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THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Living Structure

down to earth and up to heaven

Challenges for validation of automated driving for GNSS

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Novel Scare

COVID-19 has spread

All across the globe, almost.

With over 4000 death counts

And over 1,27,000 infected,

Countries struggle to contain it.

The World Health Organization declares it a pandemic.=

This is unprecedented.

Along with the health crisis, the world economy is in a quandary.

A time for self-isolation, if needed

But to collaborate and support each other, surely.

A global crisis looms large.

Humankind is challenged.

Bal Krishna, Editor
bal@mycoordinates.org

Challenges for validation of automated driving for GNSS

Automotive industry will deploy vehicles equipped for automated driving. One main challenge at the time being is the validation of the intended functionality with required level of safety. The absolute position as a prerequisite today only is provided via GNSS for which no trace back to SI units exists. Therefore, today everybody is looking for a reliable way to assure integrity of provided position.

Martin Grzebellus
Managing Director
NavCert GmbH

Automated driving

The automation in driving as defined by SAE is categorised by the split of responsibility between driver and vehicle and the level of support functions provided by the vehicle. into six different categories as illustrated in Figure 1.

SAE defined 5 different levels of automation starting from level 0 with no command of automation to level 5, which represents fully autonomous driving. With increasing levels of automation, the system is entrusted to substitute the human driver incrementally e.g. vehicle steering, driving environment perception and vehicle fallback operation whereas in the highest level all driving functions are performed by the system fully automatic.

The absolute position of a vehicle can only be determined by GNSS. A delta to the absolute position especially in so-called GNSS denied environments may be determined by auxiliary sensors i.e. INS, odometer, etc. supporting GNSS.

For autonomous driving absolute positioning capability with, at least, lane accuracy and with high integrity in all driving environments is required. The required lane accuracy and performance integrity in AD are 10 cm-level and meter-level, respectively (for more details see https://inlane.eu).

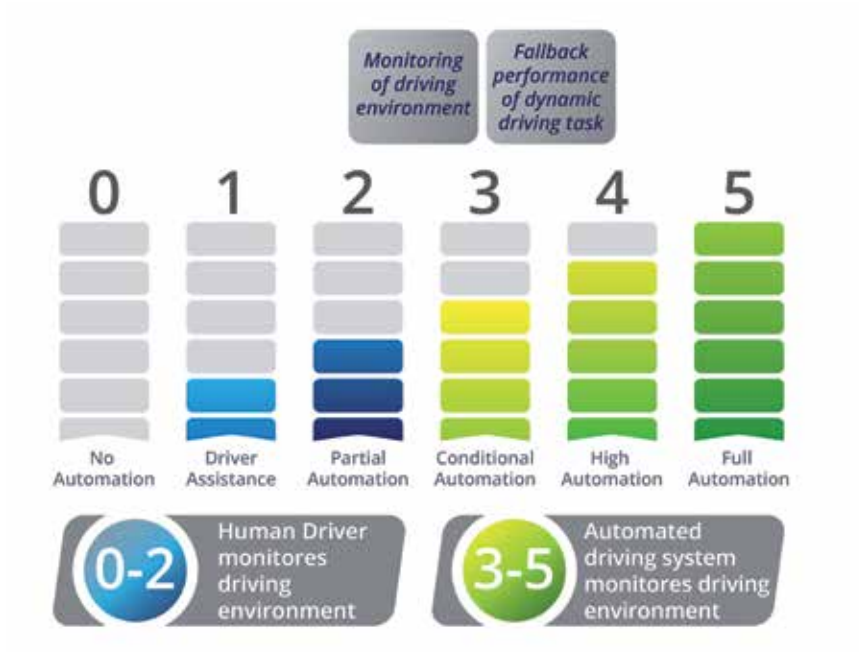

Figure 1: Levels of automation (SAE, 2016).

Validation Position Engine

All OEMs and tier 1 are developing solution / have developed solutions which shall be used in safety critical applications. However worldwide there is no way to assure the proper working of the implemented solutions. One example is Tesla creating the impression via PR that their smart vehicles drive on their own. Due to this misunderstanding driver share videos how their Tesla vehicle is driving although they are distracted by reading or even worse other activities. In case of an incident they refer to their Ts&Cs where in the contrary it is specified that the driver is of course all the time responsible for the activities of the vehicle in phases of automated driving and shall have every time the possibility to control steering wheel and speed of vehicle.

