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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

A report on GNSS performance standards

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Mark your calendar May 2020 to December 2020

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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
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The Herd and the Immunity

As many have emerged as heroes

Especially the professionals

Working with great dedication and commitment for their work

In the field of health care and other essentials services,

There are a few who seem to have used the coronavirus crisis

As an opportunity to camouflage their failures

And further their authorities and control

Almost all across the globe.

It appears that the powerful are set to acquire

More and more immunity for themselves

And reducing the rest to just as herd,

Herd only.

Bal Krishna, Editor
bal@mycoordinates.org

A report on GNSS performance standards

GNSS service providers are to be commended for providing performance standards, and verifying they are being met. With multiple constellations, there is an opportunity to learn from one another and improve the service commitments

John W. Lavrakas
President
Advanced Research Corporation, USA

Introduction

Today, the world is experiencing a jump in GNSS/RNSS capabilities and services, advancing beyond the decades-long monopoly of GPS, and to some extent GLONASS, in providing worldwide positioning and timing services. Galileo and BeiDou Navigation Satellite System (BDS) now offer limited global services, and Quasi-Zenith Satellite System (QZSS) and Navigation with Indian Constellation (NavIC) offer regional services.

We are in a significant transition period as new satellite navigation service providers move from initial operation to full operation over the next several years. While each system provides similar services, these services differ in implementation and capabilities, in signals, codes, navigation data, data authentication levels, and ancillary services. Satellite navigation service providers issue documents that describe the service they are providing with commitments on the level of service that users can expect. These include core performance standards such as accuracy, availability, continuity, integrity, and coverage.

In this article, the term "performance standard" is used. Some organizations refer to their performance standards documents by other terms, such as a service standard, open service standard, or service definition document. For the purpose of this article these terms are considered synonymous.

Historical perspective

When the United States first offered a global navigation satellite service through its Navstar Global Positioning System (GPS), it became clear to leadership that for its open service to be adopted by users, written commitments of the service were required. This began with a publicly available interface control document, "Navstar GPS Space Segment / Navigation User Interfaces", ICD-GPS-200, released January 25, 1983 (ICD-GPS-200V1, 1983). While this described the format and content of the open service signal, it did not describe the performance levels that the service would provide.

During the same year GPS reached initial operational capability in 1993, the U.S. Department of Defense issued its first statement of open service, called the Global Positioning System Standard Positioning Service (SPS) Signal Specification (GPSPS1, 1993). Contained in the document was a letter stating that the signal specification defined "GPS services provided by the Department of Defense to the Department of Transportation to support the needs of civil users." The document included a statement of policy for the provisioning and usage of the system, system overview, and detailed description of ranging signal characteristics. It also included an annex specifying the Standard Positioning Service, including coverage, service availability, service reliability, and positioning & timing. Later versions appeared at subsequent key points. Version 2 was published in 1995 to coincide with full operational

Table 1. Comparison of Performance Standards

Service	GPS	GLONASS	Galileo	BeiDou	QZSS
Edition	SPS PS V4 September 2008	Rev 2.2 June 2019	OS OSD V1.1 May 2019	OS PS V2.0 December 2018	PS-QZSS-001 November 2018
Slot or Service Availability Probability slot occupied	≥0.957 [3.7.1]	≥0.95 [3.7.1]	≥0.87 [3.4]	≥0.98 GEO, ≥0.98 IGSO ≥0.98 MEO [5.2.4, 7.4]	≥0.95, QZO ≥0.80, GEO [4.4.2]
Terrestrial Service Volume Coverage - per satellite	100% [3.3.1]	100% [3.3.1]		100% [7.1]	
TSV Coverage - Constellation	100% [3.3.2]	100% [3.3.2]			
URE accuracy SF any satellite	≤7.8m 95% all AODs ≤12.8m 95% any AOD	≤11.7m (95%) [3.4.1]	≤7m 95% all AODs [3.3.2]	≤1.0m RMS B11, B31 ≤0.6m RMS B1C, B2a [7.2.1]	≤2.6m 95% [4.3.1]
URE accuracy DF any satellite		≤11.7m (95%) [3.4.1]	≤7m 95% all AODs [3.3.2]		
URE accuracy SF all satellites		≤7.8m (95%) [3.4.1]	≤2m 95% [3.3.2]		
URE accuracy DF all satellites		≤7.8m (95%) [3.4.1]	≤2m 95% [3.3.2]		
URRE accuracy	≤0.006m/s 95% [3.4.2]	≤0.014m/s (95%) [3.4.2]		≤0.006m/s RMS [7.2.2] B11, B31	
URAE accuracy	≤0.002m/s2 95% [3.4.3]	≤0.005m/s2 (95%) [3.4.3]		≤0.002m/s2 RMS [7.2.3]	
Continuity	≥0.9998/h [3.6.1]	≥0.998/h [3.6.1]		≥0.995/h GEO ≥0.995/h IGSO ≥0.998 MEO [7.3]	≥0.9998/h [4.5]
Advance Notice	NANU 48 hr [3.6.3]	Notice 48 hr [3.6.2]	NAGU 24 hr [3.6.1]	Notice 24 hr [8.3]	48 hr [4.5]
Unscheduled Notice	As soon as possible after event [3.6.3]	As soon as possible after event [3.6.2]	within 72 hr after event [3.6.1]	within 72 hr after event [8.3]	
Range Integrity	≤1x10-5 prob over any hour of URE exceed NTE tolerance without timely alert [3.5.1]	≤1x10-4 prob exceeding instantaneous SIS URE set threshold [3.5.1]			≤1x10-5/h ISF 0 ≤1x10-8/h ISF 1 prob of SIS URE exceeding NTE threshold [4.6]
PDOP ≤ 6 global	≥98% [3.8.1]	≥98% [3.8.1]	≥77% [3.4.3]	≥0.95 B11, B31 ≥0.85 B1C, B2a [8.2.1]	
PDOP ≤ 6 worst site	≥88% [3.8.1]	≥84% [3.8.1]			
95% Horizontal Availability global average	≤17m ≥99% [3.8.2]	12m ≥99% [3.8.2]	7.5m ≥77% [3.4.4]	20m ≥95% global B11, B31 20m ≥85% global B1C, B2a [8.2.2]	
95% Horizontal Availability worst site	17m ≥90% [3.8.2]	12m ≥90% [3.8.2]	7.5m ≥70% [3.4.4]		
95% Vertical Availability global average	37m ≥99% [3.8.2]	25m ≥99% [3.8.2]	15m ≥77% [3.4.4]	20m ≥95% global B11, B31 20m ≥85% global B1C, B2a [8.2.2]	
95% Vertical Availability worst site	37m ≥90% [3.8.2]	25m ≥90% [3.8.2]	15m ≥70% [3.4.4]		
95% Horizontal Accuracy	≤9m [3.8.3]	≤5m global [3.8.3]		≤10m global B11,B31 ≤10m global B1C, B2a [8.1]	
95% Vertical Accuracy	≤15m [3.8.3]	≤9m global [3.8.3]		≤10m global B11,B31 ≤10m global B1C, B2a [8.1]	
95% Time Transfer	≤40ns [3.8.3]	≤40ns [3.8.3]		≤20ns [8.1]	
UTCOE accuracy	≤40ns 95% [3.4.4]	≤40ns 95% [3.4.4]	≤30ns 95% over all AODs [3.3.3]	≤20ns RMS global [7.2.4]	≤40ns 95% [4.3.3]

capability (GPSPS2, 1995), Version 3 in 2001 to report amended service levels following the turn off of selective availability (GPSPS3, 2001), and Version 4 appeared in 2008 (GPSPS4, 2008). A Version 5 is in development to specify new services, including possibly the L2C and L5 frequencies and codes.

Other satellite navigation service providers also issued their own service standards, and today we have the following:

- BeiDou Navigation Satellite System Open Service Performance Standard, (Version 2.0), December 2018 (BDSOSS2, 2018)
- European GNSS (Galileo) Open Service Service Definition Document,

May 2019 (GalOSSDD1, 2019)
- Стандарт эксплуатационных характеристик открытого сервиса (СТЭХОС), translated "Global Navigation Satellite System GLONASS Performance Standard for Open Service", Revision 2.2, 2019 (GLOOSSP1, 2019)
- Quasi-Zenith Satellite System Performance Standard, November 5, 2018 (QZPS1, 2018)

The inevitable question one asks after considering these published performance standards is, are the service providers meeting their commitments? For several of the systems, the answer is generally yes, although insufficient data from monitoring and assessment services for each of the GNSS/RNSS is available to be conclusive

The value of standards

To support safety-of-life applications, space and ground-based systems have been developed to augment the services provided by the core GNSS services. The Wide Area Augmentation System (WAAS) is one such system that augments the GPS SPS by broadcasting differential correction messages through GEO satellites and supports signal integrity by transmitting integrity data in the WAAS messages, thereby making the augmented GPS Standard Positioning Service a trusted air navigational aid. Putting this another way, WAAS could not offer its service levels without a corresponding commitment from the GPS SPS. When the WAAS performance standard was issued in November 2008, then Federal Aviation Administration GNSS Program Manager Leo Eldredge explained, "For civil aviation purposes, we depend on the commitments contained in the SPS PS as the basis for our commitment to provide service through augmentation and the approvals for aviation use of standalone GPS. Before we could approve use of L5, for either standalone use or as part of an augmented service, the commitment to provide that service would first need to be provided by DoD in a [Performance Standard]." (InsideGNSS, 2008).

The performance standards provided by each of the GNSS and RNSS systems have many similarities, although the commitment levels vary. Table 1 compares the contents of the performance standards for GPS, GLONASS, Galileo, BDS, and QZSS. In some cases, the performance parameters were consistent across most or all of the systems. In other cases, the performance parameters applied only to one of the systems, and these were omitted from the comparison. The table below summarizes the performance level commitment provided in the performance standards for each of the performance parameters. Note that GPS and GLONASS are fully operational, while Galileo, BeiDou, and QZSS are still in development, which influences to a degree their performance commitments.

In reviewing the broad categories of performance parameters, it is observed at this point that some performance parameters are universally provided by all GNSS/RNSS service providers. These include slot/service availability, user range error accuracy, and UTC Offset Error accuracy. Some of the performance parameters are provided by all global though not regional services, including PDOP and positioning service availability. And some performance parameters are not provided until the system's full implementation, like terrestrial service volume coverage, multifrequency ranging accuracy, and positioning accuracy. There is a desire on the part of GNSS/RNSS service providers to standardize the implementation of their performance standards, which is discussed in the next section.

"Standardizing the standards"

In 2011, the United Nations International Committee on GNSS (ICG) met in Tokyo, Japan, and adopted a recommendation to form a consensus on open service GNSS performance parameters, including definitions and calculation methods (ICGWGA, 2011). In the recommendation, it was proposed that a working group develop a template for individual GNSS providers to consider in their publication of signal and system information, the policies of provision, and the minimum levels of performance to be offered for open services. This work has been carried forward by a group within the Working Group on Systems, Signals, and Services, called the Performance Standards Team, comprised of representatives of China, European Union, India, Japan, Russia, and United States. In 2018, the ICG adopted a set of guidelines for developing performance standards prepared by the Performance Standards Team (ICGPSG, 2018). The Team continues to work on definitions for each of the parameters used in the Guidelines document. Table 2 provides a list of the performance parameters by category that are considered for implementation in GNSS/RNSS performance standards. While the Guidelines document identifies which performance parameters to include in a performance standard, these are not binding. The ICG operates by consensus, meaning that a position is adopted only if it reflects the views of all its members. Performance parameters that are determined to be critical in defining a performance standard are identified as Key. The other performance parameters are listed as Optional. The expectation is that all members will implement the Key performance parameters and may or may not implement the Optional performance parameters.

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Table 2. Guidelines for Performance Standards – Categories and Performance parameters

Satellite domain

Slot Availability (maintenance of satellites to orbital slot parameters) [Optional, proposed to be Key]
Terrestrial Service Volume Coverage [Key]
Space Service Volume Coverage [Optional]

Range domain

Range Accuracy (all signals) [Key]
Range Accuracy (by Age of Data) [Optional]
Range Integrity [Optional]
Range Availability [Key, proposed to be Optional]
Range Rate Accuracy [Optional]
Range Acceleration Accuracy [Optional]
Range Rate Integrity [Optional]
Range Acceleration Integrity [Optional]

Position domain

This section applies if positioning is provided as a service.
DOP Availability [Key]
Position Accuracy (Global Average & Worst Site)[Optional]
Position Availability [Key]

Time domain

Time transfer accuracy [Key]
UTC time dissemination accuracy [Key]

Continuity

Signal in Space Continuity [Optional]

Other

Broadcast Polar Motion [Optional]
GNSS/RNSS Time Offset [Optional]
UT1-UTC Offset [Optional]
Carrier Phase Coherency [Optional]

Verifying the standards

The inevitable question one asks after considering these published performance standards is, are the service providers meeting their commitments? For several of the systems, the answer is generally yes, although insufficient data from monitoring and assessment services for each of the GNSS/RNSS is available to be conclusive. Both GPS and Galileo publish regular reports assessing performance against their standards. As early as 1993, the United States Federal Aviation Agency (FAA) began to publish quarterly performance analysis reports which scored the GPS performance against the existing standards (FAATC). In 2013, the U.S. Air Force began issuing public reports by the University of Texas Applied Research Laboratories that analyze GPS Standard Positioning Service performance (ARL:UT, Analysis of GPS SPS Performance). In 2017, the European GNSS Service Centre (GSC) began publishing a quarterly assessment of Galileo initial operational service (GSC, Quarterly Performance Report).

By and large, the performance of these systems has been stellar, with quarter after quarter of full compliance with the published performance standards. In fact, when looking at the data, we see an interesting characteristic of the performance standards, namely that the actual performance of the system far exceeds the levels set by the standards. This "looseness" in the performance standards is so extreme that in several recent major service failures, the performance standards levels were not even violated, despite the fact that numerous users were severely affected. Following are two such occurrences:

- January 2016. Fifteen GPS satellites broadcasted erroneous values of the UTC offset correction term in their navigation message for a period of over 12 hours. As a result, thousands of digital radios and communication networks around the world went off line. The satellite operators were made aware of the problem, and they restored the signals to normal operation. In its report for the period, the University of Texas Applied Research Laboratories said, "Several GPS satellites broadcast flawed UTC offset information on 25-26 January 2016. The flawed data included tot values that did not satisfy the allowable range criteria. Therefore these data were not considered in this process. No values exceeding the NTE [not-to-exceed] threshold were found in 2016." (ARL:UT, Analysis of GPS SPS Performance for 2016, 2016)
- July 2019. All satellites in the Galileo constellation were disabled from service for six days due to a technical incident related to the Galileo ground infrastructure. The satellite operators eventually were able to correct the problem and bring the service back online for its users. In its report for this period, the GSC reported only on a violation of UTC availability, but no violation of positioning service availability. The GSC said, "During this quarterly reporting period, the measured Galileo Initial Open Service performance figures exceed the Minimum Performance Level (MPL) targets specified in the [OS-SDD], with the exception of the UTC availability MPLs in July." (GSC, Galileo Initial Services Open Service Quarterly Performance Report, 2019Q3)

What can we learn from the reports regarding these incidents? One is that in some cases the performance standards lack sufficient detail to allow flawed data to be broadcast without violating the standards. Another is that it appears that since many of the performance standards are statistical in nature, accumulated over many days, that significant service disruptions are obscured by the statistics. Too many good performance days can hide the terrible performance on a few bad days.

These incidents aside, one could conclude that these performance standards are in general not set as tightly as they could

In the next few years, I believe that all GNSS and RNSS will have documented performance standard commitments, and to a great extent, these performance standards will conform to the guidelines set by the International Committee on GNSS

be. The GPS performance standard commits to 95% range error over all ages of data of 7.8 meters, yet operates at around 1 meter. Galileo's service definition document commits to 95% range error over all ages of data of 7 meters, yet operates at 20-35 cm. Not all performance standards set such a high level for range accuracy, however. BDS sets its performance level for range error at 1m RMS (roughly 2m 95%) and QZSS at 2.6 meter 95%. GNSS services may wish to revisit their performance standards and set levels that provide sufficient allowance in random fluctuations, but do not hide or obscure serious performance events.

Conclusions

GNSS service providers are to be commended for providing performance standards, and verifying they are being met. With multiple constellations, there is an opportunity to learn from one another and improve the service commitments.

Multiple GNSS systems and services are being implemented to meet national goals. While offering largely the same service of positioning and time, these GNSS systems also provide independence and redundancy, which is invaluable to PNT users. They also provide a degree of competition, which spurs providers to improve their own services. In the next few years, I believe that all GNSS and RNSS will have documented performance standard commitments, and to a great extent, these performance standards will conform to the guidelines set by the International Committee on GNSS.

I also expect that every service provider will begin to assess and publish its performance against these standards. My hope is that as this information is shared, there will be motivation to tighten up the performance standards, so that no single GNSS falls behind the others in providing reliable and accurate service to their users. This, of course, will be to the benefit of those who rely daily on these multiple GNSS/RNSS services.

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Living structure down to earth and up to heaven: Christopher Alexander

This paper is intended to defend living structure as a physical phenomenon, and a mathematical concept, clarifying some common questions and misgivings surrounding Alexander's design thoughts, such as the objective or structural nature of beauty, building styles advocated by Alexander, and mysterious nature of his concepts. This paper helps people understand why beautiful things are beautiful, and why ugly things are ugly, through the underlying living structure. Living structure is to beauty what temperature is to warmness. Readers may recall that we published the down to earth part of the paper in March issue. Here we present the up to heaven and concluding part of the paper

Bin Jiang
Professor, Faculty of Engineering and Sustainable Development, Division of GIScience
University of Gävle, Gävle, Sweden

5. The inner meanings of living structure through the I-hypothesis

The phenomenon of living structure implies that the real world is a living world, to which we human beings belong. This section further discusses the I-hypothesis, the new cosmology, and how to make better sense of living structure in our inner world.

