one can obtain more accurate and more robust parameter solutions. In the positioning domain this translates into faster executions of PPP and PPP-RTK due to the shorter convergence times and for RTK to the ability of using longer baseline lengths for which instantaneous ambiguity resolution is still possible.

Multi-GNSS and the availability of new signals with higher power and better tracking performance also improves positioning in adverse environments. With more satellites available and the resulting stronger receiver-satellite geometry, one can work with higher cut-off elevations and thus be less sensitive to (low-elevation) multipath and the masking that happens in urban canyons.

The increase in number of satellites and signals also improves the spatial and temporal sampling of the atmosphere, thus offering opportunities for more precise ionospheric modelling, which in its turn is beneficial again for, for instance, long baseline RTK.

Many countries plan GNSS systems primarily because of defence and security needs. Do you think that it would lead to 'more the merrier situation" or there has to be a limit?

Yes, as a researcher and a user, I would love to see more satellites and signals. Not so much because of the accuracy improvements that this will bring, but more because of the integrity potential and improved atmosphere sensing. After all, if you think of the 1-over-k rule, then at a certain point the gain in accuracy will become marginal, i.e. if k gets larger, 1-over-k gets smaller, but the reduction or gain gets smaller the larger k is.

The real advantages of more satellites and signals lie in the fact that the redundancy in satellites and signals would help to further robustify parameter solutions and thus improve integrity, and that the improved atmospheric sampling would allow for a better ionospheric and tropospheric modelling.

I would love to see more satellites and signals. Not so much because of the accuracy improvements that this will bring, but more because of the integrity potential and improved atmosphere sensing

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

These threats are real and serious, especially in safety-critical and liability-critical applications. Fortunately, excellent research by my colleagues is already ongoing to tackle these problems. However, one would wish that also the governing authorities would treat this topic with the seriousness that it deserves.

Given this, what's your opinion on GNSS back ups?

Back-ups are important. Back-ups introduce redundancy and redundancy has the potential to improve Integrity. What is important though is that the back-ups are independent and chosen such that they are indeed able to strengthen the vulnerable parts of the system.

How do you think the GNSS positioning technology can take the advantages of other positioning technologies cell phones, Bluetooth and WiFi, etc?

These positioning techniques can indeed benefit from each other, conceptually as well as through integration. GNSS is predominantly an outdoor positioning technique, but through integration with terrestrial techniques could contribute to indoor positioning as well. And on the conceptual level, I believe there are various GNSS positioning concepts that lend themselves for the terrestrial positioning techniques as well. One important example is in my opinion carrier-phase tracking combined with integer ambiguity resolution.

UAV is a new technology being widely talked about. How do you see its integration in GNSS technology? What kind of innovative applications it may result in?

Positioning and navigation of unmanned aerial vehicles (UAVs) already relies to a large extent on GNSS. But what I see as an exciting development is the potential that signals of opportunity bring (e.g., signals from LEO satellites, cellular, AM/FM radio). Such navigation has been demonstrated with a positional accuracy in the several metres range, but this could improve dramatically if the high-precision carrier-phase positioning concepts from GNSS can be incorporated. For instance, the fact that the relative receiver-transmitter geometry changes more rapidly with the terrestrial signals of opportunity than with the GNSS satellites in MEO-orbits, is very beneficial for carrier-phase integer ambiguity resolution. With carrier- phase integer ambiguity resolution included, one would then be able to benefit from the high precision with which the carrier-phases can usually be observed.

> One of the educational challenges I see (and this is not restricted to GNSS education only) is that with today's ease of data processing, students run the risk of acquiring a certain 'analytical laziness'. Such would however be detrimental to their development and general problem solving skills

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

I believe - since in an ever more connected world, society's reliance on high integrity positional, navigational and timing (PNT) data is rapidly growing - that the demand for satellite navigation's delivery of high-integrity products will strongly increase. The development of a proper integrity theory capable of covering the various challenging applications is therefore paramount.

New concepts of satellite navigation will also have their impact. I think we will be on the

brink of another PNT-revolution, if we really can take navigational advantage of the various new LEO-constellations with their hundreds to thousands small satellites. Also new concepts, like the Kepler satellite system, are very exciting as a next-generation GNSS. This concept builds on some of the technological breakthroughs of recent years such as the introduction of optical clocks and the development of optical ranging and optical communication.

You have made significant contributions to educating future generations in different part of the world. Would you like to share your experience in GNSS education? What challenges you see before the academic community and GNSS education?

The beauty of GNSS education is that students with very different educational backgrounds can participate and excel in it. This is true for students from the engineering disciplines, like electrical, mechanical, aeronautical, geodetic, remote sensing and civil engineering, but also true for students from mathematics and physics. I have therefore been very fortunate to work at the different universities with their bright and hardworking students having these various backgrounds.

One of the educational challenges I see (and this is not restricted to GNSS education only) is that with today's ease of data processing, students run the risk of acquiring a certain 'analytical laziness'. Such would however be detrimental to their development and general problem solving skills. It is therefore up to us educators to make sure that we keep the analytical skills of the students well trained. And this requires, also in current times when 'solutions' can be computed by a simple click of a button, that students remain well-trained (next to basic mathematics and physics) in such foundational subjects as linear algebra, probability and statistics, multivariate calculus, and numerical analysis.

Recent activity of international standardization for high-accuracy GNSS correction service

Recently, Compact SSR, which is a highly efficient open format for PPP/PPP-RTK was proposed and applied for QZSS CLAS. It is also planned to be applied as the baseline of Galileo HAS

Dr Rui Hirokawa is deputy general manager of Space Systems Department, Kamakura Works, Mitsubishi Electric Corporation. He is managing the QZS project including CLAS, a nation-wide satellite-based PPP-RTK service. He is chair of QZSS Working Group in RTCM SC-104 committee.

On emerging wide-area high-accuracy open PPP/PPP-RTK correction service and low-cost multi-frequency GNSS receivers, the centimeter-level high-accuracy positioning will be widely used in the field of agriculture, construction, drone, and automobile. For such applications, the interoperability between different correction services and receivers should be maintained to minimize the production and operational cost.

In this article, the recent activities for international standardization of PPP/PPP-RTK will be introduced. The international standardization of format has been conducted in RTCM SC-104, published as RTCM SSR. However, it doesn't support PPP-AR/PPP-RTK yet, and it is not sufficiently effective for satellite-based narrow band correction service. Recently, Compact SSR, which is a highly efficient open format for PPP/PPP-RTK was proposed and applied for QZSS CLAS. It is also planned to be applied as the baseline of Galileo HAS. The high-accuracy GNSS positioning is also demanded in mobile communication for LTE/5G, 3GPP is also working to define the PPP-RTK standard based on Compact SSR. The other useful information such as integrity, the authentication of correction data, the grid definition, the precise coordinate transformation, and the service maintenance could also be standardized.

Introduction

Recently, the high accuracy GNSS correction services, as well as the low-cost high-performance GNSS receivers, are available in the GNSS market. In Japan, Centimeter-Level-Correction Service (CLAS) [1,2], the satellite-based open PPP-RTK correction service is operational since November 2018. QZSS MADOCA is also available as an experimental open PPP service for Asia and Oceania region. The initial phase of the operational PPP service of Galileo HAS is planned to be started in 2021. The other satellite-based PPP service, GLONASS PPP, Beidou PPP, and Australian SBAS will also available in 202x as shown in Table 1 [19]. The high-accuracy GNSS positioning would be commodity in the middle of 202x in wide range of markets such as agriculture, drone, and automobile. For the high-accuracy GNSS application, the inter-

Table 1. List of open Satellite-Based High-Accuracy GNSS Correction Service

System	Service	Satellite	Status	Data Rate	Format
QZSS CLAS	PPP-RTK	IGSO/GEO	Operational (2018-)	2,000bps	Compact SSR
QZSS MADOCA	PPP	IGSO/GEO	Experimental (2017-)	2,000bps	RTCM SSR/Compact SSR
Galileo HAS	PPP	MEO	Development (2021-)	500bps	Compact SSR as a starting point
GLONASS PPP	PPP	GEO	Development (2030-)	4,000bps	RTCM SSR
Beidou PPP	PPP	GEO	Development (2020-)	1,000bps	(TBD)
Australian SBAS	PPP,SBAS	GEO	Development (2023-)	250bps	(TBD)

operability between service providers and receivers are highly important. In this article, the recent activity of international standardization for high-accuracy GNSS positioning is introduced.

High accuracy GNSS positioning

The structure of the satellite-based high-accuracy correction service is shown in Fig.1. The GNSS range measurements collected in the GNSS continuously operating reference stations (CORS). PPP/PPP-RTK correction data is generated at the ground system using the collected GNSS range measurements, it is broadcasted from the satellite.

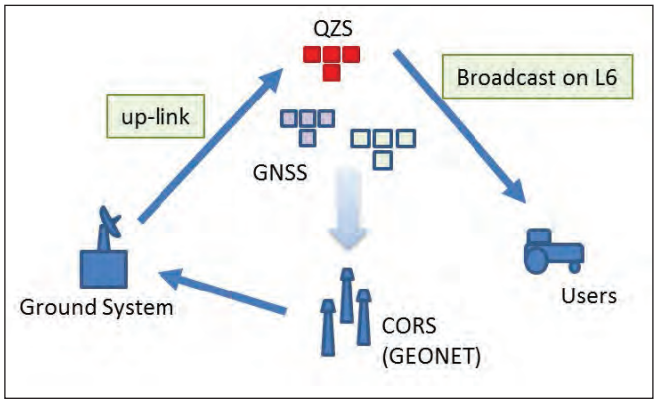


Figure 1 the structure of satellite-based high-accuracy GNSS correction service

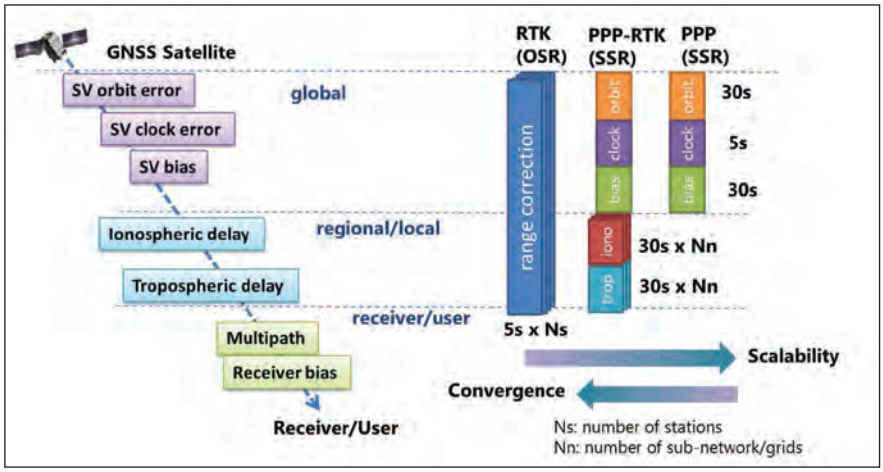


Figure 2. GNSS range error sources and corrections

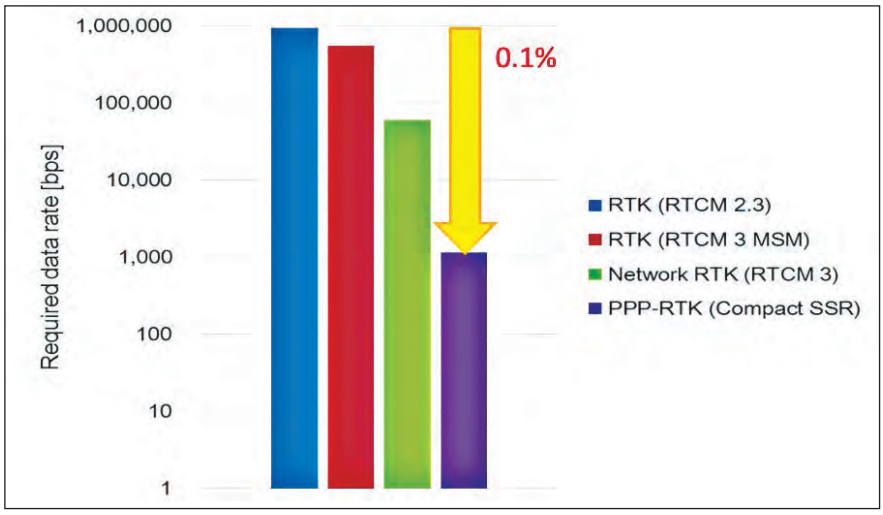


Figure 3. The required data rate for nationwide high accuracy correction service

The GNSS range measurement between satellite and receiver includes a couple of error sources. The errors can be categorized into three major types, the global (or common) error, the regional (or local) error, and the receiver (or user) error. The global error includes satellite orbit error, clock error, and signal bias. The regional error includes atmospheric delay such as ionospheric delay and tropospheric delay. The receiver error includes the multipath, the receiver noise, and the receiver signal bias. The correction service providers provide the correction data for global and regional errors, the receiver errors need to be compensated by the user receivers. For the conventional RTK based on observation space representation (OSR), the range correction is calculated by subtracting the geometric range from the measurement range. For PPP/PPP-RTK based on the state-space representation (SSR), the states representing each error sources are estimated and sent to the user. The major drawback of conventional RTK is scalability, the correction data can be applied only if the distance from the neighboring station is less than 10-20km. On the other hand, SSR based PPP/PPP-RTK correction service broadcasts the estimated states such as satellite orbit and clock correction to the user. The regional correction has the location dependency, broadcasted only for the specific region in PPP-RTK. The update interval of states can be optimized based on the dynamics of each error source to minimize the throughput. In QZS CLAS, the update interval is 5sec for satellite clock correction and 30sec for other states.

For PPP-RTK correction service, the states including global and regional errors are broadcasted for the users, whereas, only satellite terms such as orbit, clock and signal bias are broadcasted in PPP correction service. The correction data for PPP has no location dependency, the global service can be realized with the narrow-band satellite data link less than 500bps. The major limitation of PPP is the slow convergence time typically about 30 minutes. PPP-RTK needs the dense CORS network to estimate the atmospheric error, it can achieve RTK-like fast convergence time less than 1 minute.

Figure 3 shows an example of the required data rate for nation-wide high-accuracy

correction service for the service area of 40,000km^2, 14 satellites, 3 signals per satellite. For conventional RTK, the required total data rate is about 1Mbps, whereas, the required data rate for PPP-RTK is about 1,000bps, it only consumes 0.1% of the conventional technology.

Standardization of format

Standardization in RTCM

The transmission format of high-accuracy GNSS correction services such RTK and network RTK has been standardized in RTCM SC-104 committee, almost all commercially available GNSS receivers are supporting RTCM 2.3/3.x format. For the SSR based correction, the standardization activity started in 2007 at RTCM SSR working-group, the process is defined as four stages shown in Table 2. The first three stages are mainly to define the contents of PPP, PPP-AR, and PPP-RTK respectively, and the fourth stage is to define the effective format by applying the compression technology.

For stage 1, PPP including clock, orbit, and code-bias correction was standardized in February 2011 for GPS and GLONASS, it was included in RTCM 3.1 with Amendments 5. However, stage 2 is still on the proposal phase in the RTCM SSR working group, the timeline to finalize the effective format in stage 4 for PPP/PPP-RTK is unclear.

Open standard proposal

Compact SSR, a highly effective open standard for PPP/PPP-RTK was proposed in September 2015. It is defined as RTCM 3 proprietary format (Message Type 4073), it defines several message types as shown Table 3. The common part defines the satellite-based error correction such as clock, orbit, code bias, and phase bias. The local part defines the atmospheric correction including STEC and tropospheric delay. There are two types of format, standalone and combined are defined. The combined message includes the multiple types of correction such as clock and orbit, it is more effective than the standalone format. The mask message is to define the group of satellites and signals effectively. The service information is a generic format to broadcast the slowly changing or constant information such as the service operation and maintenance, grid definition, coordinate transformation parameters.

Compact SSR is mainly designed for the satellite-based narrow-band correction service, it is far more effective than RTCM SSR. The required data rate for a global PPP correction service is shown in Figure 4. In this example, 69 satellites including 32 GPS, 30 Galileo and 7 QZS with 3 signals per satellite are supported, the update interval is 5 sec for the clock, 30sec for others. The required data rate for Compact SSR is less than 600bps, it is more than 70% effective than RTCM SSR.

Compact SSR is supporting multi-GNSS including GPS, GLONASS, Galileo, Beidou, QZS, and SBAS. The integrity information to estimate the protection level on the GNSS receiver is also supported.

The other open format is also proposed. Sapcorda proposed an open standard, SAPA based on Compact SSR. It has the almost same effectiveness as Compact SSR with additional information. Geo++ also proposed a highly effective format, SSRZ. However, both format is still under development, it is not yet openly available.