A position engine as depicted in Figure 2 is used for the determination of the position combining information form GNSS supported by other sensors like IMU and additional information as correction data.

For the development of safety critical components, the standard ISO 26262:2015 is used in the automotive industry and quite recently complemented by the ISO PAS 21448:2019. Looking to the modules of the position engine, all might be developed from scratch according to the specific requirements starting with the definition of safety goals except the GNSS correction service as this exists since quite some time.

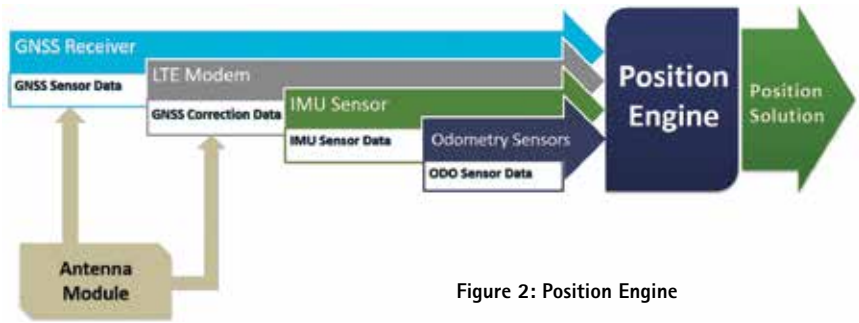

Figure 2: Position Engine

Therefore special attention has to be given how to integrate correction data into the development and validation process according to ISO 26262:2015.

Determination of ground truth

For the evaluation of the functionality of the sensors, one main challenge is to determine the ground truth of the position of the vehicle in dynamic scenarios. Here typically expensive GNSS equipment with IMU and other sensors with a higher accuracy than the position engine under test is used as a reference system. The position determined by the reference system is regarded as ground truth and the position determined by the position engine is assessed and qualified in respect to the reference position. According to ISO 26262:2015 tools used in the development process have to be qualified if the tool may cause an error in the final product. As the only reason for using the reference system is the validation of the position engine in according to the ISO 26262:2015, the reference system obviously has a strong impact on the final product. The standard defines 4 levels of tool confidence, for the lowest level (TCL1), no confidence is needed so a tool qualification is not necessary, and all other levels up to TCL4 require qualification. The following four qualification methods are suggested with a fitting to the intended ASIL level from A to D:

1. Increased confidence from use
2. Evaluation of the development process
3. Validation of the software tool
4. Development in compliance with a safety standard

The available reference equipment is a commercial off-the-shelf product typically introduced to the market recently. Therefore method 1, 2 and 4 will not be applicable and the only alternative left is the validation.

Since quite some years various methods for assessment have been experienced, however so far nobody really was successful. Looking to the task, it's obvious why this approach is very complex. In principle the reference system is also a position engine according to Figure 2 but with expected better performance like increased accuracy. In the past one approach was to construct tracks for which the trajectory could be determined with high accuracy. The device under test was fixed to a wagon driving on the track. By repeating the tests, one could statistically assess accuracy of the tested position engine or reference system. However, there was a sever disadvantage preventing the commercialization of this approach. The trajectory was reflecting the capabilities required for rail not for automotive

> For autonomous driving absolute positioning capability with, at least, lane accuracy and with high integrity in all driving environments is required. The required lane accuracy and performance integrity in AD are 10 cm-level and meter-level, respectively

The validation of the position engine can be done twofold, first driving in real world for a huge amount of time providing evidence on error behavior and second, in a simulation environment focusing on behavior in challenging situations

and as such the potential limits of the sensors could not be assessed nor critical scenarios for road approximated.

Qualification of tools

In aviation since quite some years the assessment of GNSS receiver is done with laser trackers. The position engine is installed in an airplane to which a mirror is attached. On ground there are laser stations automatically following the mirror attached to the airplane. By this in a limited space but under real world conditions the airplane is traceable, and the trajectory can be determined as ground truth to which the calculated position of the position engine in the airplane is compared.