5.1 The I-hypothesis and how it comes

The I-hypothesis states that there is, physically in the universe, and underlying all space and matter – at every point of space and matter – a single underlying substance that shall be simply called "I". It can be called or expressed in a variety of ways: the concept of "I", the universal "I", the luminous ground, the blazing one, the I-substance, the "I", the Self, the heaven, the spirit, the soul, the domain of "I", the ground of "I", the eternal "I", the plenum of "I", something luminous, the underlying "I", the concept of beings, and even God. In this paper, I do not refer to it as God but instead as the "I", hence the I-hypothesis. The I-hypothesis goes beyond the mechanistic world picture, under which the human inner world is separated or disconnected from the physical world. The I-hypothesis implies an organic world view, under which the human inner world is tightly united with the physical world through the "I". This is difficult for our minds to understand, because we have become used to the mechanistic world picture. The mechanistic world view is superficial, and could be simply wrong (Whitehead 1938). We have to get out of the mode of thought to which we have become accustomed, just as Alexander did, in order to make better sense of the inner meaning of living structure. This philosophical and visionary part of living structure is metaphysical, and remains highly mysterious, and probably can never be verified.

The following quote shows how Alexander (2002–2005, Volume 4, p. 136) himself struggled with the I-hypothesis:

"When thinking as a scientist, it must of course be this question of truth which occupies one's mind. It is for this reason that I have kept records, and written down my observations, for the last thirty years, as carefully as possible. As a result of my observations, and as a result of my experiences in the field – as an architect building buildings, as a craftsman

making things, as a planner laying out buildings and precincts and seeing them come to life – I have gradually become convinced that this theory [the theory of I-hypothesis, note by this paper's author]*, or at least something very much like it, is indeed likely to be true. In short, as a scientist, I have gradually come to the belief that the I must be real. And as an architect, I have also become convinced that the I is certainly real in buildings, and must necessarily play a fundamental role in architecture."*

This I-hypothesis or a version of it first came to Alexander's mind while he was studying Turkish carpets. As he wrote at the very beginning of the book:

"A carpet is a picture of God. That is the essential fact, fundamental to the people who produced the carpets, and fundamental to any proper understanding of these carpets.

This does not mean, in Anglo-Western terms, that a carpet is a picture of a man with a long white beard. God, the all seeing, everlasting stuff, is the target of Sufism - as it is of all the mystical religions. In modern language we might also call it ultimate oneness of everything. The Sufis, who wove most of these carpets, tried to reach union with God. And, in doing it, in contemplating this God, the carpet actually tries, itself, to be a picture of the all seeing everlasting stuff. We may also call it the infinite domain or pearl-stuff." (Alexander 1993)

5.2 The new organic cosmology

From the I-hypothesis, Alexander conceived and conceptualized a new world view or new cosmology, in which the outer physical world and the inner emotional world are united as one, in one coherent world picture. Our individual inner selves and any living structures in space and matter are imbued with the "I". The density of the "I" is not uniformly penetrated in space and matter, and it depends on the degree of wholeness or living structure. In other words, the more living a center, the greater the possibility that the center reveals the "I". It is essentially a non-material view of space and matter, and is therefore hard for our mechanistic mindsets to accept. If it were accepted, it would make good sense in terms of explaining why the feeling of beauty or life – or our inner world – can be triggered by the living structure of the physical outer world.

It should be noted that the new organic world picture is not about abandoning the current mechanistic world view, but about the hypothesized "I" to make the current world picture complete and integrated. Human beings are not separated from the physical world, as is currently conceived, but united with the outer world through the ubiquitous hypothesized "I".

The new cosmology put forward by Alexander has its philosophical and religious roots. For example, Whitehead (1920) believed that we cannot have a proper grasp of the universe and our place in it until two worlds – the physical world and our experienced inner world, which are called "bifurcation of nature" – can be united in a single picture. This is exactly what Alexander did to get these two worlds united through the hypothesized "I", and based on the powerful notion of living structure. Alexander felt strongly that to build great buildings, and make great arts, one must keep the creation or design as a worship to the "I" or God. According to Alexander, the weavers wanted to be united with God through the carpet as a living center. *Places for the Soul* is a 30-minute film on the work of Christopher Alexander by an independent filmmaker, which highlighted Alexander's approach to building. In it, Alexander remarked that his approach to architecture was "*to make God appear in the middle of field*". In the first paragraph of the book on carpets (Alexander 1993), as mentioned above, he began with the sentence "*A carpet is a picture of God*", while in his essay, *The long path that leads from the making of our world to God* (Alexander 2007a), he made an explicit link between the built environment and God. All these point to the fact that his thoughts are pretty religious. If we thought anything we make or create is to sense and to see the "I", would our daily life not become more meaningful?

It should be noted that the new organic world picture is not about abandoning the current mechanistic world view, but about the hypothesized "I" to make the current world picture complete and integrated. Human beings are not separated from the physical world, as is currently conceived, but united with the outer world through the ubiquitous hypothesized "I". This new world makes better sense as to why our consciousness comes from the human brain, which is the most living center in the body, and enables us to sense or see the ground "I".

5.3 Making sense of living structure in our inner world

Let's see how the I-hypothesis makes better sense of living structure in our inner worlds than the purely psychological view. According to Alexander (2002–2005), space is neither lifeless nor neutral, but a living structure capable of being more living or less living. This living space view includes everything in the physical world, as large as the universe (10^{27}), as small as the Planck size (10^{-35}), and sizes in between the largest and the smallest. This living space view is very much like extending the picture of Figure 5 at its

A physical phenomenon and mathematical concept for people to understand objective or structural nature of beauty, or to setup a dialogue with those who are skeptical about Alexander's profound design thoughts

two ends: beyond the Earth toward the entire universe, and further down from the building façade toward the smallest. In this living space, according to the I-hypothesis, the "I" exists everywhere. Therefore, any human being is part of this living space, and he – the human body – is also fused or tunneled with the "I". Like any space, the human body is not uniform in terms of living centers; some parts are more living and some parts are less so. For example, the human brain is the most living center in the human body. This explains why we have consciousness or why we have the feeling of beauty or life, and why great architecture and works of art are religious, and why ancient carpets are religious. This is because the human brain is the most living center, through which one can sense or see the "I". In other words, the living center acts like a window, through which one sees the "I": the more living a center is, the higher the possibility one sees the "I" through the center. Whether the I-hypothesis is true may never be verified. However, this physical or metaphysical view of the universe seems better than the psychological explanation about beauty and life.

A living structure – or a living façade in particular – is full of hundreds or thousands of living centers, which Alexander (1993) called "beings". A being is the most beautiful or most living center in a living structure. It is autonomous, capable of uplifting the human spirit. For example, the front gate of the Taj Mahal façade is such a being or being-like center (Figure 6b). One could also say that the upper dome is being-like because it contains many elaborate and intricate sub-structures. As Alexander (2002–2005) gazed at the humble yet beautiful tile (Figure 10a), he felt clearly as though he was looking through to heaven. This expression of his own feeling may seem far-fetched or romantic under the current mechanistic mode of thought, but it should be understood as something literal under the new world view, a non-material view of space and matter. To mimic how Alexander expressed his own feeling, we could say that by gazing at any picture of Figures 5, 6 and 10, our spirit is uplifted. Through contemplation, we develop a deep sense of feeling that we are part of Earth, part of the building, or part of the city, and eventually part of the universe. In the same fashion, any picture of Figure 6 enables us to see the "I" or the luminous ground, or we can become united with the luminous ground and our spirit is uplifted. In a secular tone or in the current mechanistic mode of thought, we feel at ease emotionally, as our personal feeling, or our true feeling.

Figure 10: (Color online) Living structure enabling us to see the luminous ground (Note: (a) A small humble panel made of marble strips inlaid in the west wall, and (b) gold and mosaic ceiling, of the Baptistery, Florence, 11th century (Alexander 2002–2005).)

6. Conclusion

This paper is intended to defend living structure as a physical phenomenon and mathematical concept for people to understand objective or structural nature of beauty, or to setup a dialogue with those who are skeptical about Alexander's profound design thoughts. Living structure is a mathematical structure of physical space, which is able to be reflected in our minds psychologically: the more living the structure is, the more beautiful one feels. By drawing evidence from Alexander's work and through our own case studies, this paper has shown that beauty is essentially objective or structural. In other words, beauty exists in the deep structure of details, or in the scaling hierarchy of "far more smalls than larges". Beauty and ugliness can be clearly defined by scaling law; that is, a structure with a flat scaling hierarchy – with maximum two levels of scale only – is objectively considered to be ugly, whereas a structure with a steep scaling hierarchy – with at least three levels of scale – is objectively considered to be beautiful.

Armed with the kind of simple analysis on scaling hierarchy, people can understand why beautiful buildings are beautiful, and why ugly buildings are ugly. Simply put, a building is beautiful because of its steep scaling hierarchy, or ugly because of its flat scaling hierarchy. By claiming objective or structural beauty, our intention is not to deny idiosyncratic aspects of beauty, which account for only a small proportion of our feeling. This dominance of the objective over the subjective can be compared to any statistical regularity with a majority of agreement, such as an

The I-hypothesis is a powerful concept that makes better sense of the inner meaning of living structure than purely psychological or cognitive explanations. The third view of space provides a fresh look at our surroundings, whereby everything is a living structure, and should become more living or more beautiful through our daily makings.

r square value of 0.75 instead of 1.0. In addition to the scaling hierarchy or scaling law, Tobler's law plays an important role in the objective or structural beauty as well. As one of the two laws of living structure, Tobler's law – or the notion of "more or less similar" – recurs on each level of scale. The true meaning of "more or less similar" is neither "completely same" nor "completely unique", but something between the same and the unique. These two complementary laws work together, governing living structures, with the scaling law being primary, and Tobler's law being secondary.

The I-hypothesis is a powerful concept that makes better sense of the inner meaning of living structure than purely psychological or cognitive explanations. The third view of space provides a fresh look at our surroundings, whereby everything is a living structure, and should become more living or more beautiful through our daily makings. The new cosmology solves the problem of the bifurcation of nature (Whitehead 1920), for we human beings are not separate from, but are part of the universe, thus making our daily lives more meaningful. Human beings can be uplifted by good space, reflected by good architecture, and eventually united and re-united to the hypothesized "I". To end this paper, we would like to claim that living structure may actually be the *"bead game conjecture"* (Alexander 1968, cited from Gabriel 1998, and Grabow 1983), a mechanism that unites all structures or forms in mathematics, science, art, philosophy, and religion. This claim requires further research on living structure from these multiple disciplines or contexts, and implies that living structure is not a dogma, and can instead be further discussed, argued and even challenged.

Acknowledgement

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In Coordinates

10 years before...

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Maps: Changing approach

William Cartwright

President , International Cartographic Association Professor, School of Mathematical and Geospatial Sciences, RMIT University, Australia

With access to sophisticated computer hardware and software, linked by communications devices that are now readily available, the map-maker's palette is now richly and extensively provisioned with the means for depicting and delivering renderings of geographical information in a more timely, resourceful and exciting manner.

The use of Social Software and Web 2.0 typifies this. Web 2.0 allows small amateur mapmaker to produce maps that can almost immediately be published to promote and support their cause. The use of such technologies and their ability to communicate globally is clear. How best to include emotion in these sandardised look and feel products needs to be addressed if powerful messages are to be delivered.

Being under watch

Martin Grzebellus
Managing Director NavCert GmbH

All cars in the Netherlands will be equipped with an OBU logging all movements. At the end of the month the registered keeper of the car will be invoiced for the usage of the infrastructure. That's the plan of the government and the implementation beginning in 2012 should be finalized in 2017. Does this open the door for a continuous monitoring of citizens?

On the estimable parameters for selenodesy with space VLBI

Wei YAN

Ph.D candidate, School of Geodesy and Geomatics, Wuhan University, China

Erhu WEI PhD

Professor, School of Geodesy and Geomatics, the Key Laboratory of Geospace Environment and Geodesy, Wuhan University, China

Jingnan LIU

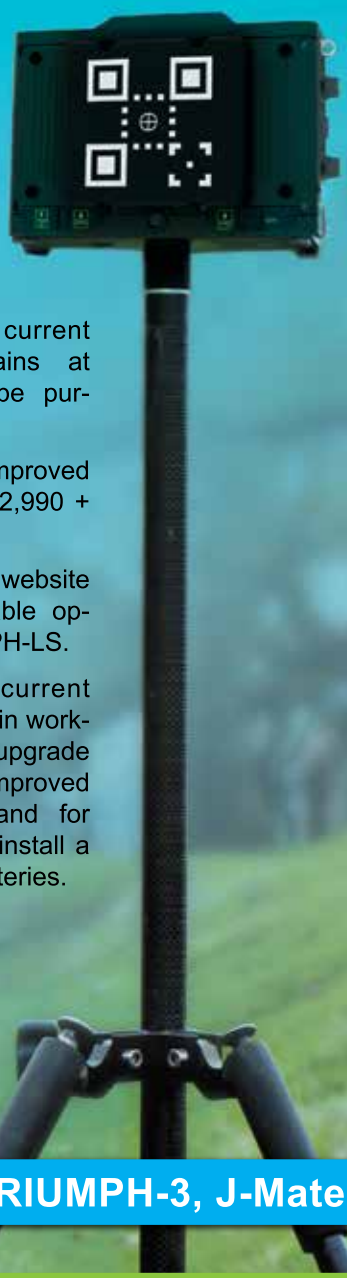
Professor , Academician of CAE (P.R. China) , GNSS Center, Wuhan University, China

Space Very Long Baseline Interferometry (SVLBI) is an extension of the ground based VLBI technology to space, which involves a simultaneous observation of the same radio source by two stations; one on the ground, the other being space-based. It could not only overcome the baseline length limitation problem specific to ground-based VLBI technology, with a great improvement on the observation resolution, but could also directly interconnect the important three reference systems (that is Terrestrial Reference System, Celestial Reference System, and the Dynamic Reference System).

These advantages imply tremendous potential for SVLBI in space geodetic applications. The successful launch of Chang'e-I lunar probe makes it possible to place a VLBI antenna on the lunar probe some day to form ground- space VLBI observations. As an important component of the Chinese VLBI Network (CVN), Urumqi astronomical observatory will play an essential role. Based on all these factors, it is necessary for us to investigate the mathematical model with SVLBI observations in selenodesy studies.

Upgrade to TRIUMPH-LS Plus

Option available for the TRIUMPH-LS with the following features, using the new ASIC:



- **Improved signal tracking and signal processing (wideband tracking) and adding Galileo and BeiDou L6 bands and Galileo AltBoc and BeiDou AltBoc signals.**
- **Improved multipath reduction due to wide band tracking.**
- **Improved spectrum analysis to show and reject spoofers and jammers option.**
- **Improved RTK with four "Super Engines". Each engine uses all signals of all satellites but with different parameters for different conditions.**
- **Improved internal Wi-Fi antenna that works both as directional and omnidirectional. No need for external Wi-Fi antenna.**
- **Improved internal Bluetooth antenna and longer range.**
- **Lower power consumption and extended battery life.**
- **J-Mate ready: Integrated J-Target painted on the back of TRIUMPH-LS.**

Price for the current TRIUMPH-LS remains at $12,990 and can be purchased as before.

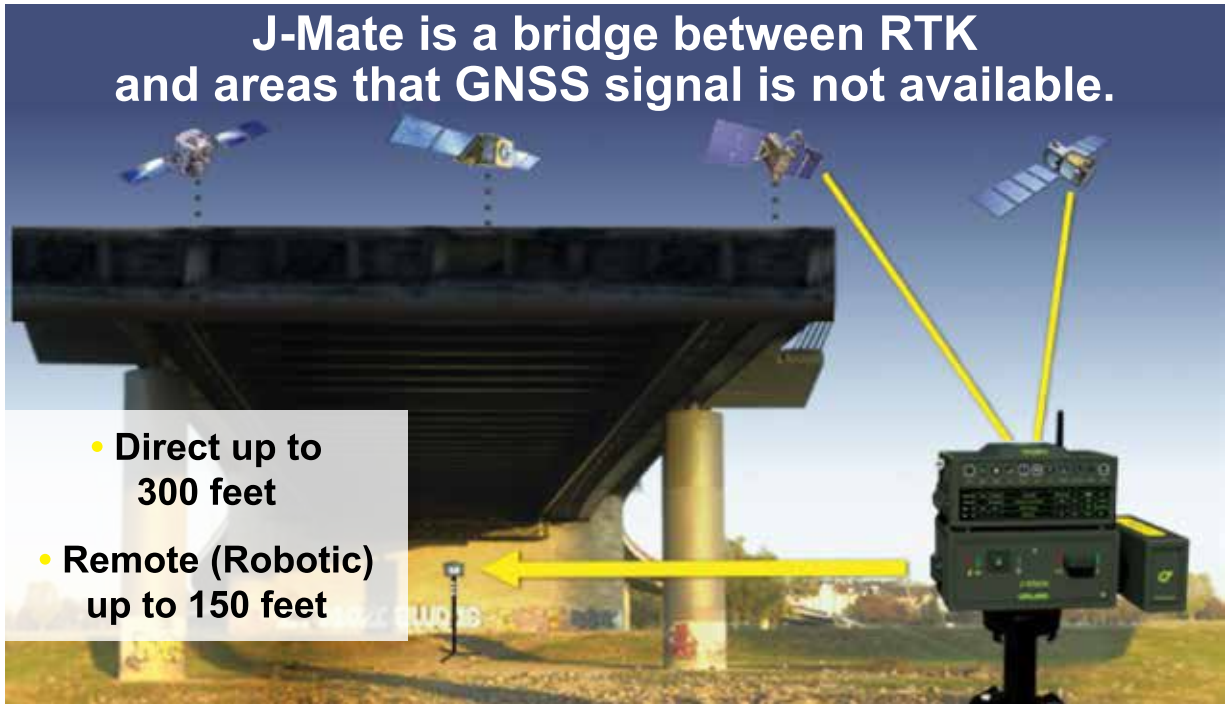
Price of the improved option is $4,990 ($12,990 + $4,990 = $17,980).