Standardization in mobile communication

In the mobile communication market in LTE/5G, the high-accuracy GNSS positioning service is highly demanded. Recently, the major mobile carriers in

Table 2. SSR standardization process in RTCM SC-104 committee

Stage	Type	Application	Status
1	orbit, clock, code bias, URA	PPP	GPS/GLONASS in RTCM 3.1a5 RTCM SSR working proposal for Galileo/Beidou/QZSS/SBAS
2	VTEC, phase bias	SF-PPP, PPP-AR	RTCM SSR working proposal
3	STEC, tropospheric delay	PPP-RTK	(TBD)
4	compression	PPP/PPP-RTK	(TBD)

Table 3. Message Types in Compact SSR

Part	Type	Message (standalone)	Message (combined)
Common	Mask	SubType 1	-
	Clock	SubType 3	SubType 11
	Orbit	SubType 2	
	Code bias	SubType 4	SubType 6
	Phase bias	SubType 5	
Local	Functional	SubType 8	SubType 12
	Gridded	SubType 9	
Service Information	Operation, Grid, Coordinate Transformation	SubType 10	-

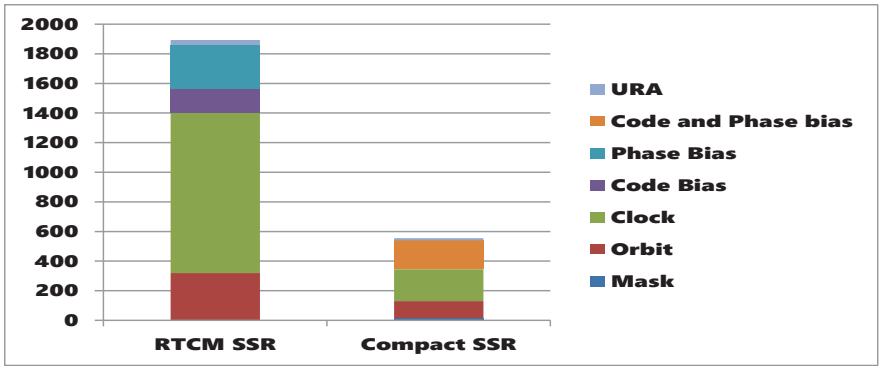


Figure 4. Required data rate [bps] for a global PPP correction service

CHCNAV

All-in-one GNSS RTK

Brings speed and accuracy in one GNSS solution

i50
GNSS RTK

GPS+Glonass+Beidou+Galileo for robust data quality

Internal UHF and 4G modems for optimized field operations

WWW.CHCNAV.COM

Japan, Softbank, and NTT Docomo announced the launch of the nation-wide RTK-GNSS correction service using their LTE/5G network. Similar services would be available in other countries. The industrial standardization group in mobile communication, 3GPP is working to define high accuracy GNSS correction service base on the existing open standard. Figure 5 shows the roadmap of GNSS positioning standardization in 3GPP. The conventional GNSS technologies such as RTK and network-RTK are already standardized based on RTCM 3 standard in Release 15. PPP is also standardized in Release 15 based on RTCM SSR. For PPP-RTK, it is not standardized yet as RTCM standard, it is working to standardize based on the existing open standard, it is decided to define the specification for PPP-RTK based on Compact SSR, it is plan to be included in Release 16 which will be released on February 2020.

Reference implementation

For the implementation of PPP-RTK positioning software, the conversion of correction data from the SSR domain into the OSR domain should be conducted. To minimize the development effort by the receive manufacturers and to maintain the interoperability for different GNSS receivers, the reference implementation of SSR-to-OSR converter is highly demanded.

For QZSS CLAS, an open-source toolkit for PPP-RTK named CLASLIB is developed, and distributed from QSS Web site (https://www.qzss.go.jp/). Figure 6 shows the structure of CLASLIB, it is implemented as an extension of RTKLIB, an open-source toolkit for RTK. CLASLIB includes the Compact SSR to OSR converter with documents and test datasets. Although CLASLIB is developed for QZSS CLAS, Compact SSR is generically defined for PPP-RTK service, it could be applied for other PPP-RTK correction services with minor updates.

Service information

Definition of Service Information

The format for SSR-based high accuracy service is mainly designed to send the correction data for PPP/PPP-RTK. There is also demand to receive other useful information such as operational information in the same data stream. In Compact SSR specification, the service information message (SubType 10) is defined to send the slowly changing or constant information as shown in Table 4. The contents of service information are divided into multiple parts of SubType 10 messages, it is concatenated and decoded in the user receivers.

Grid Definition Information

For PPP-RTK positioning, the atmospheric correction is provided on the grid located in the service area, the user receiver calculates the atmospheric correction at the user position by interpolating the correction data of surrounding grids. In QZSS CLAS, the 212 grids are defined for their nation-wide PPP-RTK service for Japan as shown in the right part of Figure 7.

In the current service of QZSS CLAS, the coordinates of grid points are defined and documented in the ICD, IS-QZSS-L6. However, the grid definition is demanded to be included in the stream to make better consistency. A highly effective grid information message is proposed

Table 4. Specification of Service Information message in Compact SSR

Type	Message content
1	Service Provider Information
2	Service Operation Information
3	Grid Definition Information
4	Coordinate Transformation Information

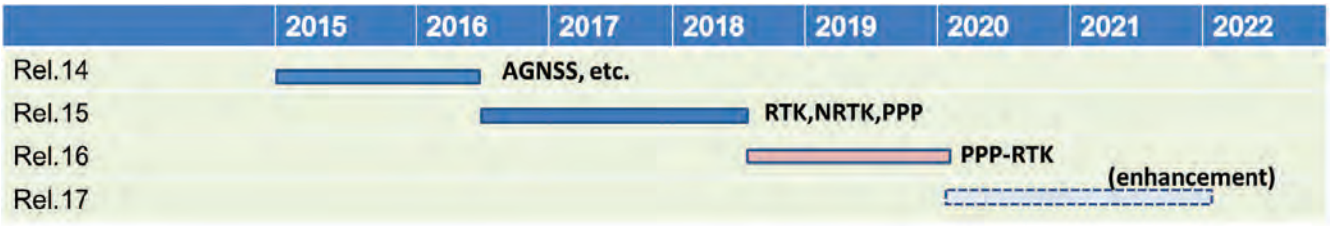


Figure 5. Roadmap of GNSS positioning standardization in 3GPP

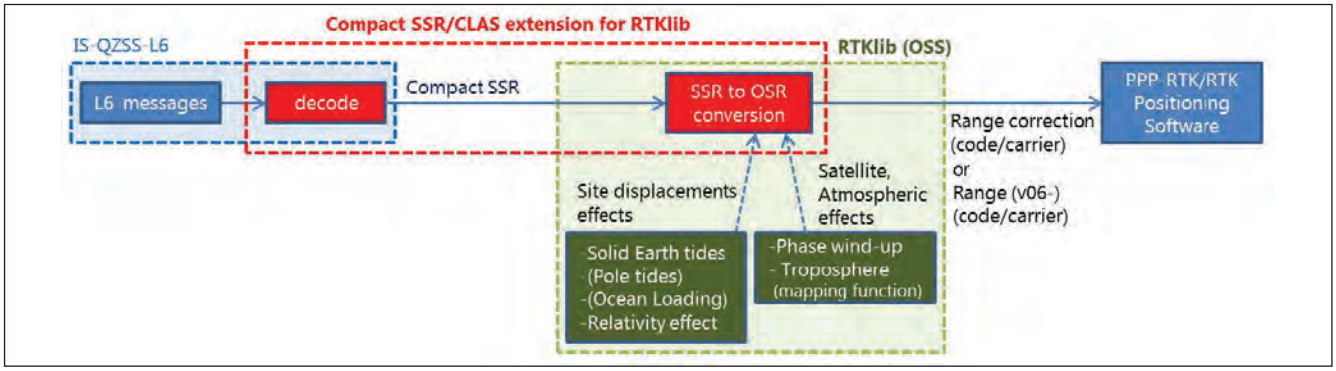


Figure 6. Open-source toolkit for PPP-RTK: CLASLIB

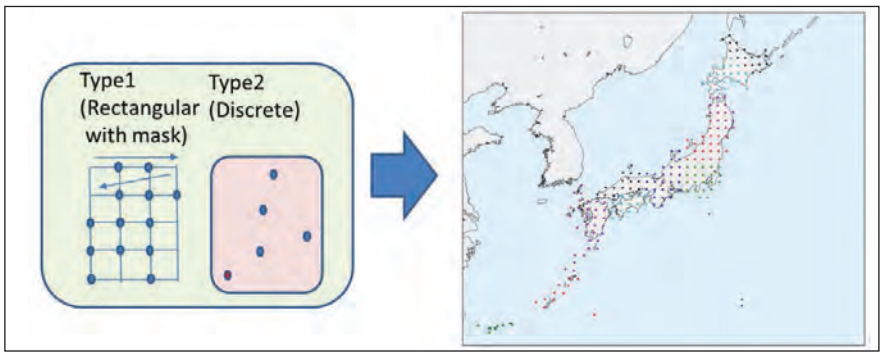


Figure 7. A grid information proposal for PPP-RTK

for 3GPP by ESA, u-blox and Mitsubishi Electric. It includes the two types of grid definition as shown in left part of Figure 6. Type 1 is to define the equally spaced grids, it also includes the mask information to represent the valid grid point in the rectangular area. Type 2 is to define the randomly located grids, it is normally located on the physical reference stations. If the proposed message implemented as Compact SSR SubType 10 is applied for QZSS CLAS, the coordinates of total 212 grids can be transmitted within 4 minutes by consuming 6bps of the stream.

Coordinate Transformation Information

For a robotic application such as automatic driving, the precise location on the static datum used in digital map should be required. However, the position derived from PPP or PPP-RTK correction service is based on the dynamic datum of current epoch. In Japan, the difference between the national static datum JGD2011 and the dynamic datum of current epoch is more than 1.5m on the worst case, it is changing up-to 10cm per year. The upper part of Figure 8 shows the latitude and longitude offset between two geodetic datum. The offset between two geodetic datum is highly nonlinear because of the earthquakes and the crustal deformation, it cannot be represented in the simple coordinate transformation parameters. The Geospatial Information Authority (GSI) in Japan is defining the highly accurate offset database with 5km resolution to transform between JGD2011 and the current datum, it is available on their web site. However, the GNSS receivers without internet connection cannot easily access the database, and the size of database is about 760kB in text format, it is so huge to send in the narrow-band data stream.

Recently, a highly efficient coordinate transformation information is defined for the service information message of Compact SSR. By applying the similar compression technique as atmospheric correction, the size of

coordinate transformation parameters can be reduced considerably, the message can be sent as Compact SSR SubType 10 messages within 15minutes by consuming 6bps of stream. The bottom part of Figure 7 shows the offset after correction of offset, the expected accuracy is about 3cm (rms).

Interoperability and future direction

Interoperability between services and receivers

As shown in Table 1, multiple high-accuracy GNSS correction services will be available in this decade, the interoperability between different services will be important. Figure 9 shows the recent activities to standardize PPP and PPP-RTK correction services based on RTCM SSR and Compact SSR. Galileo HAS plan to use an open standard for their PPP correction service, Compact SSR is selected as a starting point. European Commission (EC) and Japan Cabinet of Office (CAO) started the discussion to maintain the interoperability between Galileo HAS and QZSS CLAS. GLONASS PPP proposed to use RTCM SSR for its PPP service. Australian SBAS is also planning to use open format for its PPP correction service. As mentioned in previous section, 3GPP is working to standardize PPP/PPP-RTK format based on RTCM-SSR/Compact SSR.

The usage of open-format for satellite-based or ground-based open correction services could be highly beneficial for the high-accuracy GNSS market by reducing the development and evaluation cost of GNSS receivers supporting the multiple satellite-based or ground-based correction services.

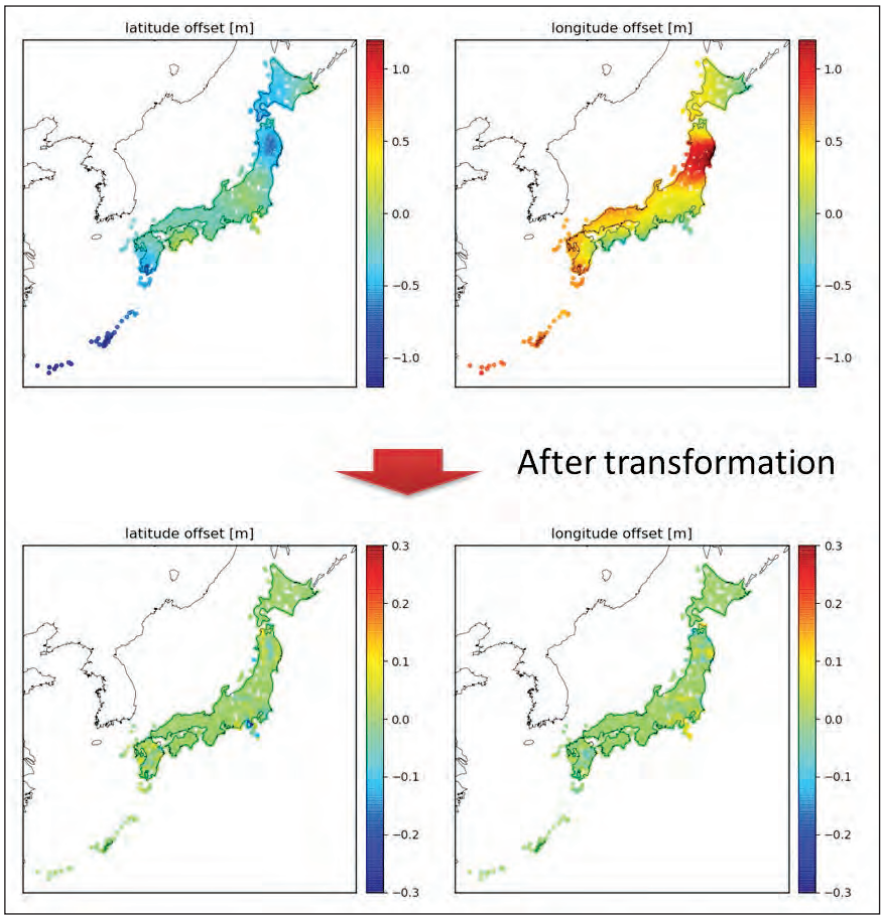


Figure 8. A grid information proposal for PPP-RTK

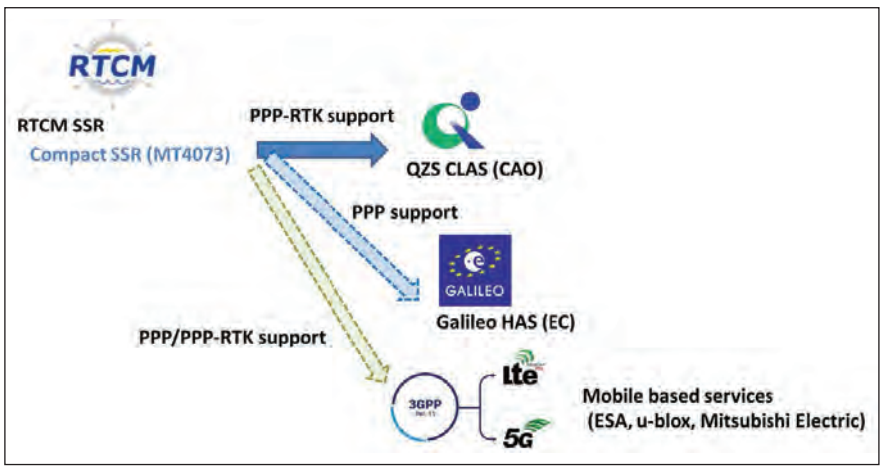


Figure 9. Activities to standardize PPP/PPP-RTK correction services

Integrity and security

Currently, the high accuracy positioning is mainly applied for the survey market, it is expected to be applied for the high volume market such as automotive, agriculture, drone, construction. For safety-critical robotics applications such as automatic driving, the integrity of navigation system is highly important. For aviation application, the integrity requirement is defined as 10^{-7}/h in SBAS, the open standard is discussed in RTCM SC-134 for the other applications. Compact SSR messages include the quality information of the correction data, it can be used to calculate the protection level on the GNSS receiver. The integrity information needs to be standardized for high-accuracy positioning.

There is a concern about cyber-security attacks such as spoofing. Recently, GNSS service providers such as GPS and Galileo proposed the navigation message authentication or the navigation signal authentication for their services. The authentication of correction service

is also proposed for SBAS. Recently, the authentication message for PPP/PPP-RTK correction service is proposed as an extension of Compact SSR. The interoperability of GNSS authentication service is also important to minimize the cost of implementation on GNSS receivers.

Conclusion

In this article, the recent activities of international standardization for high-accuracy GNSS correction services are introduced. The high-accuracy GNSS positioning will be widely accepted in a wide range of applications for next decade, the inter-operability of different services and receivers is highly important. The industrial standardization group such as RTCM SC-104 committee and 3GPP is working to standardized to define the open-standard for high-accuracy GNSS positioning. The inter-system inter-operability is also discussed in the International Committee on Global Navigation Satellite Systems (ICG).

The usage of open-format for satellite-based or ground-based open correction services could be highly beneficial for the high-accuracy GNSS market by reducing the development and evaluation cost of GNSS receivers supporting the multiple satellite-based or ground-based correction services

References

1. Cabinet Office, "Quasi-Zenith Satellite System Interface Specification, Centimeter Level Augmentation Service," *IS-QZSS-L6-001, 5 November 2018.*

2. Cabinet Office, "Quasi-Zenith Satellite System Performance Standard," *PS-QZSS-001, 5 November 2018.*

3. RTCM SC-104, "Differential GNSS (Global Navigation Satellite Systems) Services – Version 3," *RTCM Standard 10403.3, Octoer 2016.*

4. Hirokawa, R., Sato, Y., Fujita, S., and Miya, M., "Compact SSR Message with Integrity Information for Satellite-based PPP-RTK Service," *Proceedings of 29th International Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2016), Portland, OR, September 2016*, pp. 3372-3376.

5. RTCM Paper 115-2018-SC104-1071, "Specification of Compact SSR Message for Satellite-Based Augmentation Service," *Mitsubishi Electric Corporation, RTCM SC-104 meeting, Frankfurt, Germany, October 2018.*

6. Motooka, N., Hirokawa,R. , Nakakuki, K., Fujita, S., Miya, M., Sato, Y. ,"CLASLIB: An Open-source Toolkit for Low-Cost High-precision PPP-RTK Positioning," *Proceedings of 32th International Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2019), Miami, Florida, September 2019.*

7. Pasynkov, V., "Status and prospects of the Russian PPP System for high-precision determination of Navigation and Ephemeris-time Information," the Workshop on the Applications of Global Navigation Satellite Systems, Suva, Fiji, June 2019.

8. Blonski, D., "Galileo Status and High Accuracy," the Workshop on the Applications of Global Navigation Satellite Systems, Suva, Fiji, June 2019.

9. Reynolds, S., "The Australian SBAS Program: Progress and Motivation for a PPP Service," the Workshop on the Applications of Global Navigation Satellite Systems, Suva, Fiji, June 2019.