A similar approach is nowadays feasible with robot stations for vehicles. The robot stations may be installed in testbed suitable for required driving maneuvers with respect to speed and curve radiuses. Also, this tool requires prior use validation. However, as not any technology of the position engine is used, the assessment can be done in a different way as depicted in the following.

A laboratory accredited according to ISO 17025:2017 shall use only measurement equipment traceable back to SI units calibrated when used. In cases this is not feasible as in the GNSS environment, the laboratory shall implement its own method for validation. The laboratory has to provide evidence during accreditation and in regular internal and external audits that it is experienced in selection, verification and validation of methodologies assuring traceability and validity of results. Here special attention is required in the determination of the measurement uncertainty with an in-depth analysis of impacting factors, quantification and respective mathematical analysis.

The validation of measurement equipment is valid only for a dedicated period same as the calibration. Thereafter the validation has to be repeated by the accredited laboratory.

Validation of correction services

The usage of correction service implies same impact to the position engine as the determination of the ground truth. If the provided information as correction service is incorrect or misleading the intended accuracy of the position engine cannot be achieved and will result into an error. For that reason, the correction service itself has to be validated as well. For SBAS a certification for aviation has been done some years ago for EGNOS assessing the respective service provider ESSP in France with the result to be a certified air navigation service provider. Therefore, the correction service provided by ESSP may be used in aviation in safety critical applications. There are ideas to certify as well the new services of Galileo the High Accuracy Service (HAS) and/or the Commercial Authentication Service (CAS) in the context of automotive.

For service provider offering correction service today there is already an assessment in place resulting into a certificate by TÜV SÜD. The real time accuracy is validated and the process of offering the service assessed. Due to this approach one can derive that the offered service will work as specified for the lifetime of the certificate. The certificate is issued always for a period of one year with a recertification in year 2 and year 3. The respective certification mark is depicted in Figure 3. Latest in year 4 a complete new certification is required even if nothing changed.

Figure 3: Certification Mark

Validation of position engine

The validation of the position engine can be done twofold, first driving in real world for a huge amount of time providing evidence on error behavior and second, in a simulation environment focusing on behavior in challenging situations. As a first step, an analysis has to be done identifying critical scenarios. Then the critical scenarios may be mapped to real world scenarios but mainly implemented in a simulation.

For the simulation the same challenge applies as for the validation of the reference system. All tools

All components developed for safety critical applications like automated driving require an intensive testing according to ISO 26262. The main challenge so far was the qualification of the required tools

Figure 4: Critical Scenario real world

have to be qualified according IS26262:2015 prior usage. This applies for the used simulation environment including hard- and software. As the environment cannot be calibrated, a validation has to be developed according to a standard like ISO17025:2018. Based on the specified KPIs of the position engine the respective error impact will be analysed. Then the measurement uncertainty has to be calculated to determine if the intended methodology fulfills all specific requirements and may be used.

Conclusion

All components developed for safety critical applications like automated driving require an intensive testing according to ISO 26262. The main challenge so far was the qualification of the required tools. Here now a feasible way forward exists for qualification of reference systems used for determination of ground truth, for the correction service intended to be used as an improvement to the GNSS determined position in the position engine and finally for the simulation environment by accredited laboratories for GNSS.

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. We present here the first part of the paper or the down to earth part. The second part or the up to heaven and concluding part will be published in April issue.

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"All of my life I've spent trying to learn how to produce living structure in the world. That means towns, streets, buildings, rooms, gardens, places which are themselves living or alive… depending on who you talk to, they'd say, 'Well, this stuff Alexander's been discovering is a lot of nonsense. There is no such thing as objectivity about life or quality.'… They are simply mistaken."