Please see our website for additional available options for the TRIUMPH-LS.

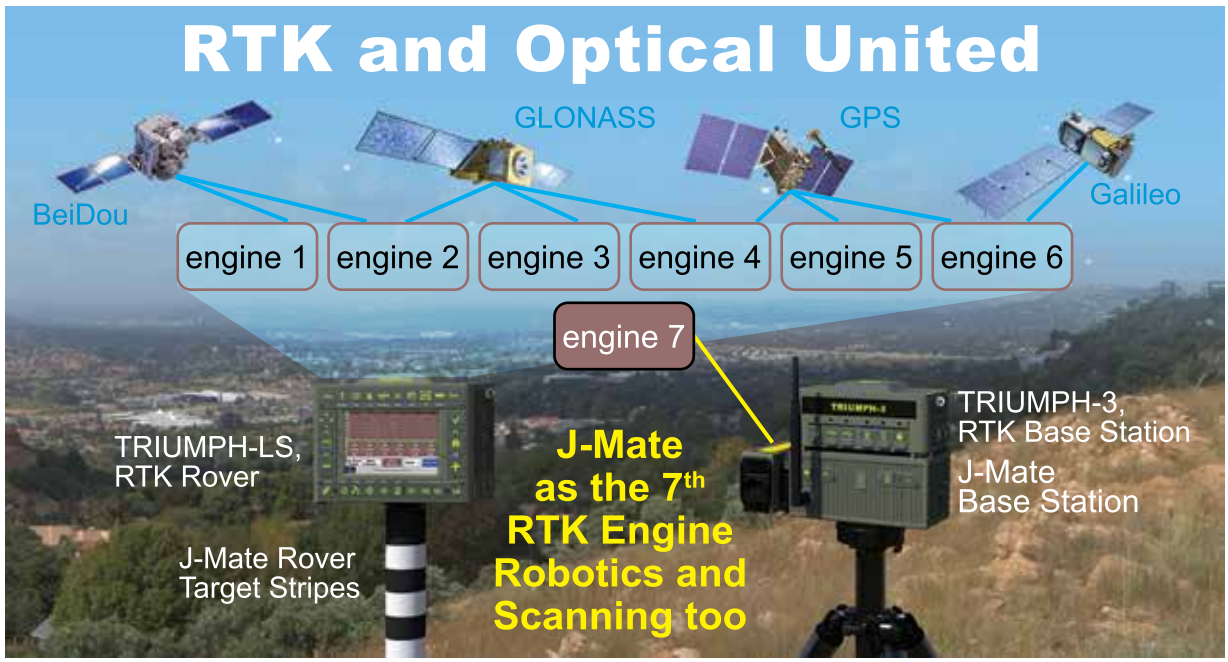
Owners of current TRIUMPH-LS units (in working condition) can upgrade their units to the improved option at $5,450 and for $5,700 we will also install a brand new set of batteries.

See inside **TRIUMPH-3, J-Mate, GNSS Signals** and more **>>**

J-Mate



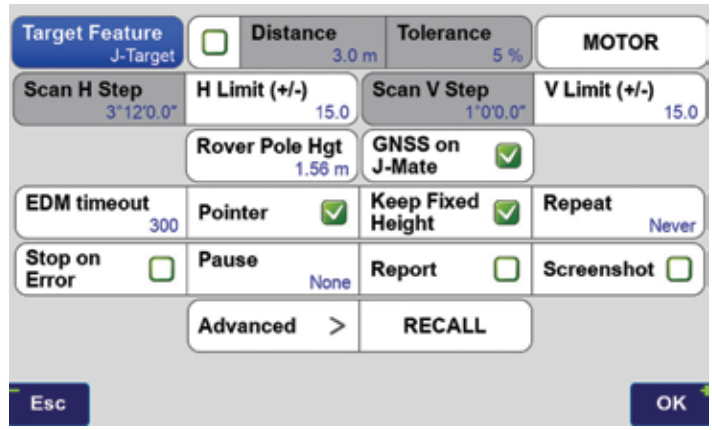
J-Mate is not a total-station. J-Mate and TRIUMPH-LS together make the "Total Solution" which is a combination of GNSS, RTK, camera, angle encoders and laser range measurements that together do, conveniently and cost-effectively, a lot more than a total station. For long distances, you use GNSS and for short distances (maximum of 300 feet in Direct mode and 100 feet in Remote/Robotic mode), you use the J-Mate along with the TRIUMPH-LS. Together they provide RTK level accuracy (few centimeters) in ranges from zero to infinity.



Searching and finding objects by laser and by Optics

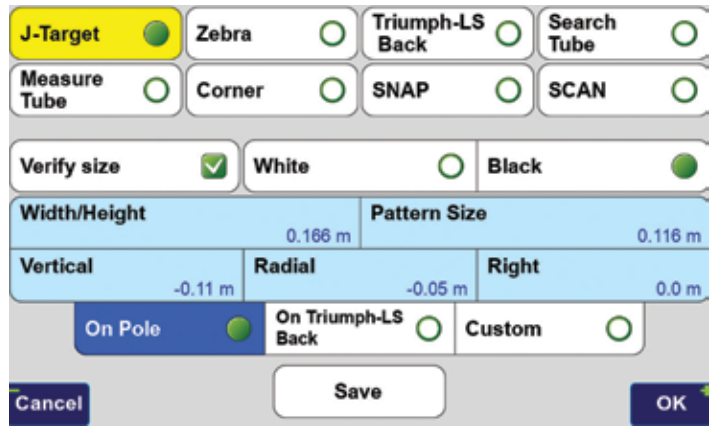
J-Mate has the unique feature of searching for objects by laser and by optics (camera).

Click button  and select “Target Feature” to see the setup screen for target selection and parameters. If you know the approximate distance to the target, click the check box and enter the distance and accuracy percentage. This will help J-Mate to ignore targets that are outside the range.



Horizontal and Vertical Limits are the limits that J-Mate will search around the starting point to find targets.

“Keep Fixed Height” check box, scans horizontally on fixed target height. You may rarely need to use this feature. It will reduce the scanning speed by a factor of 2.



“Laser time limit”

The time that it takes for a laser measurement depends on the reflective surface of the target and weather conditions (dust and moisture in the air).

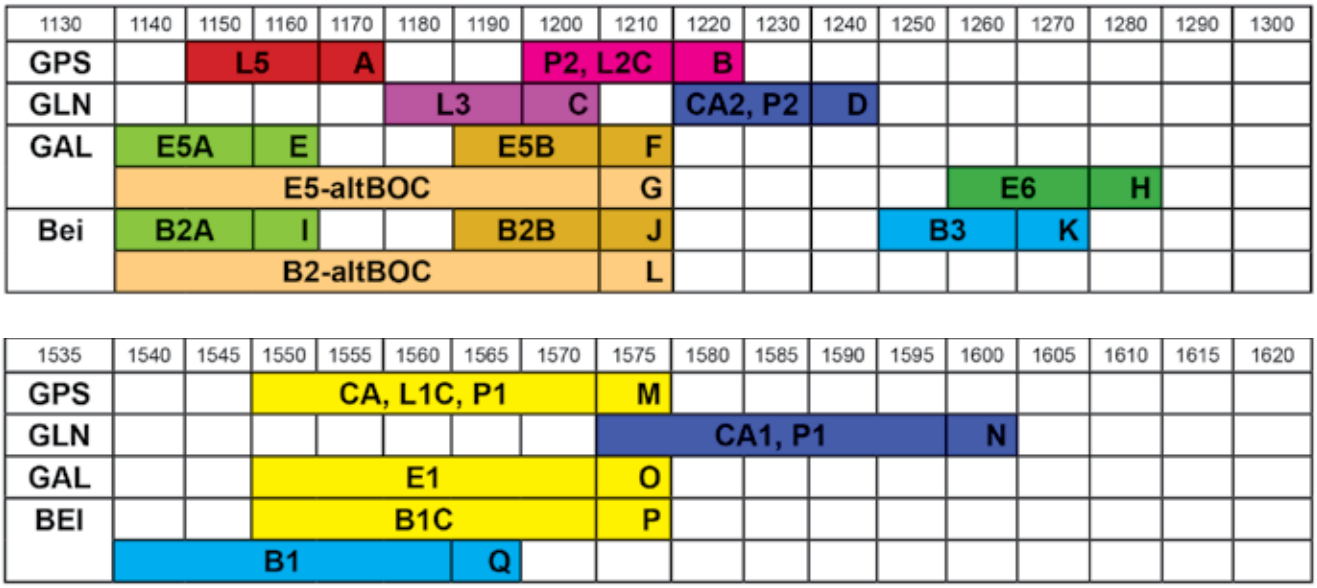
On a good white reflective surface and in clean air, it takes about 50 milliseconds to have a laser reading. If there is no reflective surface, or the reflective surface is black, it may take up to 4 seconds to have a laser reading.

If the surface of the object that you want to scan is a good reflective surface, limit the laser time to a fraction of a second. This will cause the laser to skip points that do not reflect enough energy in the time limit that you specified. This will significantly increase the scan speed and will ignore points that are not possibly your target and reduces the chance of identifying a wrong object.

Target Features and its offset from the top of the pole are shown in the “Target Features” screen. You can change the parameters by selecting the “Custom” button.

TRIUMPH-LS Back: You can use this feature to search for the back of TRIUMPH-LS and measure to its center to make sure laser range measurement is not from an unintended object.

GNSS Signals in the improved TRIUMPH-LS with the new chip



GNSS bands for GPS, GLONASS, Galileo and BeiDou signals are depicted in the above figure.

There are total of 22 signals in 17 frequency bands labeled “a” to “q”. Note that GPS C/A, L1C and P1 are in the same band (m) and GLONASS CA/L2 and P2 also are in the same band (d) of the same satellite. In selecting signals for RTK processing, as an option, we may choose to select only one of such signals in the same band. We label this option as “No Same Frequency” option in signal selection strategy screen, discussed later.

GPS				GLN				GAL				BEI			
C/A M	1.0	8	8.0	C/L1 N	1.0	8	8.0	E1 O	1.0	6	6.0	B1C P	1.1	8	8.8
P1 M	0.8	8	6.4	P1 N	1.2	8	9.6	E5B F	1.2	8	9.6	B1 Q	1.0	9	9.0
L2C B	1.0	8	8.0	C/L D	1.0	8	8.0	E5A E	1.2	7	8.4	B2B J	1.2	9	10.8
P2 B	0.8	7	5.6	P2 D	1.2	7	8.4	Eboc G	1.5	6	9.0	B2A H	1.2	8	9.6
L5 A	1.1	5	5.5	L3 C	1.2	2	2.4	E6 H	1.1	8	8.8	Bboc L	1.5	8	12.0
L1C M	1.1	8	8.8									B3 K	1.1	10	11.0

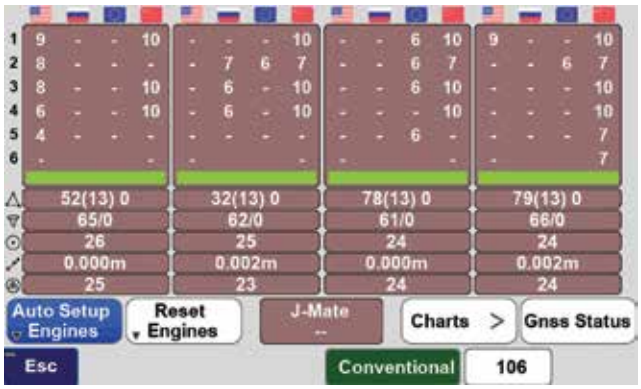
We categorize the GNSS signals as shown in the above figure. The first column is the name of the signal and its designated signal letter (e.g. GPS C/A m). Signals with the same color are those that we discussed earlier as being in the same frequency band of the same system.

The second column is the quality indicator of that signal. Because GPS P1 code, for example, is encrypted and in recovery we lose about 10db of its signal strength we give this signal the quality indicator of 0.8. GLONASS signals also get lower score because of their FDMA signal structure which results in inter-channel biases, even though we reduce such inter-channel biases in our signal processing techniques. Galileo AltBoc and BeiDou AltBoc signals get quality score of 1.5 because of their wide band and signal quality.

The third column is the number of available signals for RTK.

The multiplication of the second and third column is shown in column four, which is an indication of the value of that signal for RTK.

The four super engines



This screenshot shows the four super engine screens. Each engine shows the signals that are used for that engine.

The numbers below each engine are:

- First line is the GDOP of the selected satellites for each engine.
- Second line is the number of signals used / number of signals rejected.
- Third line is epochs since the last reset.
- Fourth line is the solution difference from the first engine.
- Fifth line is the total run time.
- Clicking on each engine, restarts the RTK fix process.
- Long click on each engine to select signals for that engine manually as shown in the figure below.

This screen shows all signals tracked by the TRIUMPH-LS which is real-time indication.

For each system, the name of the signal and its designated signal letter and quality indicator (e.g. GPS C/A M 1.0) are shown. GPS and GLONASS Signals with the same color sideband are those that we discussed earlier as being in the same frequency band of the same system.

Next to the signal name, the top number in each cell is the number of signals tracked by the Rover and the number below that is the number of signals tracked by Base. The smaller number of the two represent the number of common signals between base and rover.

You can long click on the signal name to change the quality indicator of that signal.

Each system is sorted by the number of common signals multiplied by the signal quality indicator.

The number below the signal name is the percentage of noise in that band. Numbers above 30% hint possible spoofing in that band. In case of jamming the original signal and adding a spoofed signal, this percentage may raise to even 200%.

"Auto Setup Engine" button selects signals for each engine automatically according to the strategy option selected by user.

For selection strategy, hold the "Auto Setup Engine" which leads you to the following screen.

"Maximum Signal" box allows you to limit the number of signals used for each engine. Numbers above 60 limits RTK solutions to one per second. Numbers below 30 allows 5 Hz RTK.

The "No Same Frequency" check box selects only one of the GPS and GLONASS signals in the same band as explained earlier.

Click "Strategy" button to select the strategy for automatic signal selections for each engine.

You can long click on each engine and select signals for that engine manually.

In "System based" strategy, for the first engine all GPS signals are used (subject to the check box and Maximum Signal parameters) and then complemented with the best other signals up to the "Maximum Signal" limit. The other three engines are similarly selected by giving preference to GLONASS, Galileo and BeiDou, respectively

In "All the Best" strategy, the best signals among all systems are selected and identical signals are given to the four engines (subject to the Maximum Signal number and the No Same Frequency Check box).

No signal type will be selected unless at least four satellites transmit that signal.

Each engine can accept maximum of 8 signal type. And each signal type can have maximum of 10 signals.

Clicking the "Reset Engines" button, resets all engines.

You can switch between "Convention Tracking" and Independent Tracking by clicking on this button. Conventional tracking users information from the L1 band to help other bands.

The number of the bottom right of the Figure 3 is the number of lost data from the base since the last reset. Long click to reset it to zero.

New feature

There are three types or RTK engines:

1) 6 engine GPS + GLONASS;

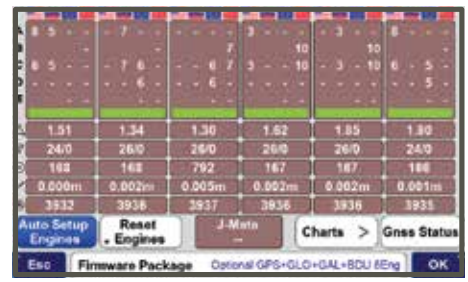
2) 6-engine multi constellation, and

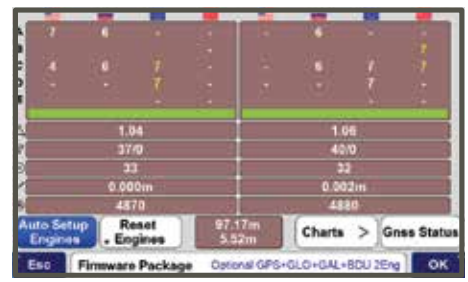
3) 2-engine multi constellation.

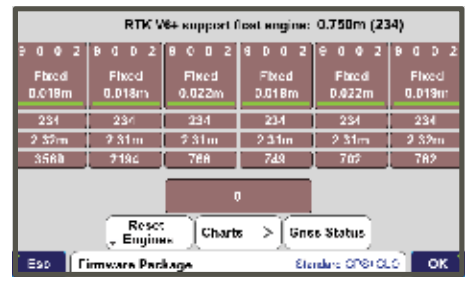
The engine selection button is on the bottom of the "engine view" screens. Changing the engine type takes about one minute for the TRIUMPH-LS to reboot.

"Auto Setup Engines" button selects signals for each engine automatically. You can click and hold on each engine to assign signals manually. The number assigned to each signal is the "Figure of Merit" of that signal according to the number and strength. "0" is perfect. "10" is very bad.

"GDOP" of used satellites are shown below each engine. "GNSS Status" button shows the Figure of Merit number for each signal. Click on any signal number to get details. The lower the number, the better the signal.







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 or 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

Who Moved My Base?

Real story by Shawn Billings

I was surveying in a rural neighborhood with lots of trees near a Corps of Engineers lake. There were not many base locations nearby, so I had to find a place about a mile by road (or 3500' straight-line) from my site to set up the base. The choices were few, but I found a place that was clear near the side of a public road about 600-700 feet from a house. I set up and started my job. All was going well and I had about 30 minutes - an hour left before I would be finished with the job. It was promising to be a productive day! Then my LS reported that my base had moved!!! I ran for my truck and quickly navigated the windy roads back to where I set it up. Adrenaline was pumping as I considered that my base was likely stolen. I showed up, semi-relieved, to see a woman standing by her car, arms folded near where my base once stood. I immediately figured this was the property owner where I put my base and she wasn't happy with my trespass. She gave me a good verbal lashing. I simply wanted my base back so I sheepishly agreed that I was in the wrong for putting my threatening equipment on her property a five feet or so from the top bank of the road ditch. About thirty feet away, they had some old culvert pipes stockpiled. There, the owner had stuffed my still-running Triumph-2 on the tribrach and tripod into one of the culverts. The HPT435BT, also still running, was plugged into my large deep-cycle battery which was placed behind the culverts. I still don't know how she didn't damage any of it by moving it from the setup and shoving it into the 12" pipe. She took my picture as I loaded up my truck and I waived affably offering to give her a business card so she'd know who I was. She replied with a few more expletives and I was on my way. I ended up completing the job with my total station (the first time I've used it in many months). But I was extremely thankful for the base guard feature that immediately warned me of trouble at my base and even more thankful that I was able to recover it and that it is still in good working order.