10. Tu, R., "Development of BDS and Stude of PPP Timing," the Workshop on the Applications of Global Navigation Satellite Systems, Suva, Fiji, June 2019.

11. Vana, S., Aggrey, J., Bisnath, S., Leandro, R., Urquhart, L., and Gonzalez, P. , "Analysis of GNSS Correction Data Standards for the Automotive Market," NAVIGATION. 2019;66 (3, Autumn):577-592.

12. Fernández¯Hernández I, Rijmen V, Seco¯Granados G, Simón J, Rodríguez I, Calle JD. "A navigation message authentication proposal for the Galileo Open Service," NAVIGATION. 2016;63(1, Spring):85-102.

13. Fernández¯Hernández I, Châtre E, Dalla Chiara A, et al. "Impact analysis of SBAS authentication," NAVIGATION.2018;65 (3, Winter):517–532.

14. Anderson, Jon M., Carroll, Katherine L., DeVilbiss, Nathan P., Gillis, James T., Hinks, Joanna C., O'Hanlon, Brady W., Rushanan, Joseph J., Scott, Logan, Yazdi, Renee A., "Chips-Message Robust Authentication (Chimera) for GPS Civilian Signals," Proceedings of the 30th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2017), Portland, Oregon, September 2017, pp. 2388-2416.

15. Hirokawa,R. , Fujita, S.,"A Message Authentication Proposal for Satellite-Based Nationwide PPP-RTK Correction Service," *Proceedings of 32th International Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2019), Miami, Florida, September 2019.*

The paper was presented at the Workshop on the Applications of Global Navigation Satellite Systems, Suva, Fiji, June 2019.

Remote Sensing for air pollution control

Air pollution in India has become one of the most serious causes of environmental damage and health risks. As per the World Health Organisation (2018), 13 Indian cities are among the World's top 20 cities with severe levels of PM $_{2.5}$ and PM$_{10}$

A K Jain
worked as Commissioner (Planning), Delhi Development Authority. He was a member of the Committee of the Ministry of Urban Development on the DDA (2015) and UN Habitat (2007-12). He is a member of Editorial Board of International Journal of Environmental Studies (UK).

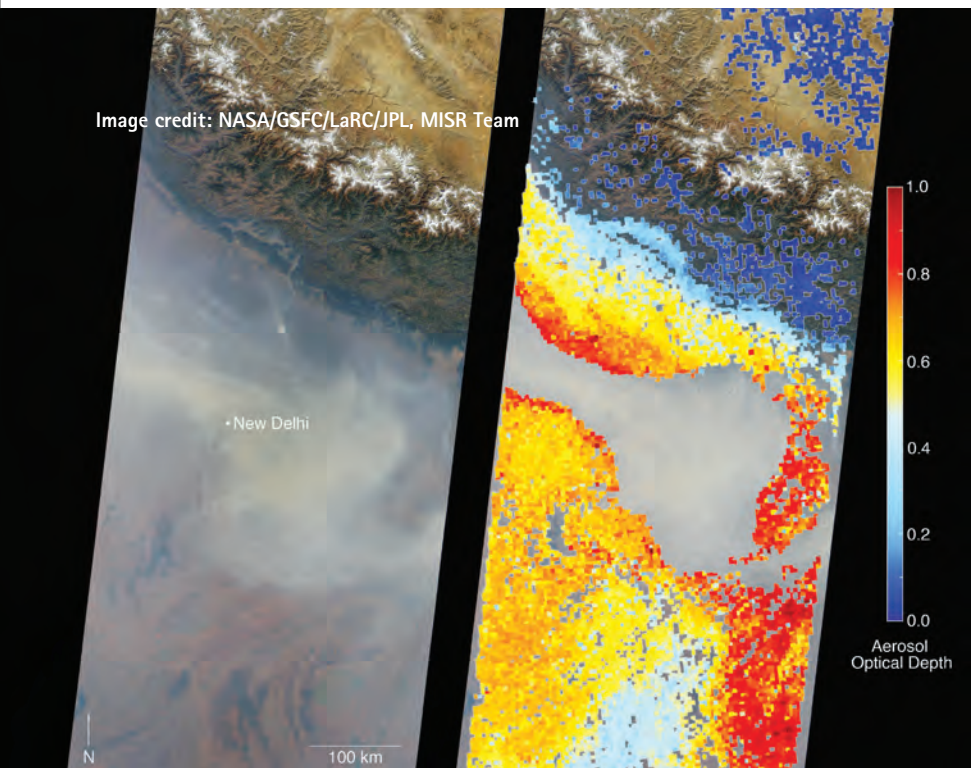
In 2017, 77% population of India was exposed to ambient PM2.5 above 40 µg/m3, which is the recommended limit by the National Ambient Air Quality Standard (CPCB 2018 & DPCC 2018). The mean ambient particulate matter PM2.5 annual exposure of 90 µg/m3 in India in 2017 is one of the highest in the world. The highest PM2.5 exposure level was in Delhi, followed by other north Indian states of Uttar Pradesh, Bihar and Haryana. India is home to 18% of global population, but accounts for 26% of global premature deaths and health loss attributable to air pollution.

The major sources of air pollution are urban transport, dust from construction and demolition activity, the use of 'dirty' fuels such as diesel, coal and wood for industries, electricity generation and cooking. The sources of air pollution are geographically dispersed, often across states. Around half of Delhi's air pollution during the months of October and November can be attributed to the burning of agricultural waste in neighbouring states. A study conducted by the John A. Paulson School at Harvard University (2018), uses satellite imaging and geospatial mapping technologies to identify agricultural fires in neighbouring States as the main source of increased air pollution during the harvesting seasons.

Data from NASA satellites was used to identify fire 'hot spots', after which the study used a particle dispersion model to track the amount of pollutants travelling to New Delhi from these sources. More than half of the 150 µg/m^3 concentration of PM2.5 and PM10 particles during these seasons can be attributed to these agricultural fires. This means that apart from developing localized solution to the air pollution the governments of Punjab, Haryana, Uttar Pradesh and Uttarakhand also have to control external source of pollution. A study by the Harvard Kennedy School states that ambient air pollution may cost the Indian economy 0.5 trillion dollars a year.

A study by the University of Surrey posits that the WHO's estimates that the exposure to PM$_{2.5}$ and PM$_{10}$ particles in Transport Micro-environments (TMEs), Asian pedestrians were 1.6x and 1.2x worse off than their European and American counterparts respectively. Furthermore, bus passengers were 3x worse off than their American counterparts, while this figure increased to 9 times when also considering car passengers. Asian pedestrians are also 7 times more susceptible to exposure to Black Carbon, which has been linked with adverse health effects such as cardiopulmonary morbidity.

Around half of Delhi's air pollution during the months of October and November can be attributed to the burning of agricultural waste in neighbouring states. This means that apart from developing a localized solution to the air pollution that is generated within its own city, the Delhi NCT Government must also coordinate with the governments of Punjab, Haryana, Uttar Pradesh and Uttarakhand to control this external source of pollution



The Multi-angle Imaging SpectroRadiometer (MISR) instrument aboard NASA's Terra satellite passed over the region on Saturday, Nov. 5, 2016, at around 11:05 a.m. local time

Air monitoring data and inventory

There is little information about the real-time pollution levels in the immediate vicinity that are affecting the people's health. Even in a large city like Delhi, the government has only 26 air pollution monitoring stations which provide local data on pollution levels. The information on air pollution is often ad-hoc and inadequate. Lack of Continuous Emissions Monitoring (CEM) equipment means that stakeholders are unable to identify the sources, diagnose and enforce that are worsening the problem.

Air quality data is significant to gaining a thorough understanding of local air pollution. Recent technological advancements have made it possible to gather data, with new low-cost monitoring devices and advanced methods of collating and analysing it. This helps to gain a robust understanding of pollution levels, their causes and effect.

Now-a-days smart electricity poles with sensors are available to monitor pollution parameters along with light, CCTV, wi-fi, etc. The NDMC has been using them in New Delhi. Citywide air quality monitoring networks and data from these can provide consumers with a continuous feed of air quality in their area.

The Google plans to map street by street air pollution that will be available to the common man. The active sensors will measure CO_2, CO, NO_x, NO_2, ozone and particulate matter.

CEMS and Air quality Data can be used to identify major components, sources, quantification and projects. It can also help the government to apply monetary incentives and penalties for polluting companies. SPCBs can provide tax benefits and ease other regulations on emission-efficient industries while penalizing inefficient ones. At the central level, the CPCB can also use this data to introduce a cap-and-trade system, instead of the existing 'command-and-control' regulations. The data can be used to analyse the issues, sources and project various options and actively schedule to assign the responsibilities, project management, including timelines and monitoring.

The challenges

Finding a solution to the problem of air pollution is daunting. A large, emerging economy such as India's has numerous and varied sources of air pollution, be they from industry, construction, urban transport or domestic use. Regulating the air pollution from all these different stakeholders is especially difficult because its impact is geographically dispersed, often across the States and jurisdictional lines. For instance, around half of Delhi's air pollution during the months of October and November can be attributed to the burning of agricultural waste in neighbouring states. This means that apart from developing a localized solution to the air pollution that is generated within its own city, the Delhi NCT Government must also coordinate with the governments of Punjab, Haryana, Uttar Pradesh and Uttarakhand to control this external source of pollution.

National Clean Air Programme (NCAP)

The Government of India have launched the National Clean Air Program and Graded Response Action Plan. The incidences of episodic air pollution in India, especially in Delhi NCR, in recent years has led to the preparation of comprehensive Clean Air Programme (NCAP) which seeks to address the issue, It seeks to have efficient data management and dissemination, public outreach and timely measures for prevention and mitigation of air pollution.

The Government is executing the National Air Quality Monitoring Programme (NAMP), which consists of 691 manual operating stations covering 303 cities/ towns. Under NAMP, four air pollutants *viz.* Sulphur Dioxide ($S0_2$), Oxides of Nitrogen ($N0_{2/}NO_x$), Suspended Particulate Matter (PM_{10}) and Fine Particulate Matter ($PM_{2.5}$) have been identified for regular monitoring at all the locations. In addition, there are 101 real-time Continuous Ambient Air Quality Monitoring Stations (CAAQMS) in 57 cities monitoring 8 pollutants viz. PM_{10}, $PM_{2.5}$, $S0_2$, NO_x, ammonia (NH_3), CO, ozone (0_3) and benzene.

The monitoring is being carried out with the help of Central Pollution Control Board (CPCB); State Pollution Control Boards (SPCB); Pollution Control Committees (PCC) and

National Environmental Engineering Research Institute (NEERI), Nagpur.

Central Pollution Control Board (CPCB) has issued a comprehensive set of directions for implementation of 42 measures to mitigate air pollution comprising action which include control and mitigation measures related to vehicular emissions, re-suspension of road dust and other fugitive emissions, bio-mass/municipal solid waste burning, industrial pollution, construction and demolition activities. Directions covering 42 action point was issued initially for implementation in NCR but have now been extended to other States in India.

Vehicles have been identified as major source of pollution. In this regard Bharat Stage IV (BS-IV) norms has been launched for mandatory implementation since 1st April 2017 and BS-VI by 1st April, 2020.

Other measures include use of cleaner and alternative gaseous fuels like CNG, LPG and ethanol blending in petrol in order to reduce vehicle exhaust emissions, promotion of public transport, Pollution Under Control Certificate, lane discipline, vehicle maintenance, etc. It is estimated that a 5% blending can save around 1.8 million barrels of crude oil.

Graded Response Action Plan (GRAP)

The Government has notified a Graded Response Action Plan for Delhi and NCR, keeping in view the key pollution sources in Delhi and National Capital Region of Delhi (NCR). While major sources of pollution-vehicles, road dust, biomass burning, construction, power plants and industries remain continuous throughout all seasons, the episodic pollution from stubble burning, increase in biomass burning, etc. varies across seasons. During winter the relative share of air pollution from the vehicles, biomass burning, municipal solid waste burning, fire-crackers, stubble burning, construction, and secondary particles increase. During summer, the influence of road dust, fly ash, vehicles, biomass burning, etc. is high. The Graded Response Action Plan includes appropriate measures for each level of pollution. The measures are graded from public health emergency level to downward. Emergency and Severe levels include cumulatively all other measures listed under Very Poor, Poor and Moderate AQI. The responsibility of implementing the GRAP lies with the EPCA.

Delhi's air quality dips to emergency levels, breaches 'severe+' mark

Delhiites woke up to the highest level of pollution this season on Friday (November 1, 2019) morning as the city was shrouded by a haze of dust and smoke.

The Air Quality Index (AQI) value was hovering at 459 at 8 am on Friday after pollution levels breached the 'severe+' zone late on Thursday night.

This is the first time that the air quality has dipped to emergency levels in the national capital this season. Such a situation was last seen in January 2019.

Even though till 8 am in the morning the air quality showed no signs of improvement, government agencies have forecast that there could be marginal improvement today. Marked improvement could only be expected on Sunday when winds are expected to pick up.

"At 8 am the PM2.5 level was standing at 350ug/m3, nearly six tomes above the daily permissible limit of 60ug/m3. The PM10 level was recorded to be 539ug/m3 which is more than five times above the permissible limit of 100ug/m3m" said a CPCB official.

According to the Graded Response Action Plan extreme measures such as odd-even road rationing, banning entry of trucks, banning construction activities and other measures such as shutting down of schools are enforced if air quality persists in emergency zone. *Hindustan Times, New Delhi, Nov 01, 2019*

Clean air and sustainable development

In order to arrest air pollution, the following can be the agenda for 2030 (adapted from SDG 7 and SDG 11):

i. Double the rate of improvement of energy efficiency in India's 5 largest metropolitan cities.
ii. Double the emission reduction from energy production.
iii. Halve the number of deaths per 100,000 persons caused by air pollution
iv. Halve the number of health complications per 100,000 caused by air pollution

Based on the identification of major components and sources of air pollution and analysis of ambient air quality, various scenarios of emission control from point sources and area sources can be worked out for next five years. This involves multifarious actions to reduce emissions from transport, power and industries, incineration of wastes, dust, etc. These measures can be geographically interlinked by a comprehensive approach towards a non-polluting and healthy city. Such a city is planned on the principles of compact and dense development, intelligent traffic management, transport demand management, efficient, comfortable and non-polluting public transport, bicycles and non-motorised transport (NMT) and walk to work (IPCC, 2014). It provides clean water, wastewater recycling, CEPTs and zero polluting industries. Coal based thermal power plants are converted into CNG based and renewal energy along with smart grids and energy efficiency. Preparation of pollution control plans at district, municipal, and local levels is linked with the principles of circular economy, recycling, underground

and black hole technology of waste management and smart utilities.

Intelligent and smart systems viz, Big Data Analytics, Supervising Control Data Acquisition Systems (SCADA), ERP solutions, GIS, Integrated Digital Control/Command Centres and Satellite Surveillance are exploited for air pollution control. The technological solutions have to be based on public engagement and collaborative partnerships.

The Environmental Pollution Control Authority (EPCA) has proposed adoption of Remote Sensing and keep a check on polluting vehicles in the NCR. All the vehicles shall be checked by remote sensing in real time for their emission vis-a -vis prescribed limit. Data collected by Remote Sensing shall be stored and linked with VAAHAN Database. Violations can be flagged and if a vehicle is classified as a high emitter or a extreme polluter, a challan shall be issued on the spot. The system shall measure NO, NO_2, HC, CO, CO_2 and opacity.

Further, the installation of engine optimization and exhaust gas recirculation technologies and promoting rail and waterways for public transport and freight can reduce black carbon emissions by 90%. Other critical areas to reduce emission from transport include increasing the use of electric vehicles and initiating a campaign for car-pooling and ride-sharing.

Clean Air Asia is also working in 30the area of mapping efficient routes and installation of emission-efficient engines. It has also developed a walkability app for Indian cities in an attempt to reduce vehicular use. Its Value Air You Use (VAYU) app tracks air quality measurements that allow users to make choices to act against air pollution.

Top court fumes over Delhi pollution

People are losing precious years of their lives due to pollution, the Supreme Court said on Monday (November 4, 2019) as Delhi and nearby areas face a public health emergency due to severe air pollution. The top court pulled up the centre and the Delhi government, saying "there is passing of buck" and that it "can't happen in a civilised country".

The Supreme Court took up a report by the Environment Pollution Control Authority or EPCA, on the pollution caused by stubble-burning. The pollution control body had asked that states in the National Capital Region be asked to stop burning of waste, toxic emissions from industries and dust from construction sites.

"Can we survive in this atmosphere? This is not the way we can survive. No one is safe even inside homes; it is atrocious," a bench headed by Justice Arun Mishra said.

Taking note of crop burning in Punjab, Haryana and western Uttar Pradesh, the Supreme Court asked the centre to call environmental experts, including those from IIT (Indian Institutes of Technology), to the court within 30 minutes. "Things are happening every year under our nose. People are being advised to not come to Delhi or to leave Delhi.State governments are responsible. People are dying in their state and neighbouring states. We will not tolerate this. We are making a mockery of everything," the top court said.

"Delhi is choking every year and we are not able to do anything. Question is that every year this is happening," the bench said, adding, "People are dying and it can't happen in a civilised country".

www.ndtv.com/india-news/delhi-pollution-supreme-court-says-state-machinery-not-acting-centre-and-delhi-must-act-dont-blame-e-2127003

Industries, Power and Fuels

Industries and power have a crucial role in shaping India's path to combating air pollution. These need to shrink their environmental footprint by following measures:

- Promoting solar energy
- Strengthening of enforcement and emissions monitoring
- Scaling up of Emissions Trading Schemes.
- The development and installation of emissions free technologies, especially in the power and brick-making industries.
- Installing continuous emissions monitoring technology (CEMS) at manufacturing locations and placing more accountability on industrial polluters
- Introduction of gaseous fuels and enforcement of stringent $SO_2/NO_x/PM_{2.5}$ standards.
- Elimination of DG set usage by provision of 24x7 electricity and by innovative tail pipe control technologies.
- Use of agricultural residue in power plants and ether industries to replace high ash coal and open burning in fields.
- Boosting of PNG Supply Network and clean-cooking stoves that use PNG/ LPG or solar energy.
- The implementation of gasification technologies to help convert waste into biomass pellets or electricity.