Christopher Alexander (1999)

Abstract

Discovered by Christopher Alexander, living structure is a physical phenomenon, through which the quality of the built environment or artifacts can be judged objectively. It has two distinguishing properties just like a tree: "far more small things than large ones" across all scales from the smallest to the largest, and "more or less similar things" on each scale. As a physical phenomenon, and mathematical concept, living structure is essentially empirical, discovered and developed from miniscule observation in nature- and human-made things, and it affects our daily lives in some practical ways, such as where to put a table or a flower vase in a room, helping us to make beautiful things and environments. Living structure is not only empirical, but also philosophical and visionary, enabling us to see the world and space in more meaningful ways. 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. For this purpose, we first illustrate living structure – essentially organized complexity, as advocated by the late Jane Jacobs (1916–2006) – that is governed by two fundamental laws (scaling law and Tobler's law), and generated in some step by step fashion by two design principles (differentiation and adaptation) through the 15 structural properties. We then verify why living structure is primarily empirical, drawing evidence from Alexander's own work, as well as our case studies applied to the Earth's surface including cities, streets, and buildings, and two logos. Before reaching conclusions, we concentrate on the most mysterious part of Alexander's work – the luminous ground or the hypothesized "I" – as a substance that pervasively exists everywhere, in space and matter including

our bodies, in order to make better sense of living structure in our minds.

1. Introduction

If the life's work of Alexander (2002–2005) – *The Nature of Order* – had to be summarized in one word, "beauty", "life" and "wholeness" would be the three top candidates. If allowed two words, it would be "living structure". What do these terms really refer to? Instead of getting into their detailed meanings (see Section 2), let us use an analogue to clarify them first. If wholeness were compared to temperature, then beauty or life would be like the feeling of warmness or coldness. The higher the temperature, the warmer one feels, and the lower the temperature, the colder one feels. The higher the wholeness, the more beautiful or the more life one feels; the lower the wholeness, the less beautiful or the less life one feels. Therefore, a thing or structure that exhibits a high degree of wholeness is called a living structure. Opposite to living structure is non-living (or dead) structure. There is a wide range between the living and the dead, so living is always to some degree or other, just as the feeling of warmness relates to a range of temperatures. Living structure is what Alexander (2002–2005) discovered and further pursued, and it is independent of any style or culture from for example Indonesia, Japan, Russia, Africa, Turkey, Iran, India, or China. Having said that, Alexander has no particular style of buildings, contrary to what his rivals or critics tend to think. Or to put it different, living structure is a living style, just as nature itself, being able to trigger a sense of belonging or well-being or healing in people who are exposed to it. To know whether a thing or space exhibits living structure, one can simply examine whether it possesses "far more smalls than larges" across all scales ranging from the smallest to the largest. For example, at the multiple levels of scale or in a recursive manner – an entire tree, its branches, and its leaves (in terms of the detailed texture) – there are always "far more smalls than larges". Therefore, a tree is beautiful or alive structurally, regardless of whether it is alive biologically.

Based on the notion of "far more smalls than larges", a simple shape that lacks of detailed smaller structures is neither beautiful nor alive. This is for the same reason why sans-serif fonts are less beautiful or less alive than serif ones. For example, the font "I" (when shown as a sans-serif) is not a living structure (one vertical line only) without "far more smalls than larges", whereas the font "I"(when shown as a serif) is a relatively living structure (one vertical line and two little bars) with "far more smalls than larges". The difference between the non-living and living fonts may be hardly sensed when the two fonts are too small, in particular when the letter's meaning is focused on. As a matter of fact, serif fonts in general are objectively more beautiful than sans-serif ones. It is based on this kind of structural fact – actually the phenomenon of living structure – that Alexander (2002–2005) established a scientific foundation of architecture. Unfortunately, the phenomenon of living structure has not yet been well accepted by the scientific community as a fact, but been sidelined as a human taste or personal preferences. This situation constitutes a major motivation of this paper. Human history is full of many great builders or architects who made great buildings, but few of them really made it clear – or even intended to think about – how to make great buildings and why the great buildings are great.