To take advantage of the base guard feature, make sure that your Javad base receiver is calibrated. You can do this by connecting to the base in base/rover setup and then going to the calibrate screens in J-Field. Calibrations made while the base is connected will calibrate the base instead of the LS. Once done, be sure the base guard feature is checked on.

Long-range single baseline RTK GNSS positioning

An alternative solution for land cadastral mapping in Indonesia

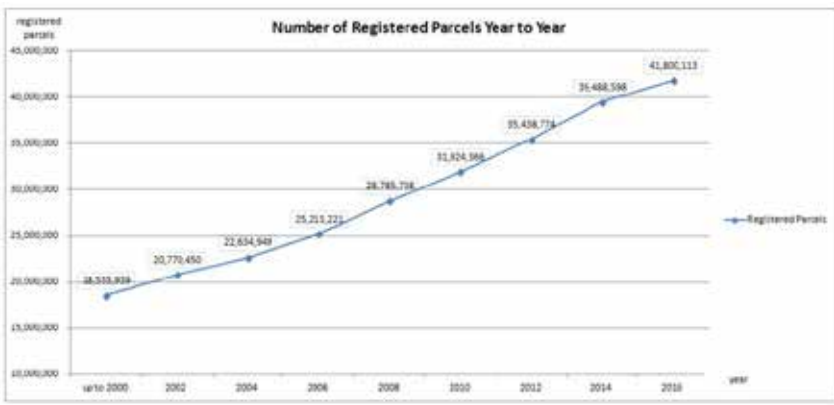
Brian Bramanto
Ph.D. Fellow, Faculty of Science and Technology, Norwegian University of Life Sciences, Norway
Research Fellow, Geodesy Research Group, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Indonesia

Irwan Gumilar
Head of Surveying and Mapping Laboratory, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Indonesia
Lecturer and Researcher, Geodesy Research Group, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Indonesia

Land registration and the challenge in Indonesia

Land registration describes, generally, a system concerning ownership and other rights of the land. As a legal matter, it also attached the legal documents to provide evidence of ownership, facilitate transactions, and protect the ownership of the land from fraud. Land registration and cadaster in Indonesia are authorized by the National Land Agency (BPN). Various schemes of systematic land registration have been initiated since 1960 using various methods of systematic land registrations, e.g., National Land Registration Project (Proyek Operasi Agraria Nasional-PRONA) and Land Administration Project (Proyek Administrasi Pertanahan) [1].

The significant number of unregistered parcels indicates that a more reliable and accurate method should be proposed to speed up the registration process. Up to the year 2016, no less than 41 million parcels have been registered in Indonesia (see Figure 1). However, these numbers



	up to 2000	2002	2004	2006	2008	2010	2012	2014	2016
Number of registered parcels per year	18,535,939	2,234,511	1,864,499	2,578,272	3,572,517	3,138,630	3,514,406	4,049,824	2,311,515
Total	18,535,939	20,770,450	22,634,949	25,213,221	28,785,738	31,924,368	35,438,774	39,488,598	41,800,113

Source: Aplikasi KKP Web per 17/1/2017

Figure 1 Number of registered land parcels until year of 2016 [1]

hold 187 of BIG' CORS GNSS and more than 70 of BPN' CORS GNSS. The Sweden National CORS GNSS, for example, demonstrated an excelent applicability of broad applications, especially the RTK (Real-Time Kinematic) service [3]. The TUSAGA-Aktif, a CORS GNSS network in Turkey, is also used massively to increase the number of registered parcels [4].

GNSS measurement is not coming without flaw. Aside from orbit and clock biases, the accuracy of relative GNSS positioning depends on the atmospheric bias. The atmospheric bias is worsening the GNSS accuracy with a greater baseline, especially in the vertical component. Atmospheric bias may reduce the accuracy of the vertical component up to several decimeters in RTK GNSS positioning [5]. To take the advantage of the CORS GNSS network, the positioning of NRTK (Network Real-Time Kinematic) method can be used. Utilizing at least three CORS GNSS, NRTK modeled an error surface in an area constrained by these three CORS GNSS. As the rover moves away from the reference station, a huge bias will occur. The errors interpolated from the error surface can minimize the bias significantly.

Although it seems promising to use the CORS GNSS and NRTK positioning method, , The implementation may face several technical challenges that need to be taken into consideration. In addition, several challenges need to be considered in using these methods such as financial sharing agreement and human resource management. The relatively dense network of CORS GNSS is only available for two main islands in Indonesia, namely Java and Sumatra

(see Figure 2 and Figure 3). The CORS GNSS sites in other main islands are separated from each other with a greater distance, which makes it untuitable for NRTK method. Establishing a temporary tie point near the survey area will also not be a great solution considering the time and financial efficiency.

We need a simple yet reliable alternative solution to overcome the sparely distribution of CORS GNSS. Fortunately, a modified LAMBDA method [8] ensures the improvement of reliability of long-range single baseline RTK. This method uses an extended functional model to implement the atmospheric bias correction and a precise orbit correction from the WADGPS (Wide Area Differential GPS) system. It also involves an optimal detection and estimation of cycle slips and code outlies in its modified Kalman filter. Lastly, partial search and fix method is embedded in the Kalman filter. Here, we evaluate the performance of the modified LAMBDA method [8] for a long-range single baseline RTK positioning method in Indonesia.

Figure 2 Distribution of recent CORS GNSS sites operating by BIG [6].

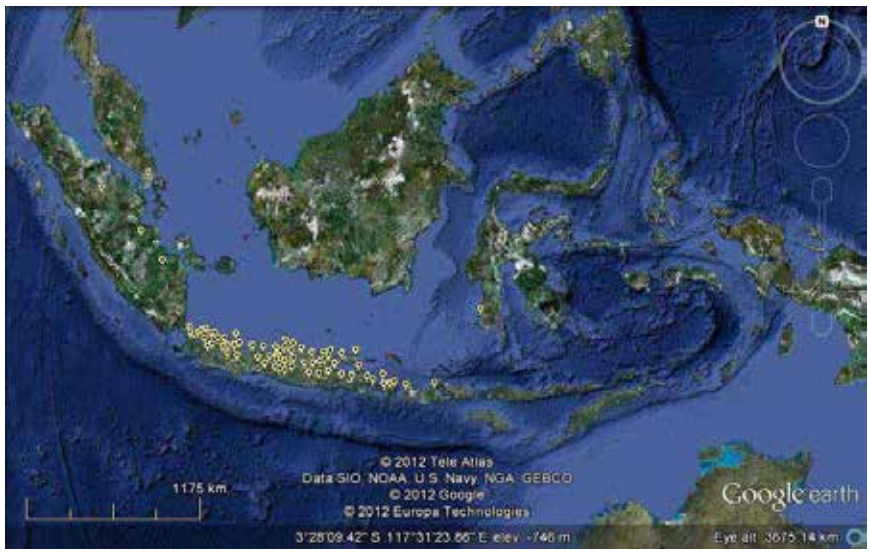


Figure 3 Distribution of CORS GNSS sites operating by BPN [7].

Figure 4 The location of base (red triangle) and simulation area (yellow dot) in the left panel and the measured points of the benchmark (yellow triangles) and land parcel (green dots) in the right panel..

Experimental setup

We established a simulated cadastral area in Pamengpeuk, Indonesia, in which is 85 kilometers away from the base station at Bandung, Indonesia. The simulated area has a vast elevation difference of 800 meters with the base station located since both areas has a contrasting geographical landscape. (Figure 4). With this setup, we expected there would be a significant atmospheric and orbit errors in the observation data. Our simulated area consisted of three land parcels and eight benchmarks.

Three aspects are being evaluated in this works, namely, position accuracy, repeatability, and area. The accuracy is evaluated by referring the estimated positions to the reference value as follows: (i) a differential static method is used as reference coordinates for benchmark points, and (ii) for land parcel points, relatively short baseline RTK method is used instead. The short baseline reduces the atmospheric bias significantly. In addition, our points are located in an open-sky condition area, which makes it an ideal condition to measure a point. Next, a bunch of coordinates can be used to assess repeatability as indicated by the precision. Finally, we calculate the area and evaluate the difference compared to the reference area. The comparison method can be used to estimate the reference area if there is no official area reported by the authority.

General concept

Observation data in RTK

The observational model for both code P and carrier phase ϕ are defined in Eq. 1 and 2. They includes the true geometric range ρ and compensates with several bias in signal propagation, namely satellite orbital error d_{orb}, tropospheric error d_{trop}, ionospheric error d_{ion}, both of satellite and receiver clock error dT, multipath M, and also noise ε. An additional error in carrier phase observation also occurred, namely carrier phase ambiguity. This is a term of error caused by the unknown true initial cycle count and defined as the multiplication of the number of cycles and the wavelength λ.

$$P = \rho + d_{orb} + d_{trop} + d_{ion} + (dt - dT) + M + \varepsilon \quad (1)$$

$$\phi = \rho + d_{orb} + d_{trop} - d_{ion} + (dt - dT) + \lambda N + M + \varepsilon \quad (2)$$

The double difference is then performed to eliminate orbital, clock, and atmospheric error in a shorter baseline. After that, three baseline components and ambiguities can be estimated by performing a least square adjustment on a linearized double difference observation. Meanwhile, for a more extended baseline, additional real-time precise satellite ephemeris (e.g., StarFire™) shall be used to remedy the orbital error. Additional unknown parameters, such as residual tropospheric and ionospheric bias, they were also estimated in the least square adjustment. Further estimation of parameter, i.e. the ambiguity resolution, can be seen at [8].

Kalman Filter principle

Kalman filter is commonly applied for navigation application. Kalman filter uses a time series observation instead of a single observation estimator. Statistically, Kalman filter able to predict parameters more accurately than other straight-forward estimator method since it assumes that the parameters also vary in time [9]. The dynamic model on the Kalman filter is represented as follows:

$$X_{k+1} = \Phi_k X_k + w_k \quad (3)$$

which then continued along with the measurement model :

$$L_k = A_k X_k + v_k \quad (4)$$

where X is the estimated parameter, Φ is the transition matrix, and A is the design matrix. Both noises from the dynamic model and observation data are symbolized by w and v. The subscript k represents the time stamp.

Kalman filler also implements recursive least square adjustment in which can be further divided into two main parts, observation and dynamic model. The observation model can be defined as:

$$K_k = C_k^- A_K^- (A_k C_k^- A + R_k)^{-1} \quad (5)$$

$$X_k = X_k^- + K_k (L_k - A_k X_k^-) \quad (6)$$

$$C_k = (I - K_k A_k) C_k^- \quad (7)$$

While the dynamic model is expressed as:

$$X_{k+1}^- = \Phi_k X_k \quad (8)$$

$$C_{k+1}^- = \Phi_k C_k \Phi_k^T + Q_k \quad (9)$$

where K is the gain matrix, C is the covariance matrix observation model, and I is the identity matrix. The covariance matrix for the dynamic model and the weighting matrix are indicated as Q and R. The superscript $^-$ indicates the prediction from the previous epoch.

Results and discussions

Here, we only assess the resolve ambiguity data in our investigation to ensure the highest accuracy. This produced more than 1840 epochs for analysis. A total of 23 point observations were obtained, and no less than 80 epochs for each point were used for the analysis.

Figure 5 displays the coordinates difference between benchmark and land parcel points and the reference coordinates. The overall accuracy for benchmark points is 3-4 cm, with one point with a slightly worse accuracy. Compared to its reference, the point shifted by nearly 10 cm to south direction. This value, however, is still tolerable considering the nature of RTK method. One possible cause to this discrepancy is the incorrectly-fixed ambiguities. [10] reported that incorrectly-fix ambiguities can lead to shift the position up to 0.1 m.

On the other hand, we obtained 10 to 15 cm of accuracy for the land parcel points. We expected that we would get a higher level of accuracy, similar to the benchmark points. We suspected that there was a systematic error occurred during the observation. Therefore, we also measured the benchmark points using a short baseline RTK method and compare the result with the long baseline RTK measurement. The comparison can be seen in Figure 6 with the circles indicate the method used. The blue circle marks the accuracy of long-range RTK, while the red circle shows the accuracy of short-range RTK. Compared to the coordinates from the static differential measurement, the coordinates from short-range RTK shifted about 10 cm to east direction and 5 cm to south direction. This difference indicates there is a systematic error present in the short baseline RTK result. We believe that this error is due to the difference of coordinate system used in both methods. Any coordinate error on the base station could also affect the estimated points that tie on the base station. By applying this systematic error to the land parcel points, we also achieve a similar accuracy level as in benchmark points.

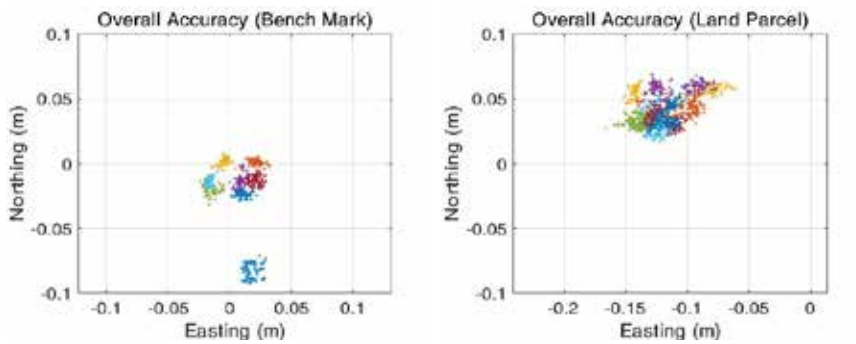


Figure 5 Accuracy of long-range single baseline GNSS RTK method for benchmark points (left panel) and land parcel points (right panel).

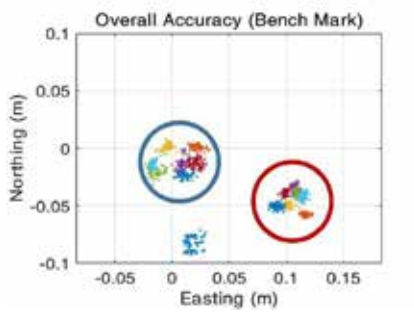


Figure 6 Accuracy of long-range single baseline GNSS RTK method (blue circle) and plotted together with the accuracy of short-range single baseline GNSS RTK method (red circle).

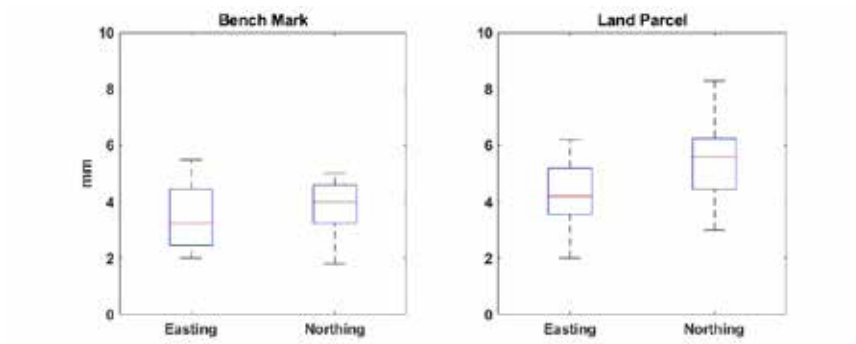


Figure 7 The box plot of precision. The box plot is representing the median (red line), maximum or minimum (uppermost and lowermost lines), and 1st and 4th quartile (blue bonding box) of the data.

Table 1 The reference area and the observed area for each land parcel.

ID	Reference area (m^2)	Observed area (m^2)	Difference in area (m^2)	Percentage
1	2490.971	2490.106	0.865	0.03
2	66,787.538	63,779.212	8.326	0.01
3	2,111.457	2,111.148	0.309	0.01

Figure 8 Land parcels used for the area calculation.

Figure 9 Internet coverage for one of the telecommunication providers in Indonesia [11]

GNSS measurement is not coming without flaw. Aside from orbit and clock biases, the accuracy of relative GNSS positioning depends on the atmospheric bias. The atmospheric bias is worsening the GNSS accuracy with a greater baseline, especially in the vertical component

The precision from timeseries data were also assessed in this investigation. Figure 7 shows the box plot of precision in easting and northing component for both benchmark and land parcel points. The median precision is ranging from 3 to 6 mm. The worst precision value is about 8 mm, while the best precision is about 2 mm. Most of the timeseries coordinates met the 2-sigma of confidence level in all the observation points. This indicates a good reliability of this method.

We have demonstrated the potential use of a long-range single baseline GNSS RTK method in the land cadastral application. The difference of the result compared to the 'true' value is within centimeters level with the precision level of several millimeters

We also calculate the area formed by coordinates from the long-range single baseline GNSS RTK method and comparing them with the reference value. In summary, there is no significant difference between observed area and the reference area. The difference is less than 0.05% as shown in Table 1. We could not find any legal document in Indonesia that stated permissible tolerance for the difference in area. Although only a limited number of land parcels are utilized in this work, the results are promising.

Final remarks

We have demonstrated the potential use of a long-range single baseline GNSS RTK method in the land cadastral application. The difference of the result compared to the 'true' value is within centimeters level with the precision level of several millimeters. The calculated land parcel areas differ by less than 0.03% from the reference value. Considering these results, we believe that long-range single baseline GNSS RTK method could be one of the solutions to increase the efficiency of land registration in Indonesia.