Dust control by screens, filters, flagging machines, vacuum cleaning, humidification, sprinkling of water and artificial rain.

Proliferation of low-carbon, green energy and smart building technologies are necessary in controlling the air pollution. Passive design of buildings can reduce the need of air conditioning. For a comprehensive approach, it is necessary to prepare local level air pollution control, energy efficiency and low carbon transport plans. Landscape, planting of trees and ground covers are important pollution abatement. It is low-cost, aesthetic, natural and simple to execute. This can be a new frontier in making the air clean and healthy.

Top 10 most polluted cities in India

Rank	City	AQI	Condition	State
1	Jind	448	Severe	Haryana
2	Baghpat	440	Severe	Uttar Pradesh
3	Ghaziabad	440	Severe	Uttar Pradesh
4	Hapur	436	Severe	Uttar Pradesh
5	Lucknow	435	Severe	Uttar Pradesh
6	Moradabad	434	Severe	Uttar Pradesh
7	Noida	430	Severe	Uttar Pradesh
8	Greater_Noida	428	Severe	Uttar Pradesh
9	Kanpur	427	Severe	Uttar Pradesh
10	Sirsa	426	Severe	Haryana
14	**Delhi**	**407**	**Severe**	**Delhi**

as on 4 Nov, data is average of the last 24 hours (4PM-4PM)
Source: CPCB

Conclusions

The strategic pathway towards clean air starts with digital, real time development of various sources of air pollution. This should be the basis of the preparation of pollution control plans at district, municipal, and local levels. Low carbon urban systems require alternatives such as zero net energy buildings, black hole technology of waste management and smart utilities. According to the IPCC (Climate Change Report, 2014, WG III) the critical aspects of spatial planning for clean air comprise:

- Density, FAR optimisation
- Land use (mix of activities, population)
- Connectivity, walkability and traffic density
- Accessibility for all by public transit, cycle, walk

Along with these strategies, the concept of AQLI (Air quality Life Index) should be adopted for each city and local area. It is necessary that a comprehensive, digital and real time data is developed to facilitate the civic engagement and public participation.

This needs an air-shed approach and making proper use of data and monitoring. Big Data Analytics, Supervising Control Data Acquisition Systems (SCADA), ERP solutions, GIS, Integrated Digital Control/ Command Centres and Satellite Surveillance can mitigate the air pollution to a great extent.

References

1. Central Pollution Control Board (2018) Report on Air Pollution in India, New Delhi.

2. Centre for Science and Environment (2013) Vehicles-Taming Emissions Workshop, New Delhi

3. Delhi Pollution Control Committee (2018) Real Time Ambient Air Quality Data of Delhi, India, Delhi Pollution Control Committee (DPCC). http://www.dpccairdata.com/dpccairdata/display/index.php.

4. Greenstone, Michael, Rohini Pande, Anant Sudarshan, and Santosh Harish (2018) A Roadmap Towards Cleaning India's Air, India Policy Forum, 2017-2018.

5. Gardiner, Beth. The Challenges of Cleaning Up Cooking. The New York Times. December 21, 2017. https://www.nytimes.com/2015/12/09/business/energy-environment/the-challenges-of-cleaning-up-cooking.html.

6. Harvard John A. Paulson School of Engineering and Applied Sciences (2018), Agricultural Fires Can Double Delhi Pollution during Peak Burning Season https://www.seas.harvard.edu/news/2018/03/agricultural-fires-can-double-delhi-pollution-during-peak-burning-season

7. IPCC (2014) Climate Change Working Group III, 5th Assessment Report, Cambridge University Press, New York

8. Jain, A.K, (2009) Low Carbon Cities-Policies, Planning and Practice. Discovery Publishing House, New Delhi.

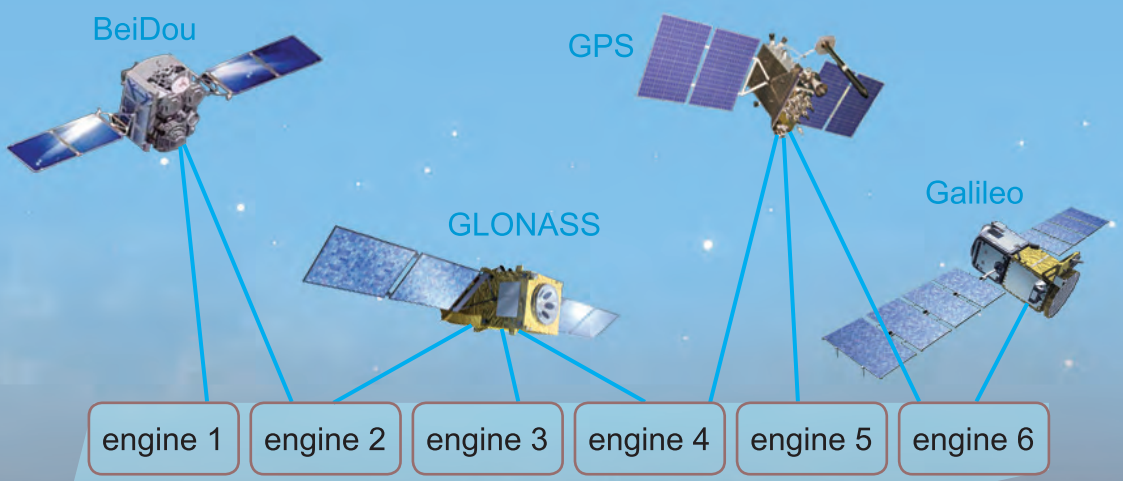
9. Jain, A.K, (2019) Sustainable Architecture, Buildings and Cities, Synergy Books, New Delhi

10. Jiang, Jing Jing, Bin Ye, and Xiao Ming Ma (2014) "The Construction of Shenzhen's Carbon Emission Trading Scheme." Energy Policy75: 17-21. doi:10.1016/j.enpol.2014.02.030.

11 World Health Organisation, (2018) WHO Global Ambient Air Quality Database, Geneva.

RTK and Optical United

J-Mate as the 7th RTK Engine
Robotics and Scanning too



TRIUMPH-LS, RTK Rover

J-Mate Rover Target Stripes

TRIUMPH-3, RTK Base Station

J-Mate Base Station

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.

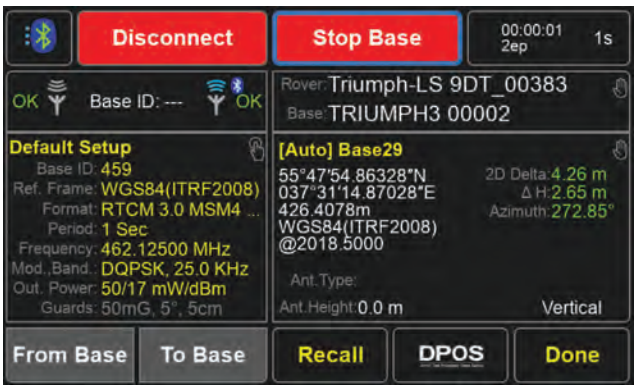
The system is self-sufficient for all jobs. No need to pay RTN service providers for RTK base stations and no need to pay communication service providers. The communications are done via integrated and included Bluetooth, UHF, and Wi-Fi embedded in the system.

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.

We added the "Aim" option for stake-out. In this mode J-Mate points to the selected stake point and you follow the laser to reach the intended point. This is in addition to the robotic mode which J-Mate follows your Zebra pole.

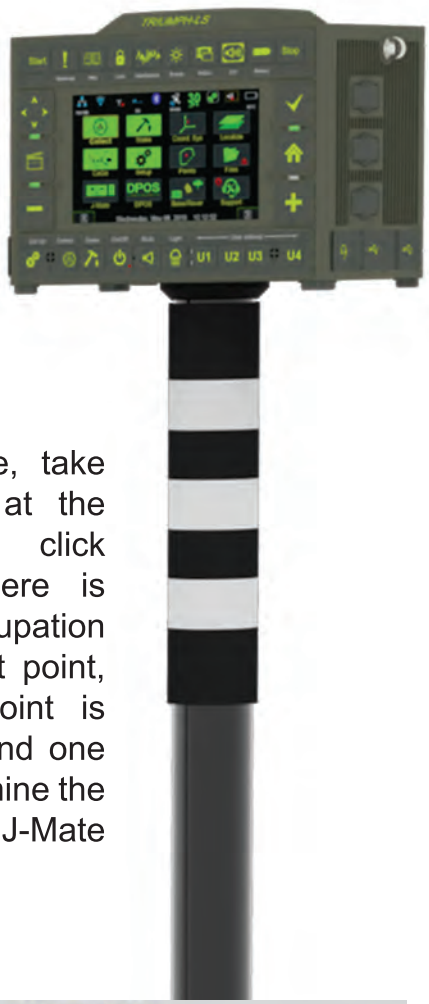
At TRIUMPH-LS = 2.13 kg (4.40 lb), TRIUMPH-3 = 1.26 Kg (2.20 lb), and J-Mate = 2.17 kg (4.41 lb), The total package of 5.6 kg (11.02 lb), weighs less than one conventional optical total station alone.

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

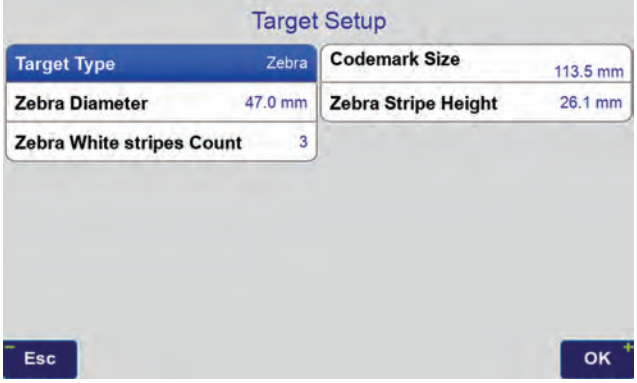


FL

Take Backsight with a Single Shot

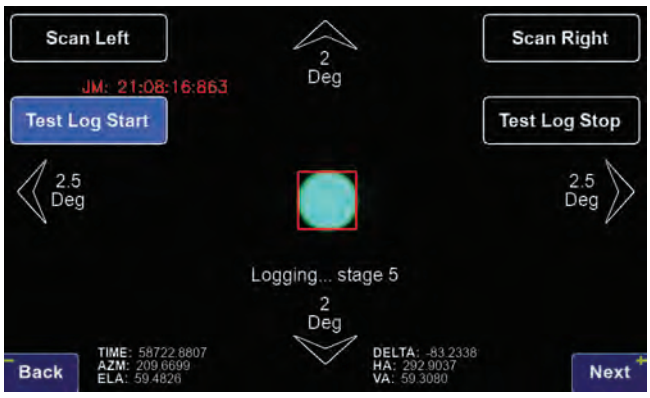


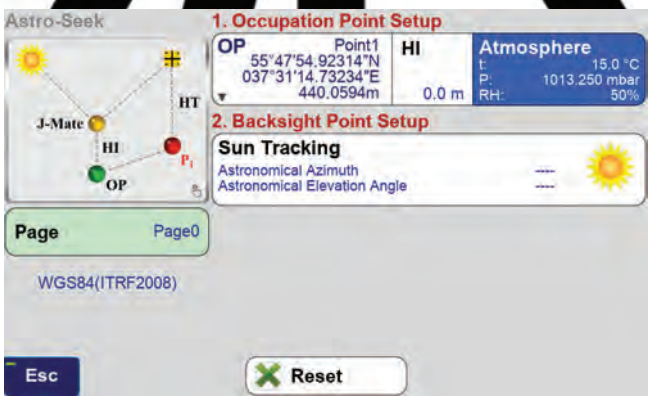
To calibrate the J-Mate, take few seconds of RTK at the Backsight point, and click “Backsight” button. There is no need to locate Occupation Point and the Backsight point, because Occupation point is the RTK Base station and one point is enough to determine the azimuth to calibrate the J-Mate angular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

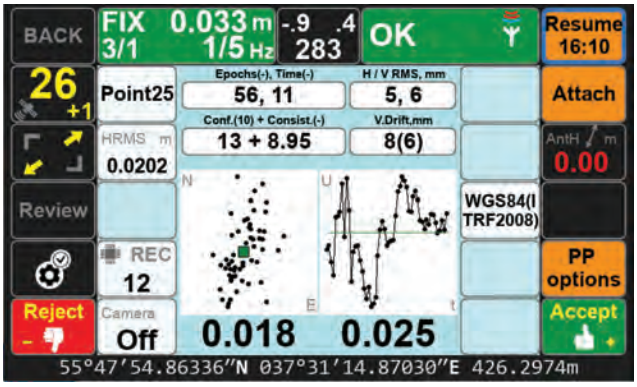
Complete RTK Base & Rover.
Complete optical system.
Complete controller and software.
Free updates.
Robotic & Scanner...
...all under $40K

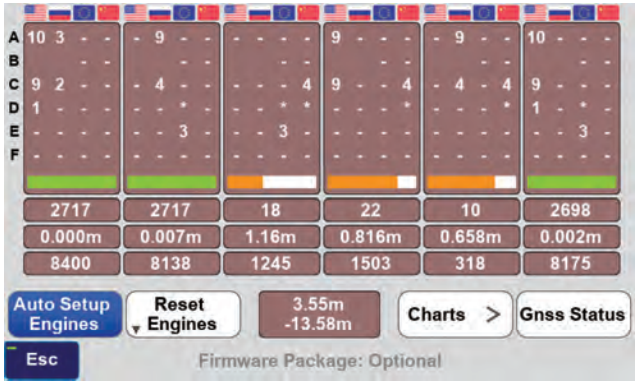
And it all fits in a small carrying bag.

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. We present here the first of the three parts of the paper

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

Preamble

Any engagement in dialogue on proposed changes to land registry services delivery, either through privatization or Public Private Partnerships, is a minefield. You need to have your eyes wide open, be well informed, ask the right questions, critically analyze, discern the hype from facts, and be prepared for the unexpected. Through this paper, it is hoped that the reader is better enabled to navigate the PPP and privatization minefields. Here's a sample of the diversity of opinion from what may be encountered from both proponents and opponents:

"There's no doubt, it's been done around the world, so it's been done in Canada, there are no concerns there, provided you've got the regulatory functions, which we do. …..…We will retain the data and the information, which we do, there's a ministry function that can be done, and to provide benefits through economy of scale, in addition for potentially other services that can be provided to the consumer." Former New South Wales Premier, Mike Baird (2016).[1]

"I am very pleased to announce the appointment of Land Services SA to provide the State with a range of land services for a 40-year concession period – these services cover both lands titling and land valuation activities. ..The sale will deliver the State an upfront return of $1.605 billion now plus a considerable ongoing royalties stream over the concession period. This is an absolutely outstanding result for the State. …I am also very pleased to say that all protections for the people of South Australia, that I announced in last year's budget, will be achieved, including indefeasibility of title, continuation of the current fees and charges regime, strong protections for privacy and data security, and maintaining current service delivery standards. ....South Australians will notice no change in the services they receive through these functions." Hon. Tom Koutsantonis MP, Treasurer, South Australia (2017).[2]

"The recent agreement in April 2017 for New South Wales indicates the appetite for PPP is still active. When one looks at the organizations who bid for New South Wales, it is apparent that the large pension funds and banks will provide the investment required to modernize land administration." Former Ontario Assistant Deputy Minister Art Daniels (2017).[3]

"Privatization is no panacea for profligate governments. Selling assets is a one-off that provides only brief respite for those addicted to overspending.…."

The Economist (2015).[4]

"I've been a very strong advocate of privatization for probably 30 years. I believe it enhances economic efficiency [but] I'm now almost at the point of opposing privatization because it's been done to boost proceeds, it's been done to boost asset sales, and I think it's severely damaging our economy." Rod Sims (2016), Chairman, the Australian Competition and Consumer Commission.[5]

"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." Independent Consultants' review (2014) of Ontario Land Registry Services PPP under Teranet.[6]

The original version[7] of this paper was prepared to inform professional colleagues in the Australian state of Victoria regarding a proposed PPP for land registries. Subsequently, it was cited by a number of organizations in their respective submissions to the Victorian State Parliamentary Upper House "Inquiry into the Proposed Long Term Lease of Land Titles and Registry Functions of Land Use Victoria". [8] It was also cited in various media commentaries on the issues.[9]

Part A: Understanding privatization and public private parterships

Introduction

Two of the most controversial microeconomic roles of government are its role in providing public goods and its role in dealing with market failure due to externalities.[10] An understanding of the provision of public goods – which covers services and infrastructure – is critical in any consideration of alternative methods of service delivery (ASD) through the private sector. Public goods provide an example of market failure resulting from missing markets. Which "goods and services" are best left to the market? And which are more efficiently and fairly provided as "collective consumption goods" by the state?

Public infrastructure and services, have traditionally been financed, owned and operated by the public sector. However, especially over the past decades, governments have increasingly looked at ASD. Increasingly the private sector is delivering public services and infrastructure under government direction.

There have been many drivers for ASD including:

- seeking to realize an immediate upfront payment for privatization or leasing of government assets;
- fiscal constraints on the public sector preventing essential infrastructure upgrades;
- budget limitations to adequately fund operating costs;
- inefficient management of infrastructure by public entities;
- poor service delivery;
- weak public capacity;
- or policy decisions that sought to bring about change.