As an architect who was initially trained in science, Alexander wanted to make beautiful buildings, and he wanted to know in particular why beautiful buildings are beautiful. His classic work on the pattern language (Alexander et al. 1977) is widely read by ordinary people looking to make beautiful rooms, houses and gardens, and to facilitate their daily lives, for example, where to put a lamp or a flower vase, and how to lay a table cloth. His design thoughts are therefore very practical – down-to-earth – and his research is essentially empirical. On the other hand, his research is deeply philosophical and visionary, up to heaven, touching the fundamental issues of what the universe constitutes, and where our consciousness comes from. He conceived and developed – from the phenomenon of living structure – a third view of space, and a new cosmology in which we human beings – not only the body but also the mind – are part of the universe (Alexander 2002–2005, Volume 4, c.f. Section 5 for a more detailed discussion). The third view of space states that space is neither lifeless nor neutral, but a living structure capable of being more living or less living. This new view of space sets a clear difference from two traditional views of space: absolute space by Isaac Newton (1642–1727) and relational space by Gottfried Wilhelm Leibniz (1646–1716), both of which are framed under the mechanistic world view of Descartes (1637, 1954). This new view of space constitutes part of the new cosmology that unifies the physical world and our inner world as a coherent whole.

Despite a large body of literature on or inspired by Alexander's work (e.g., Gabriel 1998, Salingaros 2006, Quillien 2008, Jiang and Sui 2014, Leitner 2015, Wania 2016, Mehaffy 2017, Guttmann et al. 2019, Jiang 2019a), living structure has not yet been well recognized as a physical phenomenon or mathematical concept, for people to understand the objective or structural nature of beauty. This paper is an attempt to fill this gap, by setting up a dialogue with those who are skeptical about Alexander's design thoughts. It is intended to clarify some doubts in order for skeptics to understand three main points. First, the essence of beauty is structural or objective, lying in the notion of "far more smalls than larges", which accounts for a majority of our sense of feeling on beauty. There is a clear sign that beauty is beginning to be accepted as an objective concept in the literature of philosophy (Scruton 2009). Second, the phenomenon of living structure is universal and pervasive, not only in nature but also in what we made and built across all cultures, ethics, and religions, involving ancient buildings and cities, as well as ancient carpets and other artifacts. Thus, there is no so-called Alexander's

style of architecture; if there is, it is the living structure (just as nature itself), which is able to trigger a sense of beauty or life in the human mind. Third, there is no mystery at all regarding the *"quality without a name"* (Alexander 1979), which is actually living structure, yet the mystery of a non-material world view remains.

The remainder of this paper is structured as follows. Section 2 introduces and illustrates the living structure as a physical phenomenon, using a sketch by Alexander, in terms of its governing laws (scaling law and Tobler's law), its design principles (differentiation and adaptation), and its 15 structural properties (Table 1). Section 3 argues why living structure is scientific or empirical by drawing evidence from Alexander's own works such as the pattern language. Section 4 further presents case studies to demonstrate that living structure is objective or structural rather than just a matter of opinion. Section 5 discusses the metaphysical aspects in order to make better sense of the living structure in terms of why living structure evokes a sense of beauty or life in our minds. The paper concludes with a few remarks and suggestions for future work.

2. Living structure: Its governing laws and design principles, and 15 structural properties

The four terms mentioned at the outset of this paper can be placed into two categories – wholeness and living structure in the first group, and beauty and life in the second group – representing the outer and inner worlds, respectively. The central concept among these four is wholeness, which can be defined mathematically (Alexander 2002–2005, Jiang 2015b). It exists pervasively in our surroundings; in an ornament, in a room, in a building, in a garden, and in a city. It was previously referred to by Alexander as the *"quality without a name": "a central quality which is the root criterion of life and spirit in man, a town, a building, or a wilderness. This quality is objective and precise, but it cannot be named"* (Alexander 1979). The term wholeness is also a key concept in Gestalt psychology (Köhler 1947), in quantum physics (Bohm 1980), and in many other religious and philosophical contexts. Semantically, there may be some overlap across these different fields, but Alexander's wholeness is unique with its distinguishing features. It is not only a static structure, but also a dynamic process, through which living structure emerges. In the next part of this section, we will use a sketch by Alexander (2002–2005) (6a in Figure 1) to introduce and illustrate living structure or wholeness.