GNSS relies heavily on communication. Thus, infrastructure and telecommunication also need to be considered. The authority agencies, BIG and BPN, should keep up the excellent work in maintaining and operating all CORS GNSS stations

It should be noted that GNSS method is not a best solution in all conditions. In this work, we setup and ideal condition that is suitable for GNSS positioning. However, some considerations are needed if this method were to be used in an urban setting or in an obstructed area. A conventional terrestrial method, e.g. by using a total station might be more suitable. However, using this method might leads to a new problem in the future, e.g., the issue of overlapping land claims if there are no nearby tie points available. For this reason and recalling the One Map Policy declared by President of Indonesia, Joko Widodo, we are still in need for the GNSS positioning method. A combination of the long-range single baseline GNSS RTK method with the conventional terrestrial traverse method will be a better alternative for parcel measurement.

GNSS relies heavily on communication. Thus, infrastructure and telecommunication also need to be considered. The authority agencies, BIG and BPN, should keep up the excellent work in maintaining and operating all CORS GNSS stations. This includes providing steady power supply, keeping the hardware maintained, updating the software, and also arranging human resources to maintain the continuous operation of the CORS GNSS system. Telecommunication is not only needed for the CORS GNSS site but also for the user (GNSS rover). Most of the GNSS rover relies on the cellular network to obtain corrections. Similar to the density of the CORS GNSS location, only Java and Sumatra that have full coverage of internet service (refer to Figure 9).

Nevertheless, the use of the GNSS positioning method is needed for the land cadastral application, especially in keeping with the government wish to establish a single reference of the cadastral map throughout Indonesia to solve the overlaid boundary issue. Considering the current condition in Indonesia and referring to our results, we believe that the presented method is a promising solution to get a full potential of GNSS observation.

Acknowledgement

We acknowledge to PT General Technology Indonesia (GETINDO) for providing all the GNSS receivers used during this work. We also thank students for helping the data acquisition during this work. Several colleagues have helped with suggestions to improve the quality of this article.

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Covid-19 Lockdown 1.0 and Air Pollution in north-western India using Sentinel 5P

The paper analyses air quality through three parameters namely aerosol (AER), which is broadly referred as dust & smoke, nitrogen dioxide (NO_2) and carbon monoxide (CO) retrieved from Sentinel 5P satellite mission during first week imposition of Covid-19 Covid-19 Lockdown 1.0 by comparing multiple time-series satellite data of 2019 & 2020 and supplemented by ground measurements.

Shashi Shekhar
Scientific Officer
Himachal Pradesh State Pollution Control Board, Shimla, India

The paper explores to analyse the spatio-temporal pattern of air pollution during Covid-19 Lockdown 1.0, which witnessed high decline in pollutants such as particulate matter, NO_2, Carbon Monoxide (CO) in north-western states of India. The region had attracted global attention including the Supreme Court of India and Hon'ble Prime Minister of India apart from others during last winter of 2019, when air quality was considered to be above hazardous level. The nation-wide "Janta Curfew" followed by 21-day lockdown to combat the coronavirus outbreak in the country led to travel restrictions and closure of industries & construction activities, which showed improvement in air quality throughout the region. An attempt has been made to assess the decline in air pollutant through the time series data of Sentinel-5 Precursor satellite – also known as Sentinel-5P, which is the first Copernicus mission dedicated to monitoring our atmosphere. The satellite carries the *Tropomi* instrument (TROPOspheric Monitoring Instrument) to map a multitude of trace gases such as nitrogen dioxide, ozone, formaldehyde, sulphur dioxide, methane, carbon monoxide and aerosols – all of which affect the air we breathe and therefore our health, and our climate. The paper analyses air quality through three parameters namely aerosol (AER), which is broadly referred as dust & smoke, nitrogen dioxide (NO_2) and carbon monoxide (CO) obtained from Sentinel 5P satellite mission during Lockdown 1.0. Further two reference data of last year 2019 was also taken into analysis.

Background

India imposed a nationwide lockdown on 22nd March 2020 to stop the spread of the coronavirus Covid-19. But this lockdown seems to provide temporary relief in another pressing health issue i.e. air pollution. During the world's largest lockdown, public transport, which is considered to be the main source of air pollution in most of the Indian cities, all factories, market, shops and construction works remain suspended since 22nd March 2020. During the last year, according to World Air Quality Report, 21 of the world's 30 cities with worst air pollution were in India. Ghaziabad, a satellite city located in the national capital region (NCR) in north-western Uttar Pradesh state, was ranked as the world's most polluted city. In view of above, it was decided to analyse the atmospheric concentration of air pollutants such as particulate matter (PM) in the form of **Absorbing Aerosol Index (AAI), nitrogen dioxide (NO_2)** and **Carbon monoxide (CO)** retrieved from Sentinel 5p satellite mission.

Measurements from the European Space Agency's (ESA) Sentinel 5P satellite show that during Indian Lockdown 1.0, concentration of aerosol and nitrogen dioxide over north-western India has declined significantly

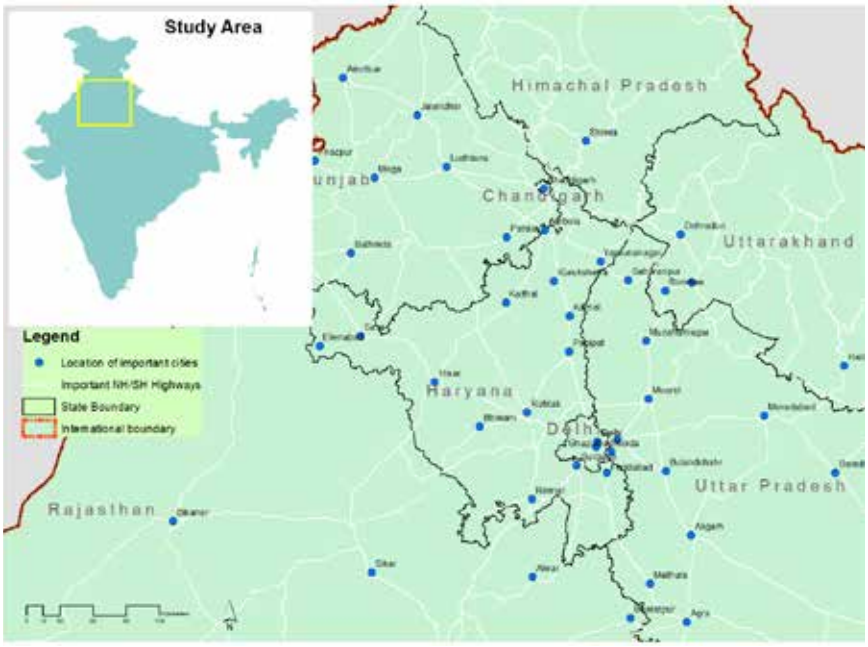

Figure-1: Baseline layers

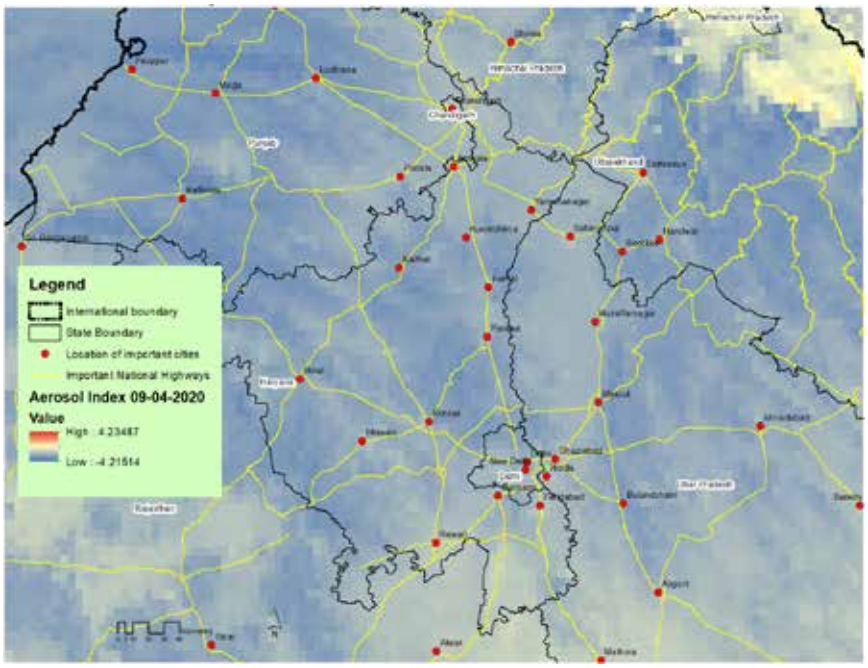

Figure-2: Two weeks after beginning of Lockdown 1.0: Aerosol Index using the 340/380 wavelength pair from spectra observed on 2020-04-09.

Recent Sentinel 5P data have shown a decline in air pollution over north-western India coinciding with its nationwide Lockdown 1.0 to prevent the spread of the coronavirus (COVID-19) during the last week of March 2020. This led to the dramatic reduction in the concentration of particulate matter and other trace gases such as nitrogen dioxide & carbon monoxide. As per the study by Central Pollution Control Board (CPCB) released on the impact of "Janta Curfew", out of 91 cities as many as 30 cities recorded 'good' air quality while 61 cities recorded 'satisfactory' air quality. Moreover the number of cities recording poor to severe air pollution also came down from 9 (March 21) to 0 (March 29), which were unprecedented.

This is worthwhile to note that during November 2019, a public health emergency was declared after the air quality index (AQI) level exceeded 800 in certain parts of New Delhi, which was more than three times the "hazardous" level. Experts say that reduced fossil fuel emission due to transport sector and slowdown in other emissions-related activity has contributed in reduction in air pollutants during lockdown 1.0.

Delhi, parts of western Uttar Pradesh, Haryana, Punjab have traditionally been hot-spots of high concentration of particulate matters and smoke. This was mainly due to emission from transport sector and burning of crop residues in neighbouring areas.

The study area and methodology

The study area of north-western India is loosely comprised parts of India consisting of Punjab, Haryana, Delhi, parts of Rajasthan, Uttrakhand, south-western parts of Himachal Pradesh and western Uttar Pradesh. This part loosely constitutes main lands of National Capital Region (NCR) and beyond.

Multi time-series Sentinel 5P Satellite data (dated 31st October 2019, 20th March

2020, 28th March 2020 & 2019 and 31st March 2020) were processed from https://s5phub.copernicus.eu. Further these data were rectified and analysed in panoply and SNAP desktop softwares. In addition other requisite vector data were obtained from other secondary sources.

The satellite & sensor – Sentinel-5 Precursor and TROPOMI

The Sentinel-5 Precursor – also known as Sentinel-5P – is the first Copernicus mission dedicated to monitoring our atmosphere. The satellite carries the Tropomi instrument to map a multitude of trace gases such as nitrogen dioxide, ozone, formaldehyde, sulphur dioxide, methane, carbon monoxide and aerosols.

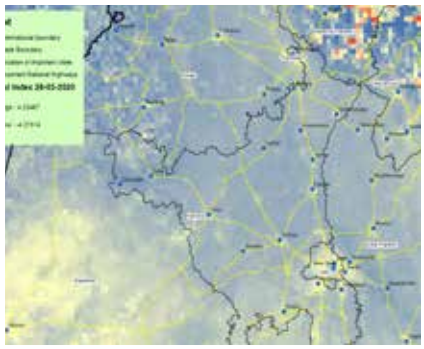

Figure-3: One week after lockdown 1.0: Aerosol Index using the 340/380 wavelength pair from spectra observed on 2020-03-28.

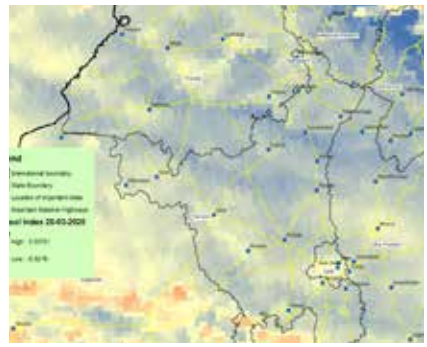

Figure-4: Beginning of lockdown 1.0: Aerosol Index using the 340/380 wavelength pair from spectra observed on 2020-03-20.

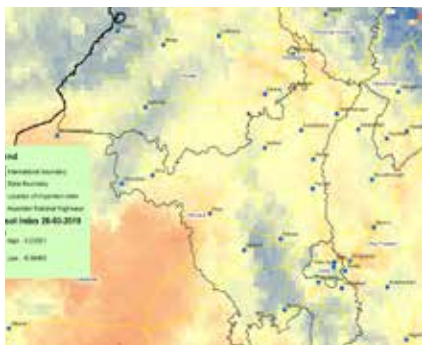

Figure-5: Same day last year: Aerosol Index using the 340/380 wavelength pair from spectra observed on 2019-03-28.

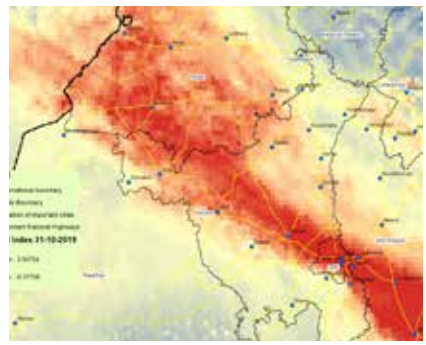

Figure-6: Three days after Diwali 2019: Aerosol Index using the 340/380 wavelength pair from spectra observed on 2019-10-31.

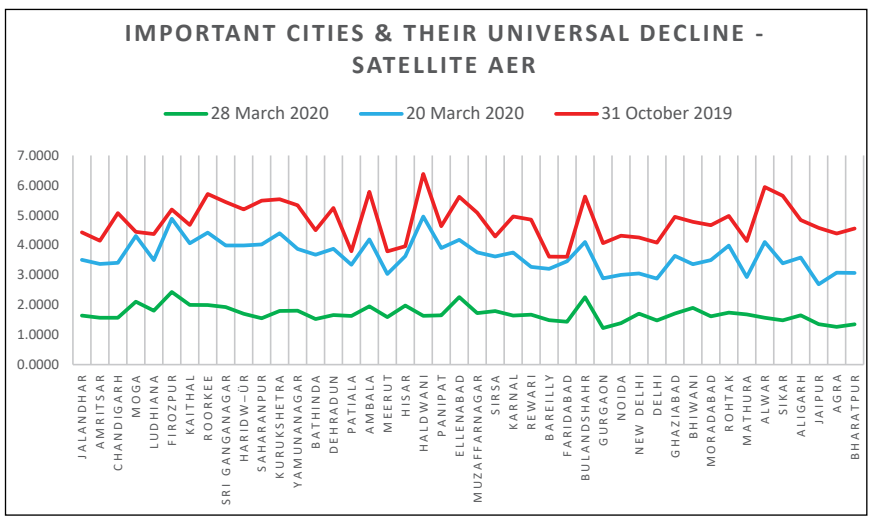

Figure-7: Temporal AER trend across 44 cities estimated from Sentinel 2020

The Sentinel-5 Precursor (S5p) mission is a low Earth orbit polar satellite system to provide information and services on air quality, climate and the ozone layer. The S5p mission is part of the Global Monitoring of the Environment and Security (GMES/COPERNICUS) space component programme. The S5p mission consists of a satellite bus, the payload consisting of the TROPOspheric Monitoring Instrument (TROPOMI), and a ground system. TROPOMI is a nadir viewing shortwave spectrometer that measures in the UV-visible wavelength range (270 – 500 nm), the near infrared (710 – 770 nm) and the shortwave infrared (2314 – 2382 nm). The instrument uses passive remote sensing techniques to attain its objective by measuring at the top of the atmosphere the solar radiation reflected by and radiated from the Earth. The instrument images a strip of the Earth on a two dimensional detector for a period of approximately 1 second during which the satellite moves by about 7-km. This strip has dimensions of approximately 2600km in the direction across the track of the satellite and 7km in the along-track direction.

TROPOMI is intended to make daily global observations of key atmospheric constituents, including ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, methane, and formaldehyde as well as cloud and aerosol properties. On 13th October 2017, the Copernicus Sentinel 5 Precursor (S5P), the first of the European Sentinel satellites dedicated to monitoring of atmospheric composition, was launched.

The mission objectives of S5P are to globally monitor air quality, climate and the ozone layer in the time period between 2017 and 2023. The first 6 months of the mission were used for special observations to commission the satellite and the ground processing systems; the operational phase started in April of 2018.

Results and discussion

Particulate matter through UV Aerosol Index Product

The Aerosol Index described is called the UVAI since it is based on spectral contrast in the ultraviolet (UV) spectral range for a given wavelength pair, where the difference between observed and modelled reflectance results in a residual value. **When this residual is positive it indicates the presence of UV-absorbing aerosols, like dust and smoke (from both biomass burning and volcanic sources), and is often referred to as the Absorbing Aerosol Index (AAI).**

The relatively simple calculation of the Aerosol Index is based on wavelength dependent changes in Rayleigh scattering in the UV spectral range where ozone absorption is very small, i.e. wavelengths longer than about 340 nm. For a given wavelength pair a ratio is calculated from measured top of the atmosphere (TOA) reflectance and pre-calculated theoretical reflectance for a Rayleigh scattering-only atmosphere and results in a residual value. Positive values of this residual indicate the presence of UV-absorbing aerosol.