ASD has many modalities including privatization and Public Private Partnerships (PPP or P3). These are not one and the same thing, although there is a frequent tendency to use the terms interchangeably. The critical distinction between a PPP and privatization relates to ownership of the infrastructure, asset or facility. When a publicly-owned asset or facility is privatized, the ownership is divested from the government and permanently transferred to the private sector. Although government may maintain regulatory control, the private sector as the owner is accountable. This is not the case for PPP, where government retains ownership of the "asset", the government defines the extent of private sector's participation in the PPP, and the government holds ultimate accountability for the provision of the services. These distinctions are non-trivial, and for those reasons this paper includes a brief overview of ASD, of which PPP is one. Also, there are many different PPP modalities. Awareness of these distinctions are very important, to effectively engage in PPP dialogue. Having said that, using terms like "sale", "divestment" and "privatization" are more likely to raise professional, political and public concerns than terms such as "lease" and "PPP". Words do matter:

"The search for the mot juste [right word] *is not a pedantic fad but a vital necessity. Words are our precision tools. Imprecision engenders ambiguity and hours are wasted in removing verbal misunderstandings before the argument of substance can begin."*[11]

So much of the debate may be side-tracked by imprecise terminology. Objecting to government's proposal for a private partner to operate the Land Registry under a PPP cannot be argued that it is a sale or privatization. It is a contractual lease and it is under government regulatory control and contractual conditions. So, objections can easily be discounted unless they are both well-informed and well-framed and use the correct terminology. Even more difficult, is understanding the micro-economics on which decision-making may be based.

Canada's Ontario Province LRS PPP, that commenced in 1992 for a twenty-five year period, was extended in 2013 until 2067. Governments and other advocates of LRS PPPs constantly refer to Ontario's successes and as best practice – the "gold standard". This paper intentionally provides a deep dive into the Ontario experience.

Therefore, the purpose of this paper is to provide an overview of experiences globally with LRS PPPs and privatization proposals. The paper is intentionally presented in three discernable parts: (i) Part A providing a background to privatization and PPPs; (ii) Part B specifically looking at country experiences; and Part C identifying major lessons and conclusions. In total, this report presents ten case studies - three

from Canada, one each from the UK, Malaysia, Philippines, New Zealand and the final three from Australia. Through this paper[12], it is hoped that people are better informed and can better advocate their interests based on evidence and facts rather than rhetoric and hearsay.

Alternative Methods of Service Delivery (ASD)

There are seven primary public service delivery modalities that are generally identified. In the list below, modalities 1-3 are delivery by the public sector, and modalities 4-7 are specifically ASD:[13]

1. Direct Delivery – Government delivers the service directly through its ministries, business planning, focusing on results, cost recovery, getting the best value for the tax dollar, and customer service.
2. Agencies – Government delegates service delivery to an agency operating at arm's length from the ongoing operations of the government, but maintains control lover the agency. Creating a new non-profit organization to undertake activities that otherwise would be provided by government, or, in instances where profits might be generated, asking non-profits interested in delivering the services to bid for the opportunity.
3. Devolution – Government transfers the responsibility for delivering the service to: (i) other levels of government; (ii) profit and non-profit organizations that receive transfer payments to deliver the service.
4. Purchase of Service – Government purchases services under contract from a private firm, but retains accountability for the service. This includes contracting out and outsourcing of services. A government that wishes to cut costs can contract out the delivery of services to private firms. In cases where numerous firms are capable of performing the work, the government usually will put out a request for tenders. Once the competition has closed, the government then makes a decision based solely on price or on price and a combination of other criteria (e.g. quality of service and track record).
5. Partnerships – Government enters into a formal agreement to provide services in partnership with other parties where each contributes resources and shares the risks and rewards. This is more commonly referred to as the PPP.
6. Franchising/Licensing – For franchising, the government confers to a private firm the right or privilege to sell a product or service in accordance with prescribed terms and conditions. For licensing, the government grants a license to a private firm to sell a product or service that would otherwise not be allowed.
7. Privatization – Government sells its assets or its controlling interest in a service to a private unlike contracting out, where the government retains responsibility to provide a service even though it hires someone else to deliver it, privatization involves selling the service to the sector company, but may protect public interest through legislation and regulation. This alternative method of service delivery allows for greater competition over contracting out if the government allows for multiple firms.

Partnerships with the private sector take a wide range of forms varying in the extent of involvement of and risk taken by the private party. The terms of a PPP are typically set out in a contract or agreement to outline the responsibilities of each party and clearly allocate risk. The following (figure1) depicts the spectrum of private sector engagement, with various PPP modalities occupying the middle sections of the spectrum:[14]

Although this may seem like too much detail, it is important to be familiar with the distinctions, as all too often terms are misused or used interchangeably.

Global endorsement of private financing

It is now globally significant that the July 2017 G20 Leaders' Declaration endorsed:

"*… the MDB's [15] Joint Principles and Ambitions on Crowding-In Private Finance ("Hamburg Principles and Ambitions") and welcome their work on optimizing balance sheets and boosting investment in infrastructure and connectivity*."[16]

The MDBs have agreed that their engagements to help countries maximize their resources for development, needs to be done responsibly without pushing the public sector into unsustainable levels of debt and contingent liabilities. As such, there should be a drawing on private resources when they can help achieve development goals, and reserving public financing for other sectors and services, where private sector engagement is not optimal nor available – hence the PPP approach. Essentially, it seeks to maximize financing for development by leveraging the private sector and optimizing the use of scarce public resources. However, the intended focus of the MDBs is on developing countries, and it should be important to keep that in mind when these arguments for PPP are proposed for developed countries, including Australia. Australia is a member state of G20.

PPP "101"

So, what is a PPP or P3? For the purposes of this paper, a common, widely accepted definition has been adopted:
"PPP means any contractual or legal relationship between public and private entities aimed at improving and/or expanding infrastructure services."[17]

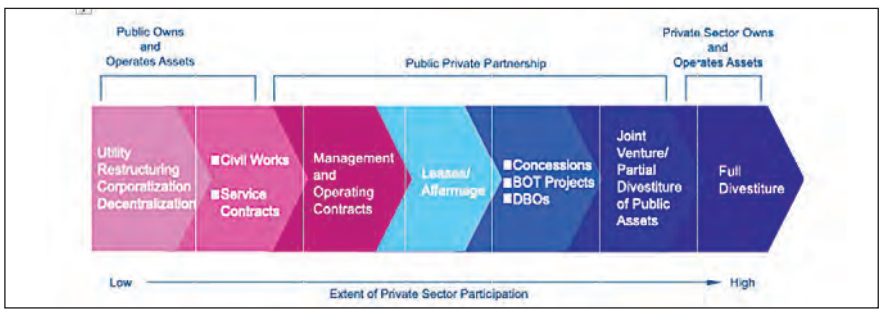


Figure 1: The spectrum of private sector engagement, with various PPP modalities

Notably, PPP is about improving or expanding services, and adopting a suitable financing mechanism. Accordingly, the valid, strong justifications for pursuing PPP would be expected to include:

- Government finance is not available to operate, upgrade and sustain the service infrastructure;
- Expertise and competence are lacking in government, but are available in the private sector, especially relevant when major information communication technology (ICT) investment is required.
- The service culture within government is lacking, and cannot be remedied, so an externally operated service is best pursued.

There are many types of PPPs, each with specific types of contractual or legal relationships. The following table is a summary of the commonly agreed PPP types:[18]

MDBs, as well as other international organizations including the European Commission, have made available online, many reports on PPP - all freely downloadable. Jeffrey Delmon (2010) has produced an excellent guide, which I would describe as the quintessential PPP "101". Delmon advises:

"The decision to adopt PPP must be political, first. The government must consider the political and social implications of PPP and whether there is sufficient political will to implement PPP. Next, consideration needs to be given to the institutional, legal and regulatory context - the extent to which government institutions have the needed skills and resources, the financial and commercial markets have needed capacity and appetite, and laws and regulations encourage or enable PPP - and whether changes need to be made to the institutional, legal and regulatory climate in order to provide the right context for PPP. Once these basic issues have been addressed, those designing the PPP solutions available to policymakers must consider the most commercially and financially viable and appropriate structures. This must involve consideration of cost benefit, value for money, the sources of finance, the commercial arrangements, the nature of investors and government participants, and a variety of other circumstances that need to be addressed in the design of appropriate PPP structures. This latter process is where a robust classification model can help."

No.	Mode of PPP	Abbrev.	Description
1	Design Build	DSB	Private sector designs and builds infrastructure to meet public sector performance terms, usually for a predetermined price, so the risk of cost overruns is transferred to the private sector. (Many people do not consider DSB as a form or kind of PPP).
2	Operation & Maintenance Contract	OMC	A private organization, under an agreement runs a publicly- owned asset for a specified term. Ownership of the asset remains with the public partner.
3	Finance Only	FIN	A private financial establishment funds a project directly or uses various methods such as a long-term lease or bond issue.
4	Design, Build, Finance & Operate	DBFO	A private organization designs, finances and constructs a new facility under a long-term lease, and operates the facility during the term of the lease. The private partner transfers the new facility to the public sector at the expiration of the lease.
5	Lease, Develop & Operate	LDO	A public infrastructure is leased to a private agency, which develops the facility to agreed standard and it's operated by the private agency until the expiration of the lease.
6	Build, Lease, Operate & Transfer	BLOT	Private sector builds an infrastructure, leases it to the public sector and operates it till the end of the lease period, when it is finally transferred to the public sector.
7	Build, Own, Operate and Transfer	BOOT	A private agency receives an authorization to finance, design, build and operate a facility (and to charge user fees) for a specified period, after which ownership is transferred back to the public sector.
8	Build, Own, Operate	BOO	The private sector finances, builds, owns and operates a facility or service permanently. The public controls are stated in the original agreement and through on-going regulatory instruments and procedures.
9	Buy, Build, Operate	BBO	The private sector finances, builds, owns and operates a facility or service permanently under predetermined state control. This is very close to privatization.

Why do Governments pursue PPPs?

The potential benefits of PPPs to the government and the public, may include:

- Improved service delivery - PPPs are expected to improve service delivery due to the merger of both sectors.
- Higher levels of service through innovation.
- Value for money – PPPs are expected to be effectively managed, which brings about satisfaction.
- Improved cost-effectiveness - due to vast experience and flexibility, PPPs are expected to deliver public services more cost effectively than other traditional partnerships.
- Increased investment in public infrastructure - basic amenities such as hospitals, schools, highways, reduce government capital cost, helping embrace the gap between the need for infrastructure and financial capacity.
- Reduction of public sector risk – PPPs are expected to shift the risk from the public to the private sector.
- Delivery of capital projects faster - private investors are expected to be more flexible in nature and have greater access to financial resources from financial institutions.
- Improved budget certainty - the transfer of risk from public-private sector is expected to reduce costs usually set aside for unforeseen circumstances. Services are expected to be more cost effective and utilize public funds more efficiently.
- Better use of assets - private sectors are expected to maximize fully the potential and returns in investments.[19]

Turning to the other side of PPPs, what are the potential benefits to the private sector investor? These may include:

- PPPs can provide the private sector access to a more long-term investment opportunity.
- Business can be set up with security and certainty of procuring a government contract.
- Payment is initiated through a contracted fee for service, or by collection of user fees. Revenues are secure for the term of the PPP contract.
- Private sector partners, by maintaining a high level of efficiency, and through managerial, technical and financial capabilities, can expand their expertise, to other business opportunities, and even to other jurisdictions (states and countries) utilizing the successful PPP track records.[20]

Later in the report, the veracity of the potential benefits, in particular to government will be discussed – these go to the heart of the arguments of both proponents and opponents for PPP.

Ontario's Auditor-General's 2014 Annual Report was highly critical of PPPs:

"Ontario Auditor General (AG) Bonnie Lysyk rebuked the Ontario government's use of public-private partnerships for public infrastructure in a damning report that revealed P3s have cost the citizens of Ontario nearly $8 billion more over the past nine years than if the government had successfully built the projects itself. The AG found that while the province assumes there is less risk of cost overruns and other problems with P3s than with the public sector, the province actually has "no empirical data" to back up that assumption. P3s, meanwhile, are more expensive because companies 'pay about 14 times what the government does for financing, and receive a premium from taxpayers in exchange for taking on the project.'

Lysyk also found that the entire process of evaluating the cost-effective ness of P3s in comparison to the traditional public procurement approach was replete with errors. The AG noted billions of dollars' worth of double counting and other inappropriate calculations that demonstrated a clear bias in favor of P3s. According to CUPE Economist Toby Sanger, these P3 projects have created an estimated $28.5 billion in liabilities and commitments still outstanding to private corporations— a cost the citizens of Ontario will have to pay back in the future. Other P3 projects in Ontario would bring 'total liabilities to over $30 billion owing to P3 consortiums and financiers, the equivalent of $6,000 per household.'"[21,22]

Canada is often described as the most active PPP market in the world, and is certainly one of the most mature dating from 1993. As at 2016, there have been some 244 PPPs, with 177 now closed and around 70 remain operational or pending.[23] PPP is a well-established financing model in Canada adopted at federal, provincial and municipality levels:

"The life cycle of infrastructures, the Canadian geography and the current economic context are all convergent factors that favor this market. Also, the improvement of public infrastructures through the use of private capital is a concept which has always benefited from the support of the federal government."[24]

Public infrastructure and services, have traditionally been financed, owned and operated by the public sector. However, especially over the past decades, governments have increasingly looked at ASD. Increasingly the private sector is delivering public services and infrastructure under government direction

Although PPPs can be a very useful and effective mode for the delivery of public services, that should not imply that PPP approach is appropriate for all public services delivery. Furthermore, moving to a PPP model should not just be about maximizing an initial lease fee and annual remittances and should be reviewed even further than the real return over the agreed life of the lease? Economists would be expected to advise government on how to maximize net social benefits through the PPP or privatization, and this is very clearly stipulated in the economic policies of many national treasuries including the United States:

"In short, a balance of elements – the project's characteristics, the economic environment in which the project is being developed, and the ability of the project sponsor to take certain actions – jointly determines whether a PPP can deliver and operate a project that yields higher social welfare than would have been the case under conventional procurement. In other words, no one single factor informs whether a project yields a higher net social benefit as a PPP than under conventional provision, while providing a competitive rate of return for the private partner. …..

An essential prerequisite to achieving the potential net benefits of a PPP is for the government sponsor's to fully understand the project's characteristics and economic environment before initiating the procurement. In addition, successful PPP implementation requires executing a set of complementary best practices before the project gets underway. Not taking these steps may lead to higher costs, failure to meet performance targets later in the project's life cycle, and a misallocation of scarce public resources."[25]

Governments, including the states in Australia, are either failing to understand or just ignoring, the characteristics and economic environment for many PPP and privatization proposals. In July 2016, Australia's lead watchdog, Rod Sims, the chairman of the Australian

Objecting to government's proposal for a private partner to operate the Land Registry under a PPP cannot be argued that it is a sale or privatization. It is a contractual lease and it is under government regulatory control and contractual conditions. So, objections can easily be discounted unless they are both well-informed and well-framed and use the correct terminology

Competition and Consumer Commission (ACCC) advised that the privatization of public monopolies should cease because governments are mishandling them:

"…..says he has become so exasperated by the way in which governments are privatizing public assets that they need an 'uppercut'.

He says governments have repeatedly botched the sale of airports, electricity infrastructure and major ports – making things worse for consumers – because, when selling the assets, they have been motivated by maximizing profits rather than making efficiency gains.

He says governments have created private monopolies without sufficient regulation to stop those monopolies overcharging users – and the public knows it and has a right to be angry.

'I've been a very strong advocate of privatization for probably 30 years. I believe it enhances economic efficiency [but] I'm now almost at the point of opposing privatization because it's been done to boost proceeds, it's been done to boost asset sales, and I think it's severely damaging our economy.' "[26 ,27]

Approaches to LRS PPP

The most commonly accepted PPP modalities for LRS would be LDO, BOO and BOOT. Both NSW and SA operated very effective, modern land registries using contemporary information technology (IT) infrastructures. Obviously over time updating will be required as required and it would be assumed that these are both LDO types. Similarly, the LRS of Ontario and Manitoba would be assumed to be LDOs, as a major reason given publicly for these PPPs was to fund computerization, for which the governments lacked funds.

LRS PPPs are typically long-term leases, such as Ontario extended to 2067, NSW is 35 years and South Australia is 40 years. The concessionaire needs to recoup the initial investment cost, and make a profit on annual operations. However, and quite frankly, after a period of 30-60 years, how would government resume operating a LRS? The government would most likely be lacking in capacity and human resources to immediately step in. If the event of an early termination of the lease for governance reasons, the private sector operators staff may not be able to be taken on board under government due to civil or criminal proceedings or key personnel may decide to take positions elsewhere. One cannot assume that the private partner's personnel would be taken on by the government. There may be a court injunction issued that precludes immediate assumption of operations by government? NSW, SA and the Victorian governments all claim that the fail-safe risk mitigation is that government resumes full control. Governments will claim they have specific penalty arrangements in place contractually, but how would such measures be implemented when the company defaults and the government has little chance of taking back control of the operation in the short-term?

Governments, including the states in Australia, are either failing to understand or just ignoring, the characteristics and economic environment for many PPP and privatization proposals

Interestingly, the Philippines, adopted a BOOT PPP modality for the Land Registry Authority (LRA, under the Department of Justice), with an initial concession period of just ten years. The reason why the Philippines adopted BOOT is that the land registration system was very much under-developed and the government lacked finance to modernize the system. Further, the LRA is a highly-decentralized organization with a Registry of Deeds (RD) in every Provincial Capital and major municipality and lacked suitable office accommodation in most locations, requiring significant civil works construction in many locations. It is now approaching 15 years, including 2 years of dispute 2004-06, where the PPP stopped and the contract went into a protracted arbitration. Investor consortium partners changed and even the IFC pulled out. The contract subsequently morphed into a BOO arrangement and it seems that no-one raises the duration of the agreement anymore. It is unlikely to ever be returned to government.

There are constantly raised concerns about all LRS PPPs in areas such as fee increases, government access to land records and even the very ownership of the information itself has most definitely continued to be concerns in the Canadian Provinces of Ontario and Manitoba, as well as in the Philippines. Transparency and governance have been raised as ongoing concern. The Philippines, which operates a modified version of the Torrens System, adopted from the State of Massachusetts in the US, has many fraudulent titles. Fortunately, public land records are maintained by the Land Management Bureau (LMB) under the Department of Environment

and Natural Resources (DENR). But there are tensions in areas such as plans of subdivisions, surveying standards and maintaining cadastral base mapping.