Table 1: The 15 structural properties of wholeness

Levels of scale	Good shape	Roughness
Strong centers	Local symmetries	Echoes
Thick boundaries	Deep interlock and ambiguity	The void
Alternating repetition	Contrast	Simplicity and inner calm
Positive space	Gradients	Not separateness

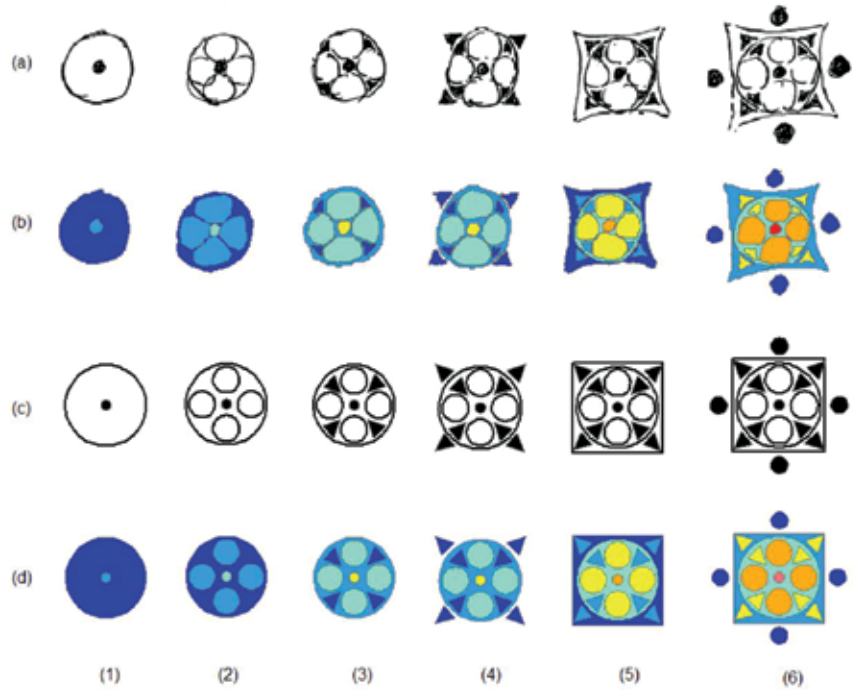


Figure 1: (Color online) A living (6a and 6b) versus a less-living structure (6c and 6d) (Note: The living structure is evolved as a product of living process, while the less-living structure comes from a simple drawing. The living structure is well differentiated and well adapted, not only among those in the figure, but also among those in the ground, whereas the less-living structure looks like an assembly from pre-determined pieces, which are not well adapted to each other. For example, the four dots outside the square in 6c and 6d are less integrated into the whole than those in 6a and 6b. The coloring indicates the degree of wholeness, with blues showing the lowest, red showing the highest, and other colors in between the lowest and highest.)

The sketch shows the evolution of a living structure, demonstrating many of the 15 properties (Table 1). It consists of at least 19 different sized mutually overlapping, nested shapes or centers in Alexander's terms, namely the four outmost black dots, the square, the big circle, the eight tiny triangles, the four small circles, and the tiny dot in the middle. Among many of the other properties, the first property of the levels of scale is the most distinguishing one. The sketch is with six levels of scale, indicated by the six colors with red being the highest, blues being the lowest, and other colors in between (6b in Figure 1). It should be noted the six levels of scale is not in terms of their sizes, but the supports

From a design or dynamic point of view, a space, or structure is continuously differentiated toward scaling hierarchy of "far more smalls than larges". Actually, these two laws are largely statistical, which does not guarantee living structure. To make the structure really living or beautiful, we must consider geometric aspects.

they receive. Overall, there are "far more blues than red", and some in between the blues and the red in the colored sketch, the spectral coloring in terms of the degree of wholeness of individual centers. For example, the tiny center in the middle has the highest degree because it receives many supports from other centers. The notion of "far more smalls than larges" reflects the very first property of living structure, namely levels of scale (Table 1), or "scaling hierarchy" or scaling law (Jiang 2015c). As a reminder, the scaling hierarchy of "far more smalls than larges" should be – more correctly – understood in a recursive manner, implying that "far more smalls than larges" for a whole, for a sub-whole, and a sub-whole of sub-wholes and so on (c.f. the above tree example). The scaling hierarchy of "far more smalls than larges" recurs multiple times rather than just once, except for some simple cases like font "I". In the living structure, the recurring happens five times (steps 2–6 in Figure 1), leading to six hierarchical levels. The living structure can be said, more precisely, to be evolved, which implies that centers are well adapted to each other as a coherent whole. The living structure is not simply an assembly of pre-existing components. In this regard, the less-living structure (6c in Figure 1) is indeed an assembly of pre-existing units.