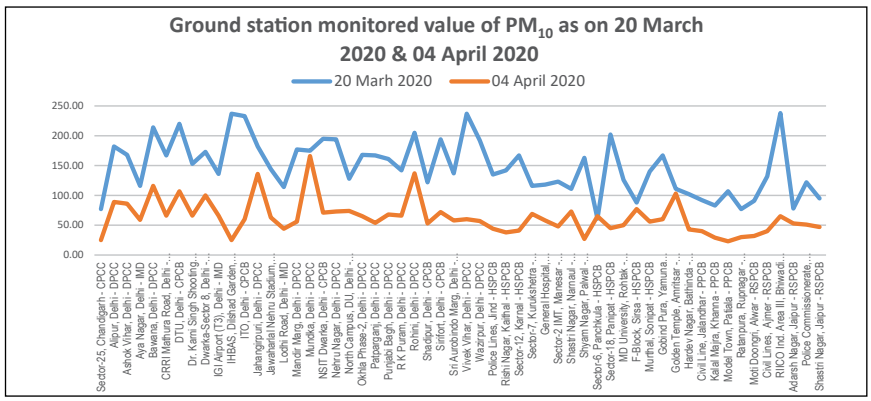

Figure – 8: Ground monitored value of PM10 as on 20 March 2020 & 04 April 2020 (Source: https://app.cpcbccr.com/AQI_India/# Conc in ug/m$_3$)

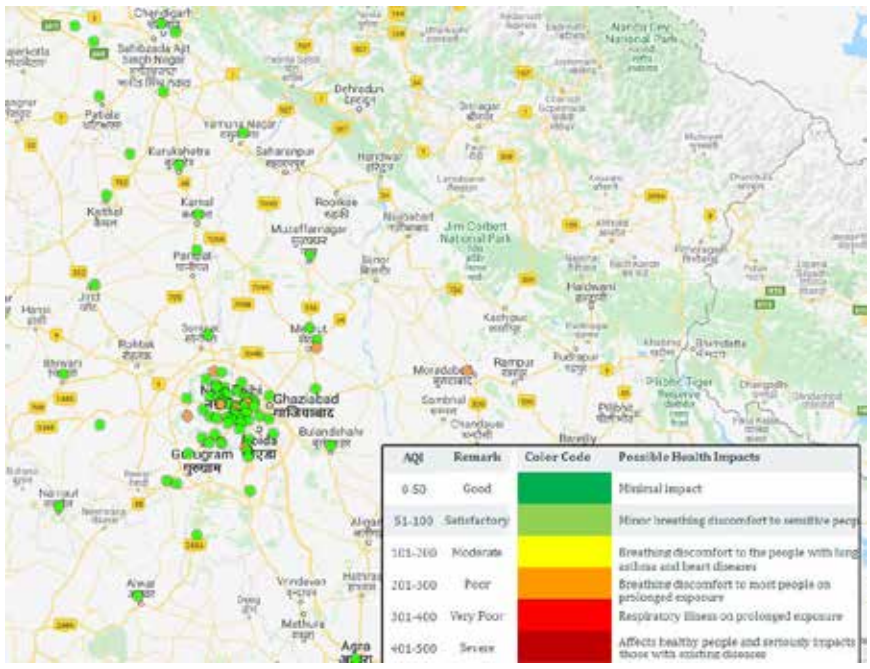

Figure –9: Increasing green dots – Air Quality Index obtained from CPCB operated web-portal as on 4th April 2020 (Source: https://app.cpcbccr.com/AQI_India/)

Spatio-temporal analysis of sentinel 5p satellite data indicate that there are visible improvement in air quality in the study area. It is obvious that there is perceived decline in the concentration of aerosol during the first week of COVID-19 lockdown (Refer Figure-2 &3). It is visible that area having yellow-white patches over cities indicate the presence of dust and smoke, which seem to be absent in the image dated 28th March 2020.

Further it is observed from the Figure -5, that on the same date of 28th March during 2019, there was higher concentration of particulate matter over the region. Further during October 2019, there observed to be much higher concentration of particulate matter as is evident from Figure-6. The high concentration of AER image is due to the fact that Diwali festival was held on 27th October 2019.

Spatio-temporal change vis-à-vis important towns in the region

A total of 44 cities were plotted in Figure -7 depicting aerosol index values of respective images of sentinel 5p of different time period as on 31st March 2020, 20th March 2020 and 31st October 2019 were were manipulated against a simple positive Y axis to visualise the changes.

The figure -8, which plots the two time series ground monitored values of 20th March 2020 & 04th April 2020 retrieved from the Central Pollution Control Board (CPCB) and respective State Pollution Control Boards/Committees (SPCBs) ground monitored result on CPCB operated web-portal also supplement the trend highlighted from the three time-series satellite imageries.

Air quality index map as per Figure-9 also indicates the presence of good air quality as on 04th April 2020 all across the region. Figure-10 demonstrates the general decline of PM10 concentration in most of the monitoring locations in Delhi.

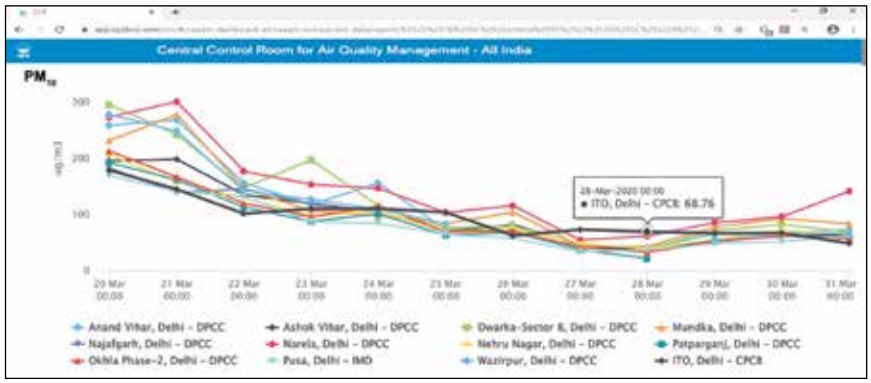

Figure – 10: General decline in PM10 concentration in most of ground monitoring stations at Delhi on 20th March 2020 and 31st March 2020 derived from CPCB webportal (Source:https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/caaqm-comparison-data)

Figure-11: At the end of Lockdown 1.0 – Tropospheric NO_2 concentrations in mol/m² as on 2020-04-14

Figure-12: One week after lockdown - Tropospheric NO_2 concentrations in mol/m² as on 2020-03-30

Figure-13: Beginning of lockdown - Tropospheric NO_2 concentrations in mol/m² as on 2020-03-20

Figure-14: Three days after Diwali 2019 - Tropospheric NO_2 concentrations in mol/m² as on 2019-10-31

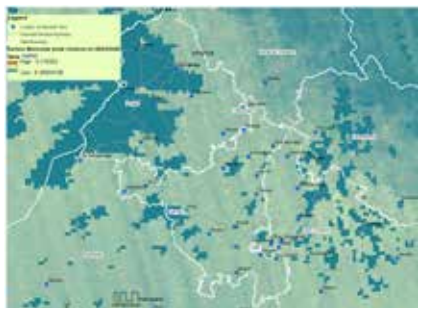

Figure-15: Two weeks after lockdown - CO concentrations in mol/m² as on 2020-04-09

Figure-16: One week after lockdown - CO concentrations in mol/m² as on 2020-03-31

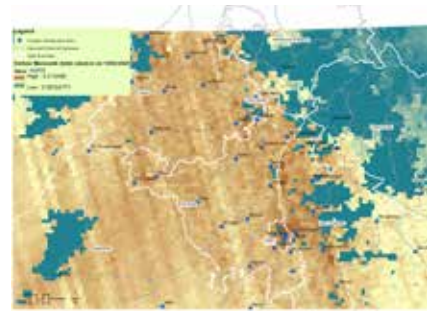

Figure-17: Before lockdown - CO concentrations in mol/m² as on 2020-03-13

The Nitrogen Dioxide (NO_2) concentration

TROPOMI NO_2 data product gives trace gas concentrations in mol/m². As nitrogen dioxide is primarily produced by road traffic, power plants, other factories and fossil fuel or biomass burning processes. It is a first-level indicator of industrial activity worldwide.

What is clearly visible is a significant reduction of nitrogen dioxide levels over north-western India, caused by reduced activity due to COVID-19 restrictions. NO_2 has a short lifetime so that concentrations are larger over land than in the cleaner air over the oceans.

The largest concentrations are found over industrial and urban regions. We can certainly attribute a part of the nitrogen dioxide concentration reduction to the impact of the coronavirus lockdown.

From above images, it emerges that NO_2 level is observed to be universally low across region one week after the coronavirus lockdown and there is no spatial city-specific concentration pattern related to anthropogenic activities around the region. However there is a perceived decline in concentration of nitrogen dioxide especially in and around Delhi. The image dated 31st October 2019 reveals a completely different picture as NO_2 concentration is observed to be slightly high in parts of Delhi, western UP, Haryana and Punjab.

The recent improvements in air quality could be made permanent by replacing fossil fuel generation with renewal energy and other low carbon sources. The ensuing lockdowns have shown the improvements to air quality that are possible when emissions are reduced on a regional/global scale

Carbon monoxide (CO) concentration

Carbon monoxide (CO) has natural and anthropogenic sources. It is emitted from soils, plants and the ocean, but its main sources are incomplete fossil fuel and biomass burning. It is also produced by oxidation of CH_4 and other hydrocarbons. The highest CO concentrations are found some parts areas of western Uttar Pradesh, Haryana and Punjab (Refer Figure-17). CO has a lifetime of several weeks and can serve as a tracer for regional and inter-continental transport of polluted air. However the CO concentration seem to demonstrate reduction in concentration in most of Punjab, Haryana and other areas as well as are evident in Figure-15 & 16.

Conclusion

Measurements from the European Space Agency's (ESA) Sentinel 5P satellite show that during Indian Lockdown 1.0, concentration of aerosol and nitrogen dioxide over north-western India has declined significantly. As new cases of Covid-19 coronavirus rose to 11,154 at the end of Lockdown 1.0, air pollution plummeted to the satisfactory level across region.

The improvement in air quality of the study area has been established across all cities in terms of AER, NO_2 and CO parameters of sentinel 5p. The area has a number of cities in the region where most of the vehicles remained off road and non-essential industrial units closed during nation-wide lockdown. Most of the these cities, which have high population density and substantial share of emissions from transport sector, showed significant improvement in air quality values with levels moving from higher to lower end of category of Air Quality Index, which is amply supported by ground monitored values of Central & State Pollution Control Boards.

The recent improvements in air quality could be made permanent by replacing fossil fuel generation with renewal energy and other low carbon sources. The ensuing lockdowns have shown the improvements to air quality that are possible when emissions are reduced on a regional/global scale.

(Note: View expressed in the paper is independent of institutional affiliation of the author.)

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Esri India continues support to the users amid COVID-19 spread

Esri India is geared up to provide remote technical support. The technical support engineers are operating from their homes but will be able to take calls on the toll-free number, respond to emails or web based technical support requests within its standard response times. As part of the global Disaster Response Program (DRP), Esri India is providing the ArcGIS Hub Coronavirus Response template at no cost through a complimentary six-month ArcGIS Online subscription with ArcGIS Hub.

Esri offers students free access to software

Esri will provide free access to its ArcGIS platform and learning resources through the Learn.ArcGIS.com website to support college and university students who no longer have access to campus computer labs during the COVID-19 outbreak.

Students will receive access to ArcGIS Online and over 20 apps including ArcGIS Pro, along with a library of lessons to continue their learning and complete courses. Access is available globally to students ages 18 and over.

PAR Government Systems introduces commercial version of GV3.0

PAR Government Systems ("PAR Government") has re-launched the popular GV3.0® raster imagery and full-motion video viewing package as a commercial product. The new release is an enhanced version of the GV3.0 geospatial visualization tool once available only to the U.S. Defense and Intelligence, and GEOINT community.

Originally developed by PAR Government as a government-off-the-shelf (GOTS) application, GV3.0 is used to view raster imagery and full-motion video typically captured by geospatial collection sensors aboard aircraft, drones and satellites. A stand-alone application, GV3.0 reads many data files common in the GIS and GEOINT communities, including the National Imagery Transmission Format (NITF)and NATO Secondary Imagery Format (NSIF). *https://gv30.net*

KOREC and NCTech launch KlearView360°

KOREC and NCTech have announced the launch of KlearView360°, a streamlined, hosted system designed for the identification of assets, defects or changes within images collected by vehicle or backpack. Developed as a cost-effective solution, KlearView360° makes vehicle-mounted asset inspection accessible to local authorities and many others.

The system is a joint partnership between the two companies, combining NCTech's iSTAR Pulsar+ high-resolution camera for capturing 360° imagery at carriageway speeds with KOREC's K-Portal cloud-based hosting solution for live progress monitoring of a project and the assignment of work orders.

WIU EAGIS Department and GIS Center create statewide COVID-19 dashboard

The Western Illinois University GIS Center, in cooperation with the Department of Earth, Atmospheric, and Geographic Information Sciences (EAGIS), have assembled a statewide web map to monitor the spread of COVID-19 (coronavirus) in Illinois.

Assembling the map began when Renée Büker, GIS Center specialist, created a map of cases in west central Illinois at the request of Fulton County Emergency Management Coordinator Chris Helle. Later, the Illinois GIS Association (ILGISA) requested the GIS Center construct a web map that could be posted on the organization's web site.

Christopher Sutton, EAGIS cartography and GIS professor, was brought in to consult with map visualization for the online Covid-19 map and WIU GIS Center Director and ILGISA President Chad Sperry built an online dashboard to accompany the map to summarize statewide totals.

The map highlights counties where cases have been reported and symbolizes the number of cases. By using a web environment, the map can be rapidly distributed and users can pan and zoom around the map to focus on particular areas of the map.

Plexscape's response to COVID-19 pandemic

In response to COVID-19 pandemic, Plexscape, developers of Plex.Earth®, one of the most popular AutoCAD tools for the acceleration of architectural, engineering and construction (AEC) projects, is doubling its customers' licenses at no extra cost, for the next 3 months.

This initiative aims to help thousands of Plex.Earth users in more than 120 countries worldwide to have a smooth transition to the new remote-work conditions by installing the software on their home computers or laptops, free of charge.

Descartes Labs unveils its advanced mineral exploration package

Descartes Labs, a New Mexico-based geospatial analytics company, has announced the availability of their Advanced Mineral Exploration Package, a specialized data platform and modeling workbench for exploration geology and data science teams to access remote sensing and machine learning capabilities globally. The Advanced Mineral Exploration Package lets clients integrate in-house data with the platform, giving them access to the most advanced artificial intelligence (AI) capabilities in the industry.

Descartes Labs provides the only platform that combines NASA's Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) global data set with the massive supercomputing resources required to fully leverage it for mineral deposit targeting. The Advanced Mineral Exploration Package provides comprehensive coverage for mineral mapping on a global scale, facilitating new discoveries and accelerating mineral exploration timelines. *DescartesLabs.com*

Ultra-Secure, Jam-Resistant GPS M-Code signal to operationalize soon

The final steps to fully-enable the ultra-secure, jam-resistant Military Code (M-Code) signal on the GPS are now underway.

As part of the U.S. military's effort to modernize GPS, the U.S. Space Force has been steadily upgrading its existing GPS Ground Operational Control System (OCS). The Space Force recently announced Operational Acceptance of the GPS Contingency Operations (COps) upgrade, developed by Lockheed Martin. COps enabled control of the operational GPS constellation, now containing 21 M-Code capable GPS satellites, including Lockheed Martin's first two GPS III satellites, until the next generation OCX ground control system is delivered.

The Space Force's M-Code Early Use (MCEU) upgrade, delivered earlier this year, will enable the OCS to task, upload and monitor M-Code within the GPS constellation, as well as support testing and fielding of modernized user equipment, prior to the completion of the next-generation ground control systems.

This Spring, work will begin to install the components needed to command and monitor the M-Code encrypted GPS signal, which enhances anti-jamming and protection from spoofing, as well as increases secure access for our forces, into the GPS OCS. M-Code signals are currently available on all the on-orbit GPS IIR-M, IIF and III space vehicles.

A key to enabling M-Code is a new software-defined receiver Lockheed Martin developed and is installing at all six Space Force monitoring sites. The M-Code Monitor Station Technology Capability (M-MSTIC) uses a commercial, off-the-shelf general purpose Graphics Processing Unit (GPU) to cost effectively receive and monitor M-Code signals. Operators can monitor the signal as needed. M-MSTIC complements MSTIC's, which Lockheed Martin developed and fielded to replace aging hardware receivers that were becoming difficult and expensive to maintain.

Cyber defenses across the upgraded GPS system were recently evaluated by a government assessment team and passed the Operational Utility Evaluation. Lockheed Martin delivered the Red Dragon Cybersecurity Suite (RDCSS) Phase III upgrade during the fourth quarter of 2019, dramatically improving Defensive Cyber Operations (DCO) visibility into GPS network traffic. Other add-ons include user behavior analytics to analyze patterns of traffic and network taps to improve data collections. *www.lockheedmartin.com*

GSA posts list of Covid 19-fighting GNSS Apps

The European GNSS Agency (GSA) has posted a list of location-GNSS-Galileo based applications that may be useful tools against diffusion of COVID-19.

The applications cover a range of uses from supporting public authorities to assisting citizens in their everyday life under social distancing, closures and quarantines. The GSA seeks more location-GNSS-Galileo App to the list;

Application Categories:

Tracking the COVID-19 Pandemic

Six applications draw on cell phone user location data in various ways, to track movements back to contacts with others if diagnosed with the disease, to govern quarantine requirements, and similar. Privacy advocates may find these invasive; many aspects of the crisis violate previous norms.

Queue management

Two applications: to set up virtual queueing systems for shops to help citizens respect social distancing; and to provide real-time crowd-sourced location data to check length of supermarket entry lines, to avoid creating crowds.

Response management

One application automatically notifies users, for example first responders, when entering a zone with an increased occurrence of infected persons, to alert them to don protective equipment.

Information dissemination

One application to help anyone feeling unwell evaluate their symptoms without ringing overburdened call centers. Administers a self-test and offers instructions and recommendations in accordance with the results. *gsa.europa.eu*

Belarus to start sharing GNSS data with European network

From March 1, the Belarusian state enterprise Belgeodeziya started uploading data to two GNSS data processing centers. Until now, Belarus has been the only European country without a EUREF Permanent GNSS Network (EPN) station.