There may be similar considerations for other jurisdictions, including Australia's State of Victoria where a PPP was under consideration for the Land Registry at the time of writing the first version of this paper. What happens to the Crown plans and records? Can there be an iron-clad guarantee that the Surveyor-General would be able to fulfil statutory functions under the Surveying Act 2004, without any limitations or restriction arising from the LRS private partner. The Victorian Surveyor-General's responsibilities include:

- (a) setting standards for survey information
- (e) & (f) correct position and description of Crown boundaries - has been alienated from the Crown or subdivided
- (g) resolve disputes over boundary determinations resolve disputes over boundary determinations that affect the Victorian cadastre;
- (i) maintain records of the status of land in Victoria and verify and certify the status of that land
- (j) register Crown plans
- (k) to prepare, or cause to be prepared, sign or approve plans of survey under any Act
- (l) Co-ordinate and provide access to survey and other information relating to land
- (m) provide surveying services to government projects and land dealings.[28]

Typically, LRS PPPs attract a special type of investor – an investor which has a very long-term investment horizon of many decades, viz. pension or superannuation funds. This is certainly the types of investor in Canada, NSW and now SA. Victoria is also being eyed by such investors and is already a topic with the major Canadian pension investor in Ontario and Manitoba. Victoria is now in its sights. Investors in PPPs are usually long-term, buy-and-hold investors, suiting OMC and LDO PPPs. Having said that there have been exceptions. For example, the Philippines LRA PPP attracted a consortium, the original investors including IFC, Samsung, Manila Ports and the Indian financier Infrastructure Leasing and Financial Services, Ltd. (IL&FS), which would seem to invest more for the medium term.

For the UK, full privatization (outright sale) was the preferred approach, although two PPP variants were also considered.

As has been seen through the media, many politicians and bureaucrats from the Australian States of New South Wales (NSW), South Australia (SA), Victoria and Western Australia have lauded the success of LRS PPPs, with particular attention given to Ontario and its private partner Teranet. The benefits espoused, as earlier mentioned, include better service delivery, cost-effectiveness, accountability, innovation and the financial benefits of large upfront payments, annual royalties and decreasing public expenditure and debt. In many cases, there have been benefits. However, there has been a tendency to cherry-pick the benefits, ignore the negatives and downplay the risks.

Any government proposing a LRS PPP should be able to address all of the following considerations:

- Are PPPs the best approach for the operation of LRS in the digital age?
- What risks and mitigations are necessary?
- How does it impact consumers?
- Why have some proposed PPPs for LRS proceeded and others not?
- What are the net social benefits?
- Can the government recover from failed LRS PPP?
- Can the government compel the PPP company to comply when it is in breach?
- Should PPP contracts be deemed commercial-in-confidence or open to public scrutiny?

References

1. Sydney Morning Herald, Dec 7, 2016.
2. SA Treasurer, Media Release, Aug 10 2017.
3. Daniels (2017), p. 40. Daniels was responsible for the strategic alliance that created Teranet.
4. https://www.economist.com/news/leaders/21593453-governments-should-launch-new-wave-privatisations-time-centred-property-9
5. https://www.theguardian.com/commentisfree/2016/oct/03/now-were-flogging-off-the-land-registry-this-is-not-good-news-for-home-owners
6. ConsultingWhere Limited & ACIL Allen, 2014, Annex B, Section 8, p.21, review for New Zealand government.
7. Bell, K.C (2017) Traverse, Professional Bulletin of the Institution of Surveyors, Victoria, Australia, Part A of Two Part Report, No. 315- September 2017; Part B of Two Part Report, No. 316 - December 2017, Melbourne http://www.surveying.org.au/docs/traverse/TRAV315.pdf http://www.surveying.org.au/docs/traverse/TRAV316.pdf
8. https://www.parliament.vic.gov.au/epc-lc/inquiries/inquiry/944

   https://www.parliament.vic.gov.au/images/stories/committees/SCEP/Land_Titles/EPC_58-12_Text_WEB.pdf
9. https://www.theage.com.au/national/victoria/feegouging-fears-over-proposed-land-registry-deal-20171001-gys7vw.html
10. http://www2.pitt.edu/~upjecon/MCG/MICRO/GOVT/Pubgood.html)
11. Gowers (1954), quoting an "anonymous civil servant".
12. A shorter version of this report was initially prepared as a set of case studies some years back. However, this version of the report, prepared on the request of the President of the Institution of Surveyors, Victoria (ISV), has revisited the earlier report and updated the coverage, especially in light of developments in Australia in 2016-17. ISV has a committee looking at the government's inquiry into leasing out the Victorian Land Registration Services (LRS) to the private sector, and this report has been prepared with the sole intention of informing ISV members. The author, a member of ISV, is a member of that committee. This report presents the views of the author, as the former Surveyor General of Victoria (1999-2003), and does not present the views of any organization. All information cited was from public source materials or other available sources.
13. Daniels, 2017.
14. https://ppp.worldbank.org/public-private-partnership/agreements
15. A multilateral development bank (MDB) is an institution, created by a group of countries, that provides financing and professional advising for the purpose of development. MDBs have large memberships including both developed donor countries and developing borrower countries. MDBs finance projects in the form of long-term loans at market rates, very-long-term loans (also known as credits) below market rates, and through grants. Examples of MDB include the World Bank, Asian Development Bank, African Development Bank and so forth. https://en.wikipedia.org/wiki/International_financial_institution
16. G20, (2017), G20 Leaders' Declaration: Shaping an Interconnected World, July 2017, Hamburg, Germany.
17. http://www.consilium.europa.eu/en/press/press-releases/2017/07/08-g20-hamburg-communique/
18. Delmon (2010), p.8.
19. CCCPP, (2004).
20. Daniels, 2017.
21. Ibid.
22. CCCPA (2015), p. 12.
23. Ontario Auditor General, 2014 Annual Report, pp. 199-200.
24. CCPPP (2016) overview of PPP is well summarized in: http://www.lavery.ca/en/publications/our-publications/2986-overview-of-the-canadian-public-private-partnerships-market.html
25. ibid
26. https://www.treasury.gov/resource-center/economic-policy/Documents/1_PPP%20paper_FINAL%2005%2017%2016.pdf
27. https://www.theguardian.com/commentisfree/2016/oct/03/now-were-flogging-off-the-land-registry-this-is-not-good-news-for-home-owners
28. https://www.theguardian.com/australia-news/2016/jul/27/acccs-rod-sims-says-privatisations-severely-damaging-economy

To be continued in next issue.

Solutions for future challenges facing our planet

25th INTERGEO: 17 – 19 September 2019 Stuttgart, Germany

The leading international trade fair for geodesy, geoinformation and land management – together with the CONFERENCE and its themed platforms INTERAERIAL SOLUTIONS, SMART CITY SOLUTIONS, GEOCAREER and GEOINNOVATION CAMPUS – drew in 20,000 visitors from over 100 countries to the exhibition halls in Stuttgart. This year, 705 exhibitors showcased their solutions surrounding geodesy, geo-IT, geoinformatics, building information modelling (BIM), drones and smart cities.

The place to be for pioneers

For the host, the German Society for Geodesy, Geoinformation and Land Management (DVW e.V.), this positive response is a sign of an industry thriving in the era of digitalisation. "Given all the challenges it is facing, our planet demands concerted action. INTERGEO provides experts with the ideal platform to tackle precisely these tasks. The multi-faceted sector it serves is doing all it can to forge a positive future for our planet," says Prof. Hansjörg Kutterer, President of the DVW. Today's paramount topics – climate change, environmental protection, sustainable mobility, energy supply and agriculture, migration towards cities and metropolitan areas, and the huge gap within society – all call for know-how to bring innovations to life. After all, the innovations in question form the basis for the future.

Engineers, visionaries, start-ups and trend-setters

At the heart of INTERGEO are businesses, academic institutes and public administrative bodies that pull together like no other community to sustainably shape social trends with technology and digital solutions. Sound knowledge in engineering, visionary thinking and an extremely determined start-up mentality join forces to ensure we make the most of digitalisation. Where others only see problems, the geoindustry is already presenting solutions.

Celebrating its 25th anniversary, INTERGEO is more relevant than ever before. "Boasting a healthy mix of high-calibre content, state-of-the-art technology and exhibitors from Germany and abroad, INTERGEO provides the

crucial basis for sharing the ideas that bring innovations and developments to life," says Christoph Hinte, responsible for managing the specialist trade fair.

Highly skilled in smart city development

City-focused solutions are increasingly coming to the fore at INTERGEO. The goal behind smart cities is to positively influence the lives of their ever-growing populations, using geodata and algorithms to gain practical knowledge as a decision-making tool. Digital twins of everything from buildings through to entire cities reveal the otherwise invisible and solve previous puzzles. They make it possible to take decisions in what used to be vacuums of knowledge. Smart cities, and within them digital BIM processes in the life cycle of buildings and infrastructure, are networked. As geographic information systems (GIS) and BIM merge, they will also tear down the barriers that still exist between IT silos.

Drones as true all-rounders

Interaerial Solutions (IASEXPO), complete with EXPO, the forum and its own flight zone, is Europe's biggest B2B drone event dedicated to civilian uses. Leading drone suppliers from 20 countries presented their solutions and applications to an international audience of experts comprising top decision-makers from the global drone community, managers of major industrial corporations and political representatives. This year's winner of the 3rd DRONE PIONEER AWARD (2019) and the € 5,000 prize money – sponsored by the German Federal Ministry for Economic Cooperation and Development (BMZ)– is the Swiss company RIGITECH for its innovative Air Bridge cargo drone. The winner of the START-UP SESSION is London-based FLOCK for its innovative data-based "pay-as-you-fly" insurance, which doesn't involve any annual contracts or administration fees.

Making sense of a complex world

INTERGEO also played host to the 67th German Cartography Conference (DKK) organised by the German Society for Cartography (DGfK), which conveyed a message that neatly tied in with INTERGEO's core focus. "If we want to be able to take the right decisions in an increasingly confusing world, we must cut down complexity," says Prof. Jochen Schiewe, the DGfK's new president. The DKK motto "Playing with an open hand" highlighted the role of free data, which is absolutely vital to making knowledge democratic.

Interactive and vibrant

This year's INTERGEO involved an unparalleled level of communication – never before were the forums, discussions and panel events so full of life. 2019 saw formats such as the themed GEOCAREER platform and its new pendant GEOINNOVATION CAMPUS train renewed focus on recruitment and career opportunities. Buoyed by year-round international communications, the live event wows sponsors, exhibitors and visitors alike. In the words of Christoph Hinte: "We will not rest until all the wonderful developments in digital solutions for our planet have been brought together under the umbrella of INTERGEO." Next year's INTERGEO will take place from 13 to 15 October 2020 in Berlin. *www.intergeo.de.*

New iTwin Cloud Services by Bentley

Bentley Systems, Incorporated has announced new cloud services for infrastructure engineering digital twins. It is digital representation of physical assets and their engineering information that allow users to understand and model their performance in the real world over their lifecycle. In effect, "evergreen" digital twins advance BIM and GIS through 4D.

iTwin Services enable engineering firms to create, visualize and analyze digital twins of infrastructure projects and assets. It federate digital engineering content from BIM design tools and multiple data sources, enable "4D visualization" of digital twins, and log engineering changes along a project/asset timeline, to provide an accountable record of who-changed-what-and-when. Engineering teams are using it to conduct design reviews, validate design data, and generate design insights. Users of Bentley's design applications can apply the *iTwin Design Review* service for ad hoc design reviews, and project teams using ProjectWise can add the iTwin Design Review service to their digital workflows to facilitate overall project digital twins. *PlantSight* is an offering jointly developed by Bentley Systems and Siemens, which enables owner-operators and their engineers to create living and evergreen digital twins of operating process plants. *www.bentley.com*

SAP partnership with Microsoft

Building on a joint commitment to simplify and modernize customers' journeys to the cloud through project "Embrace," SAP SE and Microsoft Corp. announced an extensive go-to-market partnership — from conceptualization to sales — to accelerate customer adoption of SAP S/4HANA® and SAP® Cloud Platform on Microsoft Azure.

The new partnership brings together SAP and Microsoft, along with a global network of system integrators, to offer holistic bundles that provide customers with unified reference architectures, road maps and market-approved journeys to illuminate a clear path toward the cloud. As part of this simplified customer journey, Microsoft

In Coordinates

10 years before...

mycoordinates.org/vol-5-issue-11-November-09

Sea link- a Sea change

The marvel that has brought this sea change to the life and landscape of Mumbai is the Bandra-Worli Sea Link – the fi rst ever sea link to be built in India

The marvel in the making When one sets out to achieve a first, the challenges are bound to be many. Some problems on the project were unique and needed special solutions, while other problems were those faced on any other such project around the world. The project team of over 3000 workers, HCC engineers, foreign engineers and technicians met the challenges head on and overcame them to give Mumbai its latest landmark.

Sustainable Land Governance

Prof Stig Enemark
FIG President, Aalborg University, Denmark

Land Administration Systems (LAS) are an important infrastructure, which facilitate the implementation of land policies in both developed and developing countries. LAS are concerned with the social, legal, economic and technical framework within which land managers and administrators must operate. These systems support efficient land markets and are, at the same time, concerned with the administration of land as a natural resource to ensure its sustainable development.

Towards hazards prediction

This article investigates the capability of GNSS aided smart sensor networkpositioning and Radio Frequency technology to monitor 3D deformation associated with volcanic activity and other comparable hazardous events

Rainer Mautz
Researcher and Lecturer in Engineering Geodesy at the Swiss Federal Institute of Technology Zurich

Hilmar Ingensand
Professor in Engineering Geodesy at the Swiss Federal Institute of Technology Zurich

Washington Yotto Ochieng
Professor of Positioning and Navigation Systems, Imperial College London

This paper has shown that the implementation of a wireless deformation monitoring system is feasible if the current problem of extracting precise ranging is solved. The requirement to have direct line of sights between stations can be solved by locating the nodes for optimal directs sights. The number of required nodes depends on the transmission range. The required fraction of GNSS enabled reference nodes will be around 10%, depending on the network density.

will re-sell components of SAP Cloud Platform alongside Azure. *www.sap.com*

OGC updates IndoorGML standard to v1.1; seeks public comment before approval

The Open Geospatial Consortium (OGC) is seeking public comment on the v1.1 update to the IndoorGML standard.

The goal of IndoorGML is to represent and allow for the exchange of the location information required to build and operate indoor spatial services such as indoor navigation systems. Several standards, such as CityGML, KML, and IFC, have been published to describe 3D geometry and semantics of buildings for outdoor/indoor spaces, but they lack some important features that are specific to indoor spaces. IndoorGML aims to provide complementary and additional encoding features for indoor space. In this respect, IndoorGML is a complementary standard to CityGML, KML, and IFC.

IndoorGML v1.1 introduces a new feature for level (i.e. storey or floor) information as an additional attribute of cell space to respond to the requirements from many indoor spatial applications. IndoorGML v1.1 is fully compatible with the previous version IndoorGML v1.0.

The OGC IndoorGML Encoding Standard was developed to provide a common schema framework for interoperability between indoor spatial applications. These cover a broad spectrum of application areas such as indoor location services, indoor web map services, indoor emergency control, indoor IoT sensors, guiding services for visually handicapped persons in indoor space, and indoor robotics. Cross-platform, vendor-neutral communication of indoor spatial information is essential to meet the market demands of these applications. *www.opengeospatial.org*

SAIC wins $68 million contract with NGA

The National Geospatial-Intelligence Agency (NGA) has awarded the $68 million Zeus contract to Science Applications International Corp. The Zeus acquisition is the follow-on contract for the Innovative GEOINT Application Provider Program (IGAPP) that SAIC has supported since 2014. SAIC serves as the unbiased trusted broker for NGA, partnering with startups and innovative sources to acquire apps and data content that support geospatial intelligence missions.

Zeus expands the scale and scope of the IGAPP program. It will be responsible for identifying, prescreening, price negotiating, recommending, and delivering candidate applications and data content to NGA. The program will continue to operate under the IGAPP program name. *saic.com*

Maptitude Geodemographic Segmentation Streamlines Neighborhood Targeting

Caliper has announced the release of the Maptitude Geodemographic Segmentation for the USA. It is providing 8 segments and 32 sub segments that provide an intuitive way to explore the demographic makeup of neighborhoods across the country. These locations can be analyzed with the tools and data already included with Maptitude, such as spatial/SQL filters, reports, overlay, and radius/ring tools. This provision of a low-cost lifestyle segmentation product for the entire USA is unprecedented.

GPS III ground system operations contingency program nearing operational acceptance

The Global Positioning System enterprise reached another major milestone on Oct. 21, when the GPS III Contingency Operations Program (COps) successfully connected with the first GPS III satellite on orbit. The COps system will allow the Air Force to operationally command and control the new, more powerful GPS III satellites as well as legacy GPS satellites currently in the constellation. The first GPS III satellite was launched on Dec. 23, 2018.

The GPS III COps program achieved several successes in recent months. First, the program completed final ground control system software testing and verification in May 2019. This was followed by delivery to sustainment and final system test completion in June 2019. After final system test, the Air Force approved installation of COps to command and control legacy operations at the Master Control Station at Schriever Air Force Base in Colorado Springs, Colorado and at the Alternate Master Control Station at Vandenberg, Air Force Base near Lompoc, California. In October 2019, the COps program received approval from Air Force Space Command's Operations and Communications Directorate (A3/6) to enter a trial period. The trial period includes testing COps command and control with the live, on-orbit GPS III satellite, which allows the program office to conduct developmental and operational testing needed to thoroughly verify requirements and functionality of the satellite. The testing aims to confirm readiness for operational acceptance targeted for December 2019 and April 2020 for the GPS III satellite and COps respectively.