The less-living structure (6c and 6d in Figure 1) looks smooth, glassy, and uniform, but it exhibits a lower degree of wholeness. There are several reasons for this, a few of which are highlighted here. First, the less-living structure is created (at once) by assembling rather than generated (step by step) by adaptive design. The lack of adaptation can be clearly seen from figure and ground relationship (Rubin 1921), or the fact that the space between these geometric shapes is not well shaped, or not convex like ripening corn, *"each kernel swelling until it meets the others, each one having its own positive shape caused by its growth as a cell from the inside"* (Alexander 2002–2005). Second, the four dots outside the square of the less-living structure are less integrated into the whole inside the square. This is because the space outside of square is fully open and therefore lacks a sense of belonging for the four dots, as strikingly shown in the living structure. Third, the less-living structure misses the property of roughness. Interested readers can compare against the 15 structural properties (Table 1) to learn why one structure is more living than the other: the more structural properties, the more living a structure is.

There are two fundamental laws of living structure, scaling law and Tobler's law, which also underlie the 15 structural properties (Table 1). The first structural property (levels of scale) reflects scaling law, as elaborated above, while the remaining properties are largely a reflection of Tobler's law (Tobler 1970), probably except for the property of "not separateness". Tobler's law, which is commonly called the first law of geography, states that *"everything is related to everything else, but near things are more related than distant things"*. Essentially, Tobler's law is complementary to – rather than contradictory to – scaling law (Table 2), indicating that on each scale, centers are "more or less similar". It is important to stress that centers that are "more or less similar" are more beautiful or more alive than centers that are precisely the same. For example, in the living structure, the four small circles are "more or less similar", and eight triangles are "more or less similar", so they are much more living than if they were precisely the same in size, as shown in the less-living structure. With the perfectly drawn shapes, some of the 15 structural properties are no longer available, such as positive space and roughness, which can be phrased as *"the perfection of imperfection"* (Junker 1991). These two properties are the most important for naturally evolved things, such as cell structures and maize grains. On the surface, naturally evolving things may look rather rough or irregular, yet they tend to exhibit the essence of natural beauty. As for Tobler's law or the notion of "more or less similar" on each scale, we can add another example: a coastline with the same degree of complexity as the Koch curve (Koch 1904), with which things (or segments) are precisely the same at each of scales such as 1/3, 1/9, 1/27 and so on. The coastline at each of its scales exhibits the property of "more or less similar" segments rather than precisely the same ones, so the coastline is more

Table 2: Scaling law and Tobler's law of living structure
(Note: These two laws are complementary of – rather than contradictory to – each other and they recur at different levels of scale of living structure.)

Scaling law	Tobler's law
There are far more small things than large ones across all scales, and the ratio of smalls to larges is disproportional (80/20). Globally, there is no characteristic scale, so exhibiting Pareto distribution, or a heavy tailed distribution, due to spatial heterogeneity or interdependence, indicating complex and non-equilibrium phenomena.	There are more or less similar things available at each scale, and the ratio of smalls to larges is closer to proportional (50/50). Locally, there is a characteristic scale, so exhibiting Gauss-like distribution, due to spatial homogeneity or dependence, indicating simple and equilibrium phenomena.

natural, more beautiful, or more living than the Koch curve.

From a design or dynamic point of view, a space, or structure is continuously differentiated toward scaling hierarchy of "far more smalls than larges". Actually, these two laws are largely statistical, which does not guarantee living structure. To make the structure really living or beautiful, we must consider geometric aspects. This is the idea of adaptation: on each level, things should be "more or less similar", or nearby things should be "more or less similar". Note that "nearby" is usually referred to in a geometrical distance, but a topological distance is better in many instances. For example, my neighbor is defined within a certain geometric distance, but an airport's neighbor is better defined in terms of topological distance of flight connections. My neighbor's house should look "more or less similar" (in size and shape) to my house, whereas Heathrow Airport should look "more or less similar" (in size or capacity) to the Paris Charles De Gaulles Airport rather than the Gatwick Airport, because there is no flight between the Heathrow and the Gatwick. Along these two laws, there are two design principles: differentiation and adaptation. The living structure in Figure 1 is continuously differentiated to reach the status of living structure.