The EPN consists of

- a network of continuously operating GNSS (GPS, GLONASS, Galileo, Beidou.) reference stations
- data centers providing access to the station dat,
- analysis centers that analyze the GNSS data
- product centers or coordinators that generate the EPN products
- a central bureau responsible for the daily monitoring and management of the EPN.

The EPN network is operated under the umbrella of the IAG (International Association of Geodesy) Regional Reference Frame sub-commission for Europe, EUREF.

Instructed by the State Property Committee, Belgeodeziya has added four Belarusian GNSS stations to the EPN, which unites more than 100 European agencies and universities. Joining the network will provide Belarusian geodesists with direct

access to international standards on the operation of permanent GNSS stations.

GNSS to assist construction on tunnel from Germany and Denmark

A European megaproject is relying on GNSS to guide supportive earthworks during construction. The Fehmarn Belt Fixed Link is a planned underwater tunnel that would allow travelers to go by car or train between Germany and Denmark in only seven to 10 minutes. Once completed, the 18-kilometer-long tunnel will be the world's largest of its kind and is expected to employ up to 3,000 people.

The 7 billion Euro project is expected to be completed in nine years. Danish construction company Holbøll A/S is building earthworks for 56 bridges on the main route crossing Denmark to where the tunnel would start. Holbøll's undertakings include ramps and drainage work for the new bridges.

Holbøll has 130 employees and a machine park of 22 machines equipped with machine control from Leica Geosystems. Geared with Leica Geosystems, Holbøll A/S has prequalified for several of the derived projects, including the draining and moving of eight hectares in Strandholm Lake in Denmark.

UK's proposed sovereign GNSS system on hold due to debate on requirements

The proposed sovereign Global Navigation Satellite System (GNSS) announced by the British government after the decision to leave the European Union (EU), and the subsequent lockout of the British space industry from the EU's Galileo GNSS programme, is reportedly on hold due to intensive debates between British polticians and officials over the UK's GNSS requirements and what a sovereign system should look like.

These debates have apparently been triggered by a revised cost estimate of a sovereign UK GNSS system that has gone from £3 – £4 billion (US$3.85 – US$5.13 billion) to an estimated £5 billion (US$6.41 billion), and these estimates do not include the post-launch sustainment and replacement costs that would normally be associated with such a system.

In the aftermath of Brexit and its removal from the EU's Galileo programme, the UK government pledged to build its own GNSS system that, in terms of numbers of satellites and architecture, would be similar to the European system and would consist of approximately 24 satellites in medium-Earth orbit (MEO), providing global coverage.

The UK government has earmarked £90 million (US$115.5 million) for a technical and industry feasibility study that was supposed to have been submitted later in March, but reportedly this is now on hold. Further, the Financial Times reports that the UK Cabinet Office has started a government-wide review on whether a global constellation is required, and there are suggestions that a smaller system that augments the signals from Galileo and the US Global Positioning System (GPS) is also being considered. *https://spacewatch.global*

Beijing is $14.4 billion-bound riding on BeiDou's back

Beijing's municipal government released a three-year plan to promote the innovation and development of industries related to the BeiDou Navigation Satellite System.

The total output of BeiDou navigation and location service industry in the Beijing region will exceed 100 billion yuan ($14.4 billion U.S. dollars) by 2022, according to the plan document.

The region historically has shown a keen interest in the GNSS industry and the economic benefits to be derived therefrom. BD Star Navigation, a private navigation products and system provider company located in Beijing, is only one of many companies to be involved in the initiative.

An area centered on the megalopolis and extending along the nearby Bohai Sea coast has emerged as one of five major clusters of BDS industry. The others center on Guangzhou, Shenzhen and Zhongshan along the Pearl River, Shanghai and the Yangtze River Delta region, Central China of Hubei and Hunan province, and to a lesser extent, Western China around Sichuan, Chongqing and Shanxi provinces.

The initiative seeks to stimulate breakthroughs in key and core technologies, as well as cultivating a sound ecology for competitive enterprises; could these mean inertial and other positioning technologies?

Beijing will set up seven major demonstration projects to promote BeiDou applications in smart transportation, environment protection and intelligent logistics, according to the plan.

AER licenses UCAR system to boost use of GNSS satellite data

Atmospheric and Environmental Research, Inc. (AER), a Verisk business, will license a satellite data processing system from the University Corporation for Atmospheric Research (UCAR), building on UCAR's commitment to improve weather forecasting. The agreement will enable AER to process satellite data for commercial companies that sell their Earth observation data products to government agencies and other organizations that provide customized environmental information to a range of clients.

Under the agreement, AER will adapt UCAR's SatDAACâ software system to process observations from satellites that use a method known as Global Navigation Satellite System (GNSS) radio occultation to observe the atmosphere. Those observations can lead to significantly improved weather forecasts.

GNSS radio occultation measures the extent to which the radio signals from GNSS transmitter satellites (including GPS satellites) bend as they propagate through denser regions of the atmosphere. *www.aer.com*

NavVis IndoorViewer 2.6

NavVis has announced the release of NavVis IndoorViewer 2.6. It includes a new measurement tool that lets users take highly accurate measurements based on point clouds in realistic browser-based digital buildings. This release also makes additional features available to structured e57 point cloud files, including automatically generating highly detailed floor plans and routing.

The magnifying feature reveals the exact section of the point cloud behind the image and lets users pick the point cloud point as the basis for a measurement while benefiting from the intuitive interface of the fully immersive walkthrough. It also introduces new feature support for e57 point cloud files captured by static scanners. *www.navvis.com*

First autonomous building sustainability solution

Honeywell has announced the launch of Honeywell Forge Energy Optimization, a cloud-based, closed-loop, machine learning solution that continuously studies a building's energy consumption patterns and automatically adjusts to optimal energy saving settings without compromising occupant comfort levels. It is the first autonomous building solution focused on decreasing energy consumption, may deliver double-digit energy savings, decrease a building's carbon footprint, and can be implemented without significant upfront capital expenses or changes to a building's current operational processes. *www.honeywell.com*

Juniper rolls out new Mist service for network, location analytics

Juniper Networks has launched Mist Premium Analytics, a new service that offers enterprises visibility into their networks, as well as location-based contextual information about customers and employees. The new service is designed to provide a comprehensive look into disparate systems -- network, security and location domains - for information that can help drive both IT and business decisions. The rollout comes about a year after Juniper acquired Mist Systems to combine its wireless LAN platform with Juniper›s wired LAN, SD-WAN and security services. Juniper is also leveraging Mist›s AI capabilities to offer AI-driven operations.

The new analytics service can give customers insight into Wide Area Network (WAN) performance in branch or retail offices, as well as usage patterns of Wireless LANs to anticipate changing demands. It also lets customers compare Mist network data with data from third-party sources.

Technology for mass produced autonomous trucks

TuSimple has announced that it has established a comprehensive partnership with ZF, a leading automotive supplier, to develop and commercialize technology for autonomous trucks. TuSimple and ZF will co-develop production-quality technologies including cameras, LiDAR, radar, steering and ZF's automotive-grade central computer ZF ProAI. Concurrently, ZF will support TuSimple's pre-production driverless autonomous system, and will ultimately serve as the default supplier for their production-ready system for commercialized vehicles. As part of the partnership, ZF will contribute engineering support to validate and integrate TuSimple's autonomous system into the vehicle. *tusimple.com*

Locix launches WiFi-based local positioning solution

Locix has launched its SmartLPS 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 generation. *https://locix.com*

Android developers enticed by half-meter accuracy from smartphone

A new GNSS-centric application programming interface (API) library for Android and IoT developers is on the verge of appearing, and is now accepting registrations for its software development kit. The Fulfilling Enhanced Location Accuracy in the Mass Market through Initial Galileo Services (FLAMINGO) reportedly achieves half-meter accuracy in a smartphone.

FLAMINGO targets new applications in the location service market, using, as per its moniker, Galileo's Open Service. It is designed for the conventional developer and "leaves the accurate location servicing to the positioning experts."

The API will use specially supporting server and deployed infrastructure in smart cities to enable better location precision and accuracy than the existing Android location service. *www.flamimgognss.com*

JV for autonomous transportation service

Yamaha Motor Co., Ltd. and Tier IV, Inc.has announced the launch of eve autonomy, Inc., a joint-venture company based in Shizuoka Prefecture, Japan, that will develop an autonomous transportation service to help Yamaha Motor and other companies address chronic labor shortages and growing needs for high-mix low-volume production.

eve autonomy will begin offering easily implemented solutions that combine Tier IV's Autoware, an open-source operating system for autonomous driving, and Yamaha Motor's renowned vehicle-body development technologies. Envisioned subscription-type services and after-sales support will enable customer

factories to respond nimbly to demand fluctuations and reduce their initial costs of implementation. *https://eveautonomy.com*

Rural cloud initiative by Trilogy Networks and Chat Mobility

Trilogy Networks and Chat Mobility have announced plans for a strategic alliance to accelerate the digital transformation of the most fertile agricultural lands in America. The relationship will pair Trilogy's distributed cloud platform with Chat Mobility's wealth of network assets in Southwest Iowa. This alliance allows Trilogy to extend its expertise in Edge Cloud Computing and low latency networking to family farms and multi-national corporations focused on precision agriculture across rural America. Edge Computing optimizes the interaction of IoT sensors & devices with Cloud applications by bringing compute and storage closer to the sources of data. This dramatically reduces latency and bandwidth requirements, enabling automation of the agricultural ecosystem. Farmers will have access to accurate data captured in real time from connected devices throughout their farm during the entire crop. *www.chatmobility.com*

Propeller announces new machine tracking system, DirtMate

Propeller has announced that they are starting the beta phase for their new product, DirtMate, an innovative machine tracking system that delivers survey-grade progress and productivity data as often as users need it.

DirtMate sensors fill in the blind spots that occur between surveys with real-time data. After a quick, wireless installation, they get to work collecting RTK GPS and IMU information that is available for immediate access. And, the simplicity doesn't stop there—the sensors can run on solar power, or can be wired into the machine.

The data stream feeds directly into the Propeller Platform, which converts the data into live 3D surfaces. Worksites can use this information to generate cut and fill heatmaps, utilization graphs, and progress-to-design measurements. *www.propelleraero.com*

Toyota extends partnership with Carmera

Toyota Research Institute-Advanced Development, Inc. and leading road intelligence company CARMERA Inc. have announced new results from their ongoing partnership. A follow-up to the companies' successful camera-based mapping work in Tokyo, this latest phase used commercially available dashboard-mounted cameras to detect key road features with the relative accuracy performance necessary for automated driving. Specifically, CARMERA's machine learning, computer vision and geospatial technologies were used to detect and place key road features—such as lane markings, traffic signals and signs—along Michigan roadways in central Detroit and Ann Arbor.

These results validate TRI-AD and CARMERA's vision to use street-level cameras from production vehicles, as well as aftermarket telematics systems, to produce comprehensive, accurate mapping data for both horizontal and vertically positioned roadway features. This shared objective stems from both companies' mission to achieve significant reduction in costs and massive expansion in geographic scope of autonomy, allowing it to scale to more people in more places.

HERE signs MOU with Telangana Academy for skill and knowledge

HERE Technologies has announced the signing of a Memorandum of Understanding (MoU) with Telangana Academy for Skill and Knowledge (TASK), a state government entity formed to converge efforts of Telangana government, academia and industry players to train and upskill the youth. As per the agreement, HERE will support the training of technology graduates on mapping and location technology.

Under this initiative, HERE will work with the state government as one of the top 20 companies to create short-term and long- term skilling modules across technology verticals. The company will help diverse and young communities to build, expand and strengthen their understanding of mapping and location technologies through a range of initiatives such as curriculum, collaboration, mapathons, hackathons and eventually enabling the larger eco-system to leverage spatial insights in a business setting.

Singapore-based UNL raises $2m to create smart addresses

UNL, a Singapore-based startup that wants to create a universal addressing system, has raised US$2 million in early-stage funding co-led by location tech firm Here Technologies and VC fund Elev8.

According to UNL co-founder and CEO Xander van der Heijden, ecommerce is taking over global retail, but street names and postal codes today were never designed for the digital economy. Moreover, there's an estimated 4 billion people without an address.

Its technology divides the world into a 3D grid of microcells and assigns every cell a location ID (similar to domain names). It then adds a smart contract layer to make locations programmable and transactional, turning a location into a point of sale, point of delivery, or point of payment.

In the internet of places, real-life locations are coupled with UNL IDs, powering location-based services in industries such as ecommerce, delivery, mobility, smart-city solutions, and autonomous vehicles.

4 Earth Intelligence launches satellite land use mapping service

Earth observation company 4 Earth Intelligence (4EI) has launched a new land cover mapping service based on advanced machine learning. Created from satellite imagery the 4EI service can automatically provide large area base maps together with regular updates of land cover change. Offering a better understanding of changing landscape and vegetation patterns the 4EI Land Cover data also provides insight into the interaction between human activity and nature including improved understanding of the importance of green infrastructure – essential ingredients for solving urban and climatic challenges. In order to produce Satellite Derived Land Cover data 4EI can consider individual satellite images or mosaics of images that are close in date. Before classification different indexes, for example normalized difference vegetation index and soil-adjusted vegetation index are automatically calculated and stacked up along with the spectral bands from the satellite images. This is then processed using machine learnt algorithms before post classification quality control is undertaken.

The 4EI schema used to classify land use is adapted from the Coordination of Information on the Environment programme. Originally initiated by the European Commission and latterly administrated by the European Environment Agency the CORINE land cover project defines 44 classifications of land cover and presents results as a cartographic product. *www.4earthintelligence.com*

Pointfuse laser scanning software innovates construction workflows

U.S. construction company Howard Shockey & Sons, Inc. has greatly improved construction sequencing and significantly reduced project schedules following the introduction of Pointfuse laser scanning software into its scanning and VDC workflows. Pointfuse creates manageable, intelligent mesh models that automatically classify building features, aid in clash detection, and other construction processes – all in small, portable files that can be up to 100 times smaller than the original point cloud. This level of product integration provides for a seamless union of technologies resulting in considerable project cost savings. *http://pointfuse.com*

China launches new remote sensing satellites

China successfully sent a group of new remote sensing satellites into orbit from the Xichang Satellite Launch Center in southwest China's Sichuan Province. Belonging to the Yaogan-30 family, this group of satellites was launched by a Long March-2C carrier rocket at 11:43 am (Beijing Time). The satellites have entered the planned orbits and will be used for electromagnetic environment detection and related technological tests. *http://global.chinadaily.com.*

Defence Ministry of India simplifies aerial photography rules

New paperless system developed by Defence Ministry came into force from March 1 and hopes to cut down delays, bringing in efficiency. Obtaining defence and regulatory permissions for aerial photography or remote sensing surveys has become simpler, with the government launching a web portal for quicker permissions and transparency.

Aerial surveys are being regularly proposed by various government agencies, autonomous bodies for developmental projects and also by private agencies or individuals for private purposes. As per the existing procedure, applications for grant of No Objection Certificate (NoC) for aerial photography/ surveys received by the Directorate General of Civil Aviation (DGCA) are forwarded to various stakeholders of Single Point Clearance Committee (SPCC) under the MoD for their recommendations. Bases on the inputs of the authorities concerned, the Ministry decides upon grant/refusal of NoC.

The aerial survey is a geomatics method of collecting information by using aerial photography, LiDAR (using laser lighting) or from remote sensing imagery using other bands of the electromagnetic spectrum such as infrared, gamma or ultraviolet. *www.thehindu.com*

SUGUS kicks off, a European project for integrating drones into the airspace

GMV has been awarded the SUGUS project (Solution for E-GNSS USpace Service), which aims to speed up the takeup of GNSS and Galileo in the Unmanned Aerial Vehicle (UAV) segment. SUGUS, an 18-month, 485,000-euro, European Union R&D project, is to be carried out by a GMV-led consortium involving also Everis Aerospace, Defense and Security, VVA Brussels, ESSP, FADA-CATEC and Unifly.

SUGUS will help to develop services geared towards the effective integration of drones in the airspace. A series of trials will be held to show the benefits of E-GNSS for drone operators as well as its approval by aviation authorities.

The demand for UAV services is steadily increasing, with the potential to generate significant economic growth, as recognized in the 2015 European Union Aviation Strategy. More recently, the 2016 SESAR (Single European Sky ATM1 Research) Drones Outlook Study estimated that the European drone market will clock up 10 billion euros a year by 2035 and over 15 billion euros annually by 2050.

U-Space is a set of new airspace-management services and procedures designed to ensure unmanned aircraft's airspace access while looking out for operational security, the right to privacy and the safety of persons and infrastructure. These services rely on a high level of digitization and function automation, whether onboard the drone itself or part of the ground-based environment.

SUGUS will demonstrate the benefits for drone operations of the measures implemented at service-provision level and the new EGNSS API (Application Programming Interface) to be implemented in the project. These benefits included the mitigation of operating risks, improvement of

preparation processes and clearance of the operator's mission. Such measures as expected to ease future urban aerial mobility (UAM) operations, such as aero taxis or parcel delivery. *www.gmv.com*

High-end american-made drones for critical sectors

Skyfire Consulting has announced that it had acquired a majority stake in Viking UAS, a Maine-based drone design and manufacturing house focused on high-end unmanned systems for US Military research.

Viking has leveraged its technical and real-world application experience and is already working on several purpose-built systems for clients in critical sectors such as public safety, infrastructure and last-mile delivery for Coronavirus (COVID-19)-related medical supplies.

In addition to its ongoing work for the military, Viking will begin work immediately on developing purpose-built drone systems for Skyfire clients in police and fire departments, the oil and gas industry, and most timely, in the global public health response arena.

Drone fleet to initiate ground air disinfection in coronavirus battle

Since the emergence of new COVID-19 coronavirus outbreak in China, XPlanet drones and R80 robots have been deployed by XAG to disinfect affected areas in a series of demonstrations, which helps provide solutions for improving public hygiene and reducing the risk of virus transmission via contaminated surface contact.