EUTELSAT 5 West B successfully launched with EGNOS payload

The EUTELSAT 5 West B satellite was successfully launched on a Proton M/ Breeze M launch vehicle from Pad 39 at Baikonur Cosmodrome, Kazakhstan, at 12.17 CET on 9 October. Hosting the GEO-3 payload of the European Geostationary Navigation Overlay System (EGNOS), the

satellite will support EGNOS V3 - the next generation of the EGNOS programme.

EGNOS V3 will augment both GPS and Galileo in the L1 and L5 bands. Furthermore, it will provide additional satellite-based augmentation system (SBAS) service capabilities through a new SBAS channel on L5 and will deliver increased EGNOS service availability within and beyond the EU Member States in answer to a growing number of users.

The next generation of the EGNOS programme will also benefit from reinforced security, which will increase the robustness of EGNOS services against potential threats. EGNOS V3 will be made available in 2024 and will augment Galileo signals from 2025. *gsa.europa.eu*

Launch of new GLONASS navigation system satellite delayed

The launch of the next Russian GLONASS navigation system satellite has been postponed until December. The launch of the new GLONASS-M satellite was initially planned for November. At the moment, the GLONASS navigation system consists of 27 satellites, including 23 operational devices in orbit. Two satellites are in maintenance. To ensure the global coverage of the navigation system, 24 operational satellites are needed. *www.urdupoint.com*

Gulf Countries See Russia's GLONASS As Alternative To GPS

The countries of the Persian Gulf consider Russia's Global Navigation Satellite System (GLONASS) a reliable replacement to the US-based Global Positioning System (GPS), the director general of the Russian space corporation Roscosmos, Dmitry Rogozin, said.

"GLONASS is certainly of interest for everyone - the Persian Gulf countries display utter interest in GLONASS and in deploying ground stations. Because, apparently, the geopolitical situation has changed in the region to the extent when relying solely on GPS is hardly possible," Rogozin told.

Roscosmos and the Saudi Space Commission have signed a statement of intent to cooperation in financing space exploration and the GLONASS global navigation satellite system. *www.urdupoint.com*

GSA releases 2019 GNSS Market Report

The new GSA GNSS Market Report is now available for download. The report provides a comprehensive overview of the GNSS market and the global industry, as well as a focus on EGNSS differentiators and synergies with Copernicus, according to the publisher, the European GNSS Agency (GSA).

Areas covered include:

- A general overview of the GNSS market and a global industry overview. Analysis of macro-trends affecting GNSS, including climate change and the circular economy, big data, artificial intelligence, the silver economy, cyber security and the sharing economy.
- A review of the main GNSS market segments in detail, including trends and developments, forecasts for future shipments, revenues and the GNSS installed base, and a look into GNSS user requirements.

GNSS in Space. This year, the report features the "Editor's Special: GNSS for NewSpace," a section that introduces GNSS receivers in satellites and their relation to the evolving space sector.

GNSS market monitoring is a key activity of the GSA. Market monitoring supports GNSS stakeholders in their planning and decision-making, and offers a clear tool to understand GNSS trends and evolutions.

EU contracting for GNSS interference detection network

The Official Journal of the European Union (EU) will publish a funding opportunity in the near future for a GNSS "Advanced Interference Detection and Robustness Capabilities System," according to officials familiar with the project.

Advance notice of this procurement was first given in August of last year, with an award projected for the first quarter of 2019. Some observers have speculated that the procurement delay was related to a change in how the final system is envisioned. The current version of the notice asks for a crowdsourcing, software and networked-based solution.

GPS helping provide more precise precipitation predictions

Scientists are using GPS signals to measure air moisture for better weather forecasting. The method is now being incorporated into the Bureau of Meteorology's weather forecast models following successful tests over Australia, off the back of World Space Week 2019.

The RMIT University, Geoscience Australia and Bureau of Meteorology collaboration has harnessed the growing network of GPS receivers to provide more accurate, real time weather forecasts.

The system works by measuring the time it takes GPS signals from overhead satellites to reach ground receivers. Signals can be slightly delayed by moisture in the troposphere, causing what's known as a zenith total delay, so scientists measure this delay to assess air moisture.

RMIT Adjunct Professor and Bureau Senior Principal Research Scientist, John Le Marshall, said it was an exciting new capability for real-time weather measurements and forecasting.

GPS is proving increasingly useful to meteorologists, with another completed project using the bending of GPS signals through the atmosphere to determine temperature at various altitudes, whereas this system measures the delay in the arrival of those signals to determine water vapour levels.

While the technology could be applied almost anywhere, it's particularly valuable in a sparsely populated country like Australia where there's a lack of ground-based meteorological observation stations. *https://phys.org*

Bluesky LiDAR Reveals Archaeological Legacy of London Landscape

A detailed laser mapped aerial survey from Bluesky is helping the City of London Corporation understand and plan for the future of London's most extensive, natural grassland. The historic environment assessment of Farthing Downs was completed by the Museum of London Archaeology (MOLA) and will form the first stage in the preparation of a Heritage Conservation Management Plan for the Site of Special Scientific Interest (SSSI).

Using the LiDAR data from Bluesky, alongside historic maps, geological data, archaeological reports and aerial photographs, researchers were able to identify a number of features including evidence of post-medieval farming techniques, Later Iron Age earthworks and Second World War bomb-craters. The desk-based study, which assessed buried heritage assets (archaeological remains) concluded that survival across the site is likely to be moderate to high and the findings will provide background data for a more detailed field walkover survey.

The Bluesky LiDAR was captured to a resolution of 50 cm across the site located in Coulsdon in the London Borough of Croydon. Supplied to MOLA as a mosaic dataset, researchers rendered the Bluesky data using ArcMap desktop GIS software. *www.bluesky-world.com*

Remote sensing will advance safety and security applications in Arctic

A new consortium of international companies, called IRSA Development Group (IDG), was announced October 1, 2019, at DEFSEC Atlantic in Halifax, Canada. IDG consists of international companies with expertise in selected technology domains to bring the world an advanced remote sensing network.

Integrated Remote Sensing for the Arctic (IRSA) is a scalable, civilian, all-domain system-of- systems remote sensing solution designed to provide more persistent monitoring of the Arctic. The network comprises satellites, high altitude long endurance (HALE) drones, medium altitude long endurance (MALE) drones, small unmanned aerial systems (sUAS), sea-surface and sub-sea platforms, and ground stations. Technology development for each segment, and their integration, is underway. Initial IRSA services are expected to be available to clients in early 2020.

Recognizing the need for more persistent remote sensing, robust communication and data connectivity in the Arctic, Boeing Defense, Space, and Security (BDS) began an intensive study in 2015, mapping the challenges and identifying gaps in designing and creating a solution to address them. Since then, Boeing has invested in establishing an international consortium to develop the technologies, products and services that can provide that solution through the IRSA program.

IRSA Development Group (IDG) The IDG is a multi-national collaboration among Arctic nations and world-leading innovators in advanced technologies for the polar regions. IDG's objective is to develop and commercialize the IRSA solution as a service for safety and security in the Arctic. The partner organizations are: C-CORE (Canada), MyDefence System Integration (Kingdom of Denmark), Andoya Space Center (Norway), VTT (Finland), Scott Polar Research Institute (United Kingdom), Karl Osen (Switzerland), ViaSat Antenna Systems (Switzerland), and Boeing Phantom Works (USA). *www.spacedaily.com*

Dronecloud announces enabling LAANC capability for US operations

DronecloudTM, the drone management software company, has announced that LAANC (Low Altitude Authorization and Notification Capability) is now available for free in all subscription levels.

The DronecloudTM platform is a leading all in one business and compliance solution for drone operations capable of managing all aspects of drone operation. Integrating all the elements necessary from client communications and CRM to flight planning. *www.suasnews.com*

Locix launches SmartLPS

Locix has launched its SmartLPSTM solution that digitizes, analyzes, and displays real-time and historical operations for workers, assets, and inventory in warehouses through its patented WiFi-based local positioning system (LPS). It demonstrated the efficacy and accuracy of the solution through an extended trial with MITSUI-SOKO Supply Chain Solutions (MSCS) and Prologis in an operating distribution center in Ichikawa, Japan, proving sub-meter-accurate real-time positioning of workers and forklifts, integration with their warehouse management system (WMS), and comprehensive visibility into warehouse operations through historical analytics and report generatio. SmartLPSTM leverages Locix's patented WiFi based Local Positioning System (LPS) platform to collect spatial and sensor data from workers and assets without the extensive installation and high infrastructure costs of competing solutions. *locix.com*

Qualcomm, ISRO Supports India's Satellite Navigation System

Qualcomm Technologies is teaming up with the Indian Space Research Organization (ISRO) to support India's Regional Navigation Satellite System (IRNSS) and Navigation with Indian Constellation (NavIC) in select chipset platforms across Qualcomm's upcoming portfolio. The initiative aims to help accelerate the adoption of NavIC and enhance the geolocation capabilities of mobile, automotive, and the Internet of Things (IoT) solutions in the region. The collaboration delivered the first-ever NavIC demonstration using the Qualcomm Snapdragon Mobile Platforms on Sept. 19.

The solution is built on Qualcomm Technologies' inventions in location-based position technology. As part of the updated platforms, the Qualcomm Location Suite now supports up to seven satellite constellations concurrently. These enhancements will help enable select mobile, automotive and IoT platforms to better serve key industries and technology ecosystems in the region and will help

Focusing on true performance!

PENTAX

D-600

Precise Aerial Imaging System

6 Rotor Multicopter with Autopilot

R-1500N & R-2800N

Reflectorless Total Stations

Total surveying solutions

W-1500N & W-2800

Windows CE Total Stations

Truly integrated systems

G6 Ti | Ni

GNSS Receivers

Precision Satellite Surveying with wireless communications

S-3180V

Scanning System

3D laser measurement system

TI Asahi Co., Ltd.
International Sales Department
4-3-4 Ueno Iwatsuki-Ku, Saitama-Shi
Saitama, 339-0073 Japan
Tel.: +81-48-793-0118
Fax: +81-48-793-0128
E-mail: International@tiasahi.com
www.pentaxsurveying.com/en/

Authorized Distributor in India
Lawrence & Mayo Pvt. Ltd.
274, Dr. Dadabhai Naoroji Rd.
Mumbai 400 001 India
Tel.: +91 22 22 07 7440
Fax: +91 22 22 07 0048
E-mail: instmum@lawrenceandmayo.co.in
www.lawrenceandmayo.co.in

improve user experience for location-based applications especially in dense urban environments where geolocation accuracy tends to degrade. *www.satellitetoday.com*

Lawsuit against Google

The Australian Competition and Consumer Commission (ACCC), the country's competition watchdog, has filed a lawsuit against Google in the federal court in New South Wales. The commission has alleged that Google violated laws when it made misleading claims about user location data collection. The ACCC says that between January 2017 and late 2018, people made Google accounts on phones and tablets, they were made to believe that "Location History" was the only way to determine whether or not the company is collecting location data. *www.dw.com*

Porsche and Boeing to partner on premium urban air mobility market

Porsche and Boeing signed a MoU to explore the premium urban air mobility market and the extension of urban traffic into airspace. With this partnership, both companies will leverage their unique market strengths and insights to study the future of premium personal urban air mobility vehicles.The companies will create an international team to address various aspects of urban air mobility, including analysis of the market potential for premium vehicles and possible use cases.

Boeing, Porsche and Boeing subsidiary Aurora Flight Sciences are also developing a concept for a fully electric vertical takeoff and landing vehicle. Engineers from both companies, as well as Porsche subsidiaries Porsche Engineering Services GmbH and Studio F.A. Porsche, will implement and test a prototype.

A 2018 study by Porsche Consulting forecasts that the urban air mobility market will pick up speed after 2025. The study also indicates that urban air mobility solutions will transport passengers more quickly and efficiently than current conventional means of terrestrial transport, at a lower cost and with greater flexibility. *https://boeing.mediaroom.com*

New aircraft to carry full range of UAV scanners by LiDARUSA

LiDARUSA a global leader in the design and integration of economical LiDAR sensors announced a partnership with Innoflight Technology, a manufacturer specializing in UAV systems for surveying, mapping, and inspection. As a result of the partnership, LiDARUSA is offering the Galaxy 950 platform to carry any of its sensors while consistently providing flight times over 30 minutes.

Innoflight and LiDARUSA's partnership is another step for both companies to offer turn-key solutions focused on quickly and safely acquiring high quality data. Innoflight designed the Galaxy 950 to simplify the flying aspect of remote sensing with UAV. The helicopter includes a parachute, automatic takeoff/landing, and extended visual line of sight capabilities to maximize productive time. *www.lidarusa.com*

Airbus Enters the Commercial UTM Market

Airbus UTM has been participating in unmanned traffic management (UTM) for more than 2 years, originally as part of the company's innovation division. They are developing a digital air traffic management solution, and have developed a low altitude authorization and notification capability (LAANC) application.

To date, these solutions have been used within the company: but the LAANC capability is now available to the public via a new partnership with leading drone platform DroneDeploy. With this partnership, AirbusUTM's first commercial product becomes immediately significant in the marketplace. *www.airbusutm.com*

TerraView unveils Enterprise UAV

TerraView, a California-based aerial technology company recently unveiled the RangePro X8 — an industrial unmanned aerial vehicle (UAV) designed to fly for more than 70 minutes in real-world conditions with a standard sensor payload. Proudly engineered and assembled in the USA, it was engineered specifically for industrial, first responder and government enterprise data capture. It is a versatile platform. Compatible with multiple payload types, it is easily adaptable to a wide range of business needs. *https://terraview.com*

Robotic Skies partners with SqwaQ

Robotic Skies, network for commercial UAS (Unmanned Aircraft Systems), and SqwaQ, a global SD-WAN network company offering a powerful new redundant comm-link that enables drones to fly unlimited-range BVLOS (Beyond Visual Line of Sight), have signed an agreement that grants the Robotic Skies Service Center network access to distribute, retrofit, and provide field MRO services for SqwaQ communications equipment.

SqwaQ's patented, postcard-sized communications modem aggregates the bandwidth of up to twelve individual 3G/4G/LTE connections. This powerful multi-redundant, massive throughput enables reliable drone command and control nationwide, with simultaneous streaming of pilot view cameras, as well as downward facing cameras and sensors. *https://roboticskies.com*

EIA Canadian leader in using drones for safety

A different kind of aircraft landed at Edmonton International Airport recently as a highly specialized drone was used to conduct runway safety inspections as the airport continues to be a leader in the growing technology.

AERIUM Analytics, on behalf of EIA, flew a Microdrones mdLiDAR1000 to collect Lidar (Light Detection and Ranging) and imagery data of EIA's runways. The data collected will be used to more accurately predict when to conduct preventative maintenance on runways, taxiways and aircraft handling aprons, enhancing safety. The Remotely Piloted Aircraft System (RPAS or drone) operation was approved by Edmonton Airports in collaboration with Nav Canada and is part of the ongoing AERIUM

RPAS operations at EIA, which is one of the only airports in Canada using this technology. *www.airport-technology.com*

Airborne Response launches AirborneBeyond BVLOS UAS Testing Program

Airborne Response has unveiled their new AirborneBeyond™ program designed to provide UAS manufacturers and enterprise customers concierge-style, beyond visual line of sight (BVLOS) testing capabilities outside of the U.S. National Airspace System (NAS).

The AirborneBeyond program offers coordinated UAS fight testing at certified, proven aviation facilities in Colombia, the Dominican Republic, and other select locations throughout the Caribbean and Latin America.

The program was created to offer additional flight-testing options for UAS manufacturers and enterprise users with specialized requirements. Some of the characteristics of the available airspace include over 100 nm distances, operating ceilings up to 30,000 ft, asphalt runways, air traffic control towers and an array of local engineering and fabricating services. *www.airborneresponse.com*

Uber Eats unveils new delivery drone design

Uber Elevate unveiled a new food-delivery drone at Forbes' Under 30 Summit in Detroit.

Although the company declined to reveal the hexa-copter's designer, Uber Elevate head Eric Allison told conference-goers the UAV is vertical and horizontal flight-capable (which sounds a lot like Amazon's drone design). With a range of 18 miles and an 18-minute flight time, the six-rotor aircraft can carry "enough food to feed two adults." Allison expects the program to roll out later this year in San Diego where Uber Elevate has been testing urban aerial delivery via the UAS Integration Pilot Program (IPP).

Unlike other drone-delivery initiatives, Uber Elevate's will use landing zones rather than store-to-door flights. Uber drivers will meet a meal-laden drone at a "staging area. The drive then delivers it to the customer. *www.business-standard.com*

Pix4D introduces new products

Pix4D has introduced two soon-to-be-released offerings: Pix4Dsurvey and Pix4Dreact.

Pix4Dsurvey is a tool that bridges the gap between photogrammetry and computer aided design and drafting (CAD) tools, which replace manual drafting – and they are used extensively in engineering and construction projects.

Pix4Dsurvey is a standalone product, and allows users to take data from multiple sources including Pix4Dmapper. The product is designed to provide seamless merging of photogrammetry point clouds and images, LiDAR and third part point clouds in a single product. It helps users optimize vectorization and extraction of essential information, such as bottom of top of curbs and catenaries.

Riegl launches lightweight airborne lidar for UAVs

The Riegl miniVUX-2UAV is a lightweight airborne laser scanner designed specifically for integration with unmanned aerial vehicles and systems. Riegl added the new miniaturized UAV sensor to its portfolio of professional solutions for UAV-based surveying.

The sister type of the miniVUX-1UAV sensor, the miniVUX-2UAV offers 100 kHz and 200 kHz PRR. With the 200-kHz PRR, the sensor provides up to 200,000 measurements per second, and thus a dense point pattern on the ground for UAV-based applications that require the acquisition of small objects.

The Riegl miniVUX-2UAV makes use of Riegl waveform lidar technology, allowing echo digitization and online waveform processing. Multi-target resolution is the basis for penetrating dense foliage, and the wavelength is optimized for the measurement of snowy and icy terrain.

In addition to the stand-alone version of the miniVUX-2UAV, Riegl also offers fully-integrated solutions. *www.riegl.com*

Sensefly releases eMotion 3.8.0

senseFly released the latest version of its popular flight-planning software, eMotion 3.8.0.

With it, senseFly drone operators can enjoy a host of improvements and added functionality, including the ability to fly up to four drones simultaneously from a single computer. Drones operators that need to efficiently map large areas and/or large project sites will benefit greatly from eMotion 3.8.0's new multi-drone feature.

While the senseFly eBee X fixed-wing drone can map up to 500 ha (1,235 ac) at 400 ft in a single flight, the introduction of multiple, simultaneous drone flights offers even more coverage and in less time

Maxar Technologies and Australian Space Agency sign cooperative agreement

Maxar Technologies recently announced that it has signed a joint statement of strategic intent and cooperation with the Australian Space Agency.

Under the statement, Maxar and Australian Space Agency will investigate collaboration in areas of mutual strategic interest related to Earth intelligence and space infrastructure capabilities, and space-related Australian education and training initiatives.

These projects may include development of next-generation space robotics, ground stations focused on optimized servicing of large satellite constellations, optical and communications satellites, space-based maritime surveillance and artificial intelligence and machine learning technologies that extract insights from Earth observation data at scale. *www.maxar.com*.

Underground infrastructure mapping solution for collector for ArcGIS by Eos

Eos Positioning Systems, Inc., the leading manufacturer of high-accuracy Arrow GNSS receivers — has released its highly anticipated underground utility asset-mapping solution: Eos Locate for Collector for ArcGIS. It combines three core technologies: Eos Arrow GNSS receivers, Esri Collector, and the Vivax-Metrotech vLoc Series of locator devices.

With Eos Locate™ for Collector, one field worker can collect both GNSS locations and locator data (e.g., depth below cover) for any buried asset including water, sewer, electric, cable, gas, fiber infrastructure and more. They can do so quickly, accurately and without the need for any additional field or office support.

Eos Locate™ for Collector not only streamlines underground-asset mapping, but also improves office production times. It eliminates the need to manually combine datasets from the locator and GPS devices within ArcGIS.

The handheld fast and professional 3d mapping system

HERON LITE is appreciated in the market to be best solution for fast 3D surveying and mapping of indoor buildings, small infrastructures, underground mines and cavities. Hand able from a single person, with not initialization procedure, it is ideal to quickly and repeatedly survey complex environments. The NEW HERON COLOR LITE represent a new step in the fast mapping solutions; besides the 3D geometrical documentation, the user has now the possibility to detect scene details with 5K resolution 360° color images. *gexcel.it/en/solutions/heron-mobile-mapping*

Carlson Survey and GIS 2020

Carlson Survey 2020 OEM is now released. This version of leading office software solution for surveyors contains an AutoCAD® 2018 OEM engine built-in. This gives users the capability to run Carlson's popular survey commands natively in the current AutoCAD DWG-drawing file format.

It brings intuitive UI upgrades along with a host of new features and tools to improve day-to-day efficiency. A long-anticipated Migration Wizard for upgrading software as well as sharing settings and files across the office highlights this year's list of customer-centric updates. This new migration tool allows users to install a new release and then just simply transfer all of their previous settings, custom symbols, linetypes, fonts, etc. to the newer version.

CHC Navigation Introduces New GNSS RTK Tablet

CHC Navigation has released LT700H RTK Android tablet designed to increase efficiency and productivity of mobile field workforce in any applications requiring centimeter to decimeter positioning accuracy. Portable, rugged and versatile, the LT700H enables precision GIS data collection, forensic mapping, construction site layout, environmental surveys, landscaping and earthmoving jobs.

Powered by 184-channel high performance GPS, Glonass, Galileo and BeiDou module and superior tracking GNSS helical antenna, the LT700H provides best in class position availability in demanding environments. Its integrated 4G modem ensures seamless communication from field-to-office and robust connectivity to GNSS RTK networks corrections.

Trimble's compact GNSS board adds flexibility and high-precision positioning to UAS

Trimble has introduced its compact, high-precision GNSS board specifically designed for unmanned aerial systems (UAS)—the Trimble® UAS1. The board's simple connectivity and configuration allow UAS system integrators to easily add satellite-based positioning— with the ability to upgrade its capabilities—using rugged connectors and Trimble's easy-to-use software interface. It incorporates the latest Trimble MaxwellTM technology with advances in high-precision GNSS positioning. The GNSS engine with 336 channels is capable of tracking L1/L2 frequencies from the GPS, GLONASS, Galileo and BeiDou constellations for robust centimeter-level, real-time kinematic (RTK) positioning.

The compact Trimble UAS1 board includes a broad range of receiver capabilities—from high-accuracy GPS only to full GNSS features for positioning. Firmware options and features are password upgradeable, allowing functionality to be added as requirements change. The receiver also supports Fault Detection and Exclusion (FDE) and Receiver Autonomous Integrity Monitoring (RAIM). System integrators also have the ability to detect interference with the included RF Spectrum Monitoring and Analysis tool embedded in the receiver.

Geneq Launches SXPad 1500 Rugged Field Data Collector

Geneq Inc. has released SXPad 1500 data collector. It features a full alphanumeric QWERTY keypad and long-range Bluetooth, and was designed to meet the rigorous IP67 standard to deal with challenging field conditions. Its large 5" touch-screen has sunlight-readable display and can be connected to any GNSS receiver or compatible robotic total station to ensure the success of all survey projects. Driven by a 1 GHz processor and the Windows Mobile® 6.5 operating system, this Field Collector is a high-performance device designed to provide all the power needed to work with maps and large data sets in the field, as well as many software solutions. *www.sxbluegps.com*

OriginGPS unveils dual frequency GNSS module

OriginGPS collaborated with Broadcom to create a new miniature module with L1 + L5 support provided by the BCM47758 chip, enabling ultra-accurate GNSS positioning. The module was developed for solutions requiring super-precision GNSS and a dual frequency combination. It supports L1 + L5 GNSS reception with one RF port, enabling the use of a low-cost, dual-band antenna delivering sub-1m accuracy performance in real-world operating conditions. *origingps.com*

u-blox announces Bluetooth low energy module

u-blox has announced the u-blox NINA-B4 Bluetooth low energy module series. Based on Nordic Semiconductor's recently announced nRF52833 chip, NINA-B4 enables a number of Bluetooth features including Bluetooth long range, Bluetooth mesh, and Bluetooth direction finding.

The main highlight of the NINA-B4 series is Bluetooth's new direction finding feature, a key component of the Bluetooth v5.1 specification that brings the benefits of high precision positioning to indoor applications. NINA-B4 is the first u-blox module designed to act as both a transmitter and a receiver in angle of arrival (AoA) and angle of departure (AoD) direction finding and indoor positioning applications. *www.u-blox.com*

Taoglas launches Edge Locate

Taoglas® has announced its new Edge Locate™, a GNSS L1/L2/E5 module that combines antenna, RF electronics and receiver technology delivering reliable centimeter-level positioning. Traditionally, most IoT devices use single band GPS technology delivering on average 10 meter accuracy with existing GPS modules and antennas. Taoglas, in partnership with u-blox, has created a "smart antenna" which uses multi-band GNSS technology, providing between 1 to 3 centimeter-level accuracy. The device features multiband GNSS positioning that can be used in conjunction with cost-effective real-time kinematic (RTK) positioning capability. *www.taoglas.com*

NavCom releases Onyx software-upgradeable GNSS OEM board

NavCom Technology Inc., a wholly owned subsidiary of Deere & Company, has released the Onyx multi-frequency GNSS OEM board. Offering integrated StarFire/RTK GNSS capabilities, Onyx features 255-channel tracking, including multi-constellation support for GPS, GLONASS, Beidou and Galileo. It also provides high-performance in GNSS receiver sensitivity and signal tracking as well as patented multipath mitigation, interference rejection and anti-jamming capabilities.

The new Onyx GNSS OEM board is a fully upgradeable GNSS receiver, allowing the receiver to be upgraded from free differential GPS signal sources such as WAAS to increased accuracy services with integrated features with StarFire, through software optioning alone.

VectorNav INS earn MIL-STD and DO-160 Certifications

VectorNav Technologies has completed a series of MIL-STD and DO-160 qualification tests for its Tactical Series line of IMU and GNSS/INS products. Together with the unmatched SWaP-C to performance characteristics of the Tactical Series, the testing demonstrates yet another advantage of the Tactical Series for defense and aerospace applications. VectorNav's Tactical Series includes the VN-110 IMU/AHRS, the VN-210 GNSS/INS and the VN-310 GNSS-Compass aided GNSS/INS. The products include an onboard tactical-grade IMU (<1˚/hr in-run gyro bias stability), along with VectorNav's proprietary filtering, INS and GNSS-Compass algorithms. The products offer 1 to 2 mrad attitude performance in compact, rugged enclosures and include a 10-pin auxiliary port for integration with external RTK and SAASM-based GNSS receivers, as well as higher-performance IMUs. *www.vectornav.com*

Flowfinity and Leica Geosystems collaboration

Flowfinity Wireless Inc. has released new functionality that allows field users to collect highly precise GNSS location data via external Leica Zeno GG04 plus Smart Antennas in Flowfinity applications.

The Zeno GG04 plus is a rugged, flexible and easy-to-use smart antenna from Leica Geosystems. It uses RTK technology and Precise Point Positioning (PPP) to make high-accuracy data collection possible in real-time even in demanding locations without the need for a mobile data connection. All Flowfinity applications deployed on Android and iOS devices can now leverage the Leica Geosystems antenna to achieve 5 decimal place accuracy for GNSS location data. *www.flowfinity.com*

Hexagon launches Power Portfolio 2020

Hexagon's Geospatial division has launched Power Portfolio 2020, the latest version of its leading photogrammetry, remote sensing, GIS and cartography products. It leverages new GPU-acceleration technology to help users more quickly address big data management issues. It offers users more data sharing options for better collaboration and data management workflows.

The release also includes enhacements to Hexagon's industry-leading image compression technology and an improved user experience across products.

Leica Geosystems wins innovation award in 2019 Mondial du Bâtiment

Leica Geosystems part of Hexagon, recently announced that its 3D image measurement solution, the Leica BLK3D, has won the 2019 Mondial du Bâtiment Innovation Competition.

Selected by a jury of industry professionals, the BLK3D was praised for its innovative and unique way of capturing and documenting reality. The BLK3D was selected from 79 applications and a shortlist of 32 nominees. This is the third time Leica Geosystems has been presented the award, winning with the Leica BLK360 imaging laser scanner in 2017 and with the Leica DISTO™ distance laser metre in 1993.

Septentrio and CORE announce a GNSS receiver

Septentrio have announced an agreement to jointly develop a receiver which can utilize the Centimeter Level Augmentation Service (CLAS) of Japan's Quasi-Zenith Satellite System (QZSS). The two companies have also entered into a distribution contract which allows CORE to sell Septentrio high-precision positioning technology including CLAS-capable GNSS receivers, in the Japanese 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

November 2019

International Navigation Conference 2019
18 - 21 November
Edinburgh, Scotland
https://rin.org.uk/events

GEOTEC HANOI 2019
28 - 29 November
Hanoi, Vietnam.
https://geotechn.vn

December 2019

Amsterdam Drone Week
4 - 6 December
Amsterdam, The Netherlands
www.amsterdamdroneweek.com

International Committee on Global Navigation Satellite Systems (ICG)
8 - 13 December
Bengaluru, India
www.icg14.org

International Workshop on 'Capacity building and Education Outreach in Advanced Geospatial Technologies and Land Management'
10 - 11 December, 2019
Dhulikhel, Nepal
www.lmtc.gov.np/workshop

39th INCA International Congress
18 – 20 December
Dehrardun, India
http://inca2019.org

January 2020

International Workshop on Advanced Spatial Analytics and Deep Learning for Geospatial Applications
20 - 31 January
Bengaluru, India
www.workshop.csag.res.in

Precise Time and Time Interval Meeting (PTTI)
21 - 24 January
San Diego, USA
www.ion.org

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

April 2020

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

May 2020

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

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

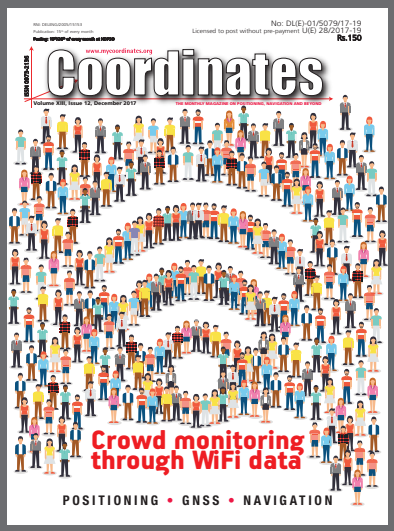
Esri User Conference
13 - 17 July
San Diego, USA
www.esri.com

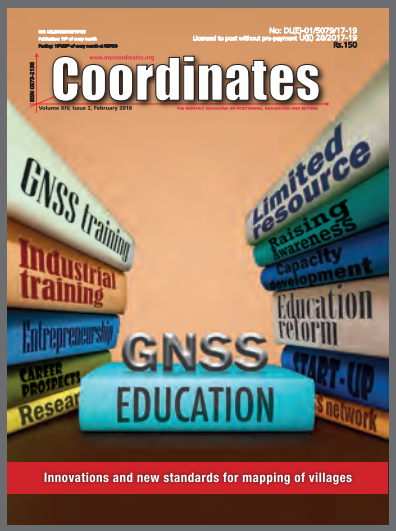
September 2020

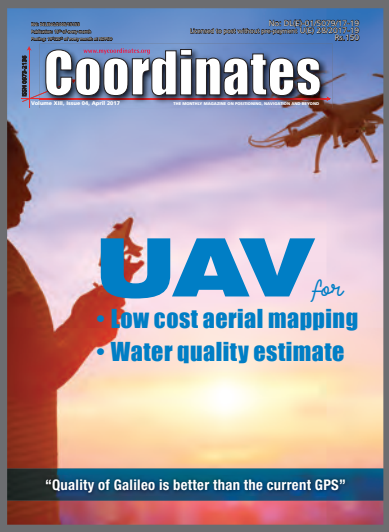
ION GNSS+ 2020
21 - 25, September
St. Louis, Missouri, USA
www.ion.org

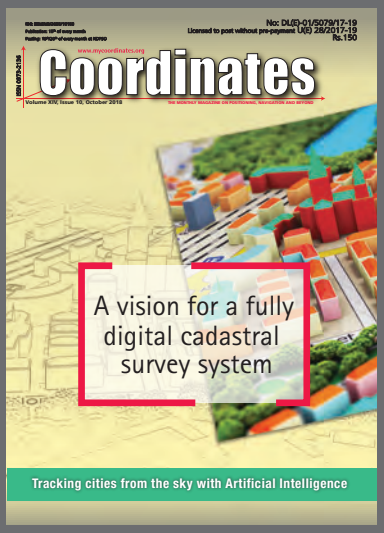
October 2020

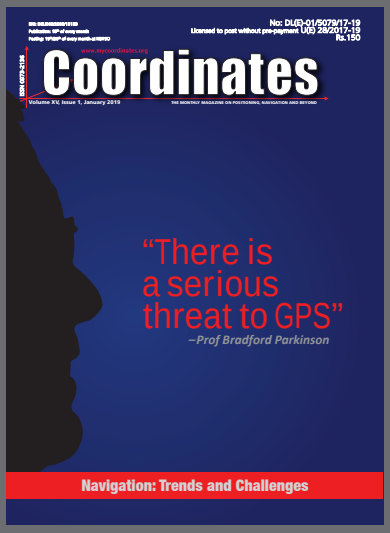
INTERGEO 2020
13 – 15 October
Berlin, Germany
www.intergeo.de

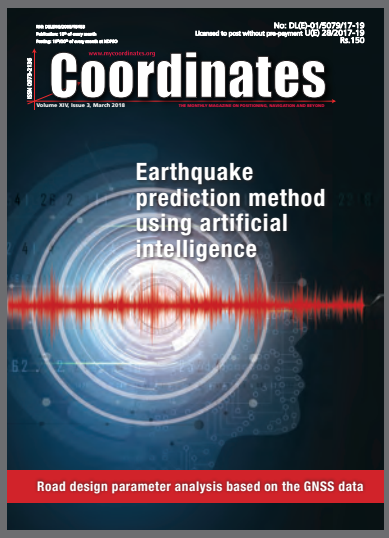


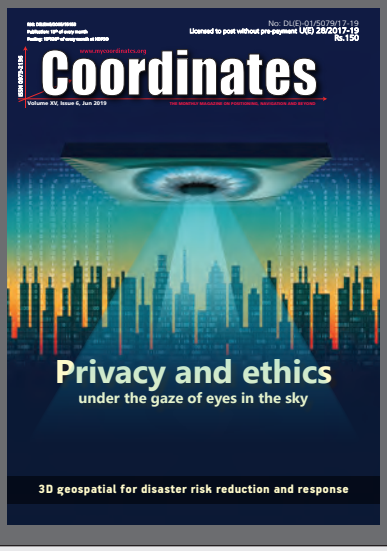


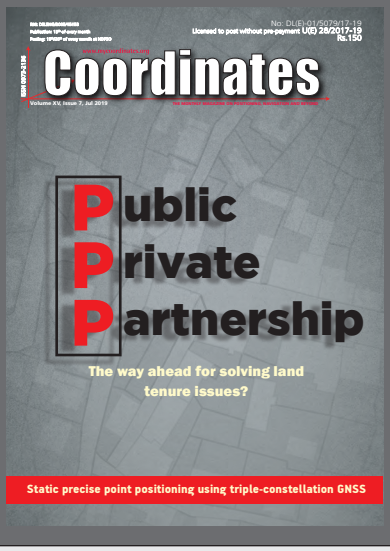












"The monthly magazine on Positioning, Navigation and Beyond"

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