According to XCloud, the only crop protection UAS cloud system authorised by Civil Aviation Administration of China, up to February 28, 2020, a total of 370 professional teams with over 2,600 XAG agricultural drones have voluntarily joined the disinfection operation, covering an area of 902 million square metres in China's 20 provinces.

Intelligence and Automation to Fight Against COVID-19

Based on advanced technologies such as robotic control, automated driving and high-precision operation, XAG's agricultural drone and robot can be easily adapted to address the urgent need for fast, accurate disinfection. Compared with manual spraying, these intelligent devices can protect operators from unnecessary exposure to virus and disinfectants. They can automatically disinfect a wider region safer, as well as targeting a specific area to embark on spot spraying and deep clean.

Instead of operating independently, drone and robot can combine together to reap the benefits of ground air disinfection against novel coronavirus. Covering a much wider area from the air with variable flying speed, one XAG drone in a day can disinfect 600,000-700,000 square metres to maximum, a task would normally take 100 workers to complete. *www.xa.com*

First UAV beyond-visual-line-of-sight flight with only detect-and-avoid

Transport Canada has approved the first unmanned air vehicle (UAV) flight beyond visual line of sight using onboard detect-and-avoid sensors, a development bringing long-range commercial drone flights one step closer to reality.

The regulatory agency granted the beyond-visual-line-of-sight Special Flight Operations Certificate to drone operator MVT Geo-solutions of Quebec, which offers aerial lidar, photogrammetry and thermography land mapping services. *www.flightglobal.com*

Japan to establish drone licenses for flights out of pilot's sight

Japan plans to establish a licensing system for operating drones when the flights are beyond the operator's line of sight. The proposal comes as the government hopes for increased usage of

unmanned vehicles for purposes such as delivering daily necessities and medicine, or assisting security patrols in areas with an aging population, the sources said.

The license, which the government hopes will be introduced in fiscal 2022, will be age-restricted, and will require operators to pass both a written and practical examination.

The licenses will be only valid for a certain period of time and will have to be renewed. Illegal drone use will lead to the cancellation or suspension of a license.

A public-private panel discussing how to facilitate the use of drones will propose the license system in a report to be complied Tuesday, the sources said.

The government plans to finalize the details and submit a bill to revise the civil aeronautics law to the Diet next year, they said. *https://japantoday.com*

Newest Virtual Surveyor Software v7.2

Virtual Surveyor has introduced a new feature in Version 7.2 of its popular drone surveying software that automatically highlights terrain slopes that exceed dangerous steepness thresholds. Called Slope Threshold lens, this capability significantly enhances the safety of operations in sand pits, quarries and other dynamic environments with steep terrains.

Virtual Surveyor software bridges the gap between UAV photogrammetric processing applications and engineering design packages. The software generates an interactive onscreen environment with UAV orthophotos/DSMs and/or LiDAR point clouds where the surveyor selects survey points and breaklines to define the topography, creating highly accurate products up to five times faster than otherwise possible. *www.virtual-surveyor.com*

Leica Nova MS60 merges total station, GNSS, imaging and 3D scanning

Leica Nova MS60 is the new and improved version of the world's first MultiStation, combining high-end total station capabilities with 3D laser scanning, GNSS connectivity and digital imaging. It merges several technologies, enabling users to get into 3D laser scanning easily and scan at a speed of up to 30,000 points per second. It can also be used as a high-end total station where users can benefit from its digital imaging and GNSS connectivity.

The target customers stem from industries such as topographic surveying/mapping, building construction, heavy construction and mining and there are numerous projects where the MS60 can be utilized.

Leica Geosystems announces new 3D laser scanning bundle

Leica Geosystems announced a new 3D laser scanning bundle for the Leica BLK360 and greater integration with Autodesk ecosystem. This new bundle consists of the Leica BLK360 imaging laser scanner, Leica Cyclone REGISTER 360 (BLK Edition) desktop software, and Leica Cyclone FIELD 360 for tablets and phones. Customers can get started straight out of the box with seamless connectivity and workflows from Leica Geosystems Reality Capture products to Autodesk's Reality Computing and design solutions. With this bundle, Leica Geosystems will deliver point cloud production while Autodesk's technology will consume the data. *leica-geosystems.com*

State governments in US using Vexcel Imagery to aid in COVID-19 response

As announced on March 17, 2020, state and federal government agencies in the US have been given no-cost or obligation access to high-resolution aerial imagery and related geospatial information captured by Vexcel Imaging to support their responses to the COVID-19 outbreak. Access has been granted at least through June and may be extended as efforts progress to controlling the outbreak of the coronavirus.

Several States have already taken advantage of this offer from Vexcel and expect to use the imagery for response planning efforts such as planning drive through testing locations to hot spot analysis of cluster locations *www.vexcel-imaging.com*

Introducing the Carlson RT4 Rugged Tablet Data Collector

Carlson Software has announced the release of the RT4 advanced tablet-style data collector. Built on the success of the RT3, the RT4 is the next evolution in rugged handheld computing and data collection. Offering performance increases across the board, the RT4 is backed by Carlson's unparalleled technical support. *www.carlsonsw.cox*

Swift Navigation and Deutsche Telekom announce partnership

Swift Navigation has announced a partnership with Deutsche Telekom that will bring the precise positioning of Swift's Skylark™ Cloud Corrections Services to Telekom's comprehensive communications infrastructure via its new Precise Positioning product offering. The Precise Positioning service is currently available across the United States and Germany, with expansion across Europe already underway.

The future is filled with possibilities for autonomous applications. From self-driving cars, rail, autonomous robotic machine navigation, autonomous flight for unmanned aerial vehicles, last-mile delivery logistics and construction safety to shared mobile positioning, the requirement for autonomy is accuracy. Swift and Telekom's lane-level accurate Precise Positioning is specifically poised to benefit level 2 and 3 automotive applications including advanced driver-assistance systems (ADAS), such as lane assist, highway autopilot, cellular vehicle-to-everything (CV2X) communications and lane level directions.

Standard GNSS positioning is accurate to three to five meters which is not suitable for autonomous systems. For higher levels of autonomous capability, high-precision localization is required to deliver accuracy down to the centimeter. This partnership brings the <10cm accuracy of Swift's precise positioning solution to Telekom customers. *https://iot.telekom.com*

Septentrio's Mosaic X5 en route to mass production

GNSS positioning expert Septentrio has announced its Mosaic X5 will be moving into high-volume production. Touted by the Leuven-based company as a next-generation multi-constellation and multi-band receiver module, the Mosaic X5 is said to offer centimeter-level positioning to a slew of technologies like robotics, telematics and smart wearables, among others.

Single chip integrates LoRa transceiver, GNSS and Wi-Fi scanning

Aimed at geolocation, the LR1110 is the first chip from Semtech's LoRa Edge low power software defined LoRa-based platform.

The geolocation solution features low power Wi-Fi and GNSS sniffing capabilities combined with simple to use and cost effective LoRa Cloud geolocation and device management services to significantly reduce the cost and complexity of locating and monitoring IoT assets. By removing the need for incremental GNSS and Wi-Fi components, LoRa Edge reduces the bill of material (BOM) costs of devices and significantly reduces design and procurement complexity. With the addition of LoRa Cloud geolocation services, providing easy-to-use and cost effective TDOA, GNSS and Wi-Fi-based location calculation in the Cloud to dramatically reduce device power requirements and improve asset management efficiency,

LoRa Edge enables customers to further manage total cost of ownership (TCO), paying only when they need an asset to be located. Best-in-class key provisioning at point of manufacture and a secure join process further simplifies the development of IoT solutions, which adhere to customers exacting expectations of security. *www.semtech.com*

Handheld introduces the Nautiz X41

Handheld Group has announced the new NAUTIZ X41, a rugged Android device built for mobile workers in logistics, warehousing, utilities, field service, public transportation, security and public safety. With its extreme ruggedness, 1D/2D scanner and a physical keypad, the Nautiz X41 enables efficient and reliable data collection in the toughest of work environments.*www.handheldgroup.com*

Carlson Software announces two special programs in response to COVID-19

Carlson Software has announced two special programs to help ease the transition to working remotely and the economic uncertainty introduced by the COVID-19 situation. It is offering both 90-day software licenses on our most popular software, and a 90-day deferred payment plan for purchases of software and hardware. *www.carlsonsw.com*

Joint scientific article by RIEGL, wins ISPRS Best Paper of 2019!

Every year the ISPRS (International Society of Photogrammetry and Remote Sensing) chooses the Best Paper of the Year from the wide range of publications in the ISPRS Journal of Photogrammetry and Remote Sensing. For 2019, this award goes to the scientific article Design and Evaluation of a Full-Wave Surface and Bottom-Detection Algorithm for LiDAR Bathymetry of Very Shallow Waters by Roland Schwarz, Gottfried Mandlburger, Martin Pfennigbauer and Norbert Pfeifer.

In cooperation with the Vienna University of Technology and the University of Stuttgart, Roland Schwarz and Martin Pfennigbauer from RIEGL Research succeeded in issuing a new and innovative contribution to topographic underwater mapping with the SVB algorithm (surface, volume and bottom) presented in their article. A considerable advantage of their method is that it relies only on a single laser wavelength. The jurors were impressed with the detailed modeling of the return waveform, the clarity of the explanation, the convincing experimental results, and the potential for broader applicability of the method.

New generation of tools for photogrammetry, drone mapping and analytics by PIX4D

Pix4D have released of next-generation software addressing the modern-day professional challenges. Developed in close collaboration with customers and partners, Pix4Dsurvey, Pix4Dmatic, Pix4Dinspect, and Pix4Dscan will contribute to revolutionizing the way professional customers operate and deliver their services.

Digital photogrammetry is an essential part of every modern surveyor's toolkit and has contributed to launching hundreds of new drone mapping businesses around the world. Pix4Dsurvey and Pix4Dmatic represent the next step in photogrammetry, addressing major challenges in the geospatial industry.

Manual inspection of industrial assets and infrastructure is time-consuming, expensive and at times dangerous. Current technology has reduced the danger but the process remains long and costly. Pix4Dscan and Pix4Dinspect will change that.

Blue Marble Geographics announces partnership with Blackbeard Data

Blue Marble Geographics® has announced its official partnership with Blackbeard Data Services — a leading supplier of geospatial data for the oil and gas industry. This partnership ensures that Global Mapper® users will have access to high-quality, mission-critical oil well data.

Blackbeard Data is primarily known for providing information to assist institutional professionals and independent investors in the acquisition of mineral assets, specifically buying oil and gas royalties. Blackbeard Data maintains the world's largest database of oil and gas royalty owners and the world's largest database of oil and gas comparables built from oil auction histories, which is invaluable to many users of Global Mapper in the energy sector. *www.globalmapper.com*

Parrot and Survae announce partnership

Parrot, the leading European drone group, and Survae, the leading software platform for managing aerial and ground-based imagery, has launched a partnership through Parrot's SDK program to combine Parrot's ANAFI and ANAFI Thermal hardware and Survae's software for professional drone use.

Parrot's ANAFI and ANAFI Thermal drones offer an ultra-compact tool for professionals, helping them gain new vantage points to make informed decisions using the drone's aerial insights. In addition to its built-in 4K HDR camera, ANAFI Thermal also integrates a FLIR thermal sensor—allowing working professionals to easily capture thermal and visual readings for faster response times, along with higher precision and efficiency.

Survae is a next-generation software platform helping enterprise, government and NGOs to visualize and understand places and events by automating video and image processing from a wide range of ground-based and aerial cameras. The company's cloud-based platform incorporates video, images and sensor data into interactive maps and timelines, providing geospatial and temporal context to organize data so it can be easily searched, visualized, and explored.

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China Satellite Navigation Conference
23-25 May
Chengdu, China
www.beidou.org

GISTAM 2020 (Virtual)
7-9 May
Prague, Czech Republic
www.gistam.org

June 2020

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

July 2020

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

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

AEC Next Technology Expo + Conference
July 27-29,
Chicago
www.aecnext.com

August 2020

XPONENTIAL 2020
August 9-12
Boston, USA
www.xponential.org

September 2020

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

7th International Conference on Geomatics and Geospatial Technology (GGT) 2020
21-24 September
Royale Chulan, Kuala Lumpur, Malaysia.
http://ggt2020.uitm.edu

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

GeoBusiness 2020
24-25 Sep
London, UK
www.geobusinessshow.com

October 2020

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

International Symposium on Satellite Navigation (ISSN 2020)
21-24 October
Nanjing University of Information Science and Technology, Nanjing, China

10th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing (IGRSM 2020)
20-21 October
Kuala Lumpur, Malaysia
http://igrsm.org/igrsm2020

AARSE2020
26-30 October
Kigali, Rwanda
https://aarse2020.org

November 2020

Autodesk University
16-19 November
Las Vegas, USA
www.autodesk.com

European Navigation Conference 2020
22-25 Nov
Dresden, Germany
www.dgon.de

December 2020

Amsterdam Drone Week & UAM Summit
December 1-3
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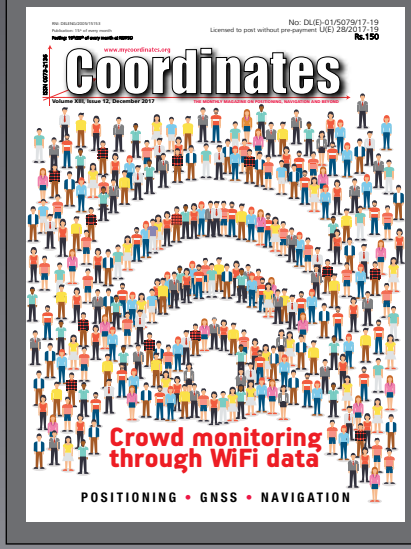

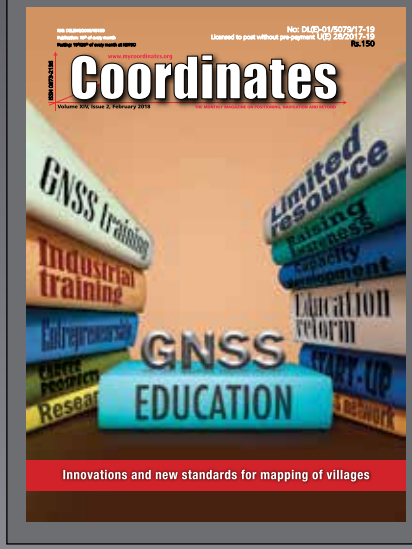

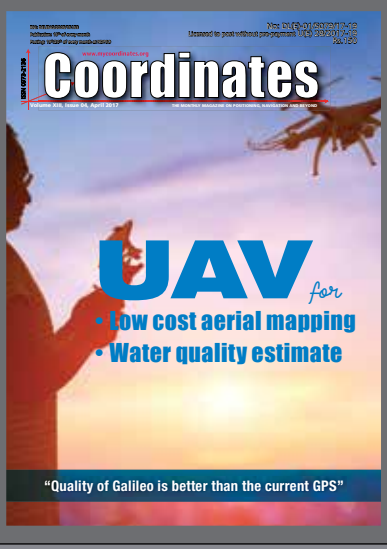

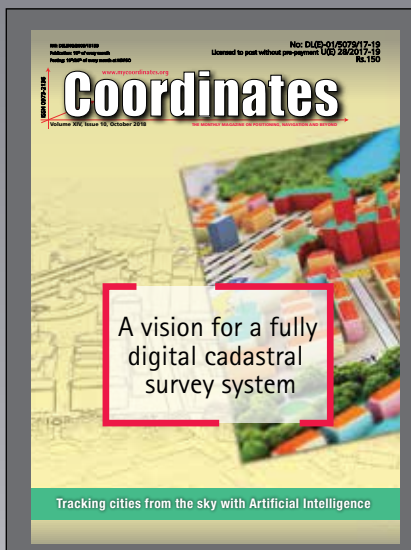

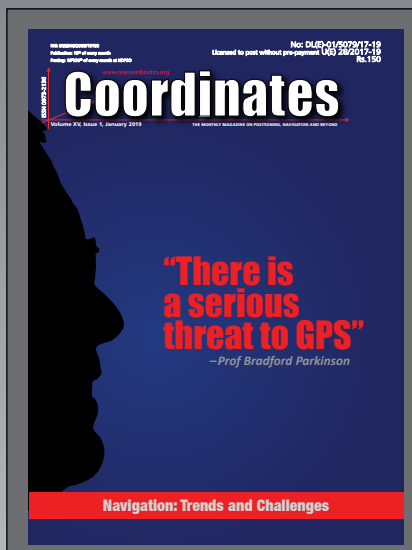

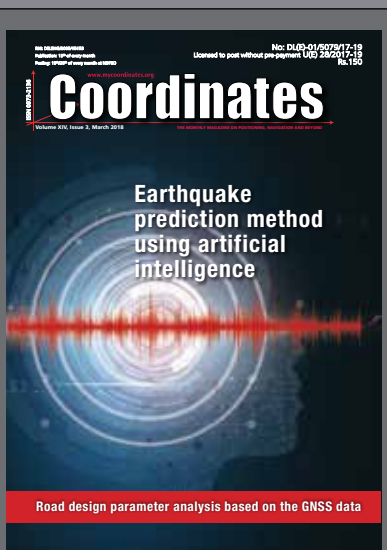

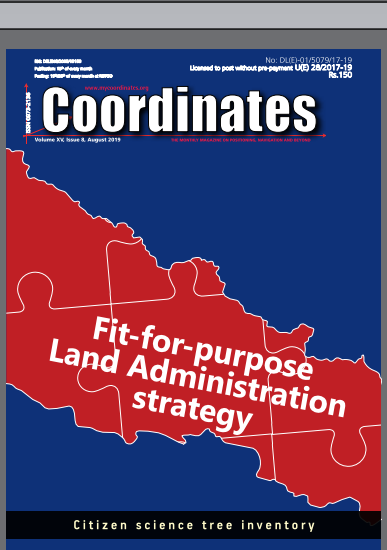

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