It is important to realize – as Alexander noted repeatedly – that the evolution process is not simply about adding new centers; more correctly, centers are induced by the wholeness. In other words, it is incorrect to say a whole comes from parts, or a whole consists of parts; it is the wholeness that induces centers to generate a coherent whole. It is incorrect to say a flower consists of petals; it is the flower as a whole that induces petals. Another design principle is adaptation. On each level of scale, saying that things are "more or less similar" implies things are adapted to each other. Again, this notion of "more or less similar" things should really be understood literally. If things are exactly the same, it tends to generate a structure that is less living or less beautiful; see also examples mentioned above about the coast line versus the Koch curve. It should be noted that adaptation could imply things adapted across scales. This is again a good example of Alexander's observation (see more in Section 3). Alexander found that, across levels of scale, the scaling ratio should be between 2 and 3; otherwise structure would look less living (see Figure 4 in Section 3). It is in this sense that Alexander's living geometry generally surpasses fractal geometry (Mandelbrot 1983). Fractal geometry hardly cares about whether the generated pattern is beautiful or not, and it only cares about automation of some structure.

3. A commonsense and humane approach to architecture

The phenomenon of living structure exists not only in human-made or -built things, but also in nature. Alexander's approach to architecture is very much commonsense and humane. More importantly, he wanted to be inspired by

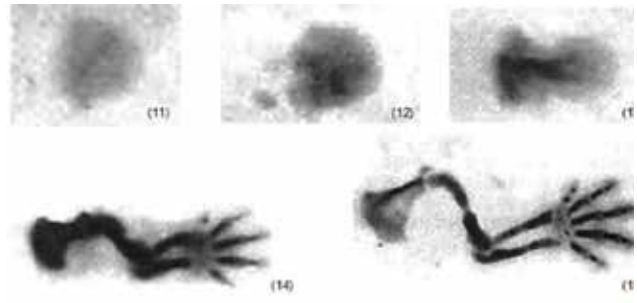


Figure 2: The mouse foot as a living structure emerging from day 11 to 15 (Alexander 2005)
(Note: Every step is based on the previous step for enhancing the degree of wholeness. Apparently, the number of centers induced is increased in the course of growth from day 13 to 15.)

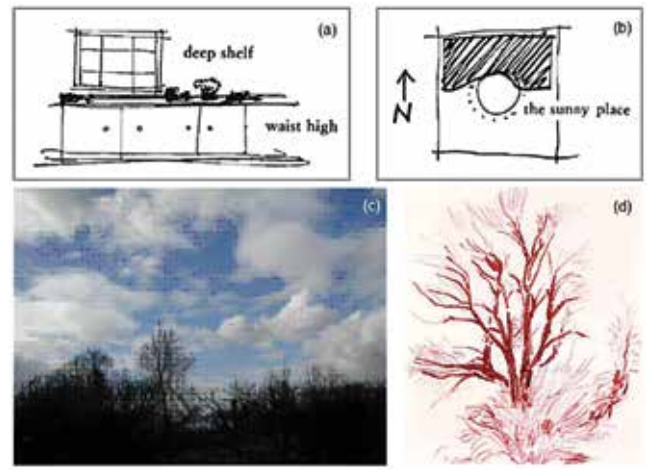


Figure 3: (Color online) Alexander's miniscule observation on architecture and nature
(Note: (a) a waist-high shelf, (b) a sunbeam coming into a room, (c) the interlocking blue sky and white clouds, and (d) positive space generated between a tree's branches (Alexander et al. 1977, Alexander 2005).)

nature and to make sure that what he observed from what humans built or made also applied to nature. For example, the 15 properties of living structure are pervasively seen not only in the built environment, but also in nature. In this section, we draw evidence from Alexander's earlier works to learn why living structure is scientific and empirical, and why this is a correct way of conducting science and art.

Alexander first described the idea of living structures in a corner of an English country garden, where a peach tree grew against a wall:

"The wall runs east to west; the peach tree grows flat against the southern side. The sun shines on the tree and, as it warms the bricks behind the tree, the warm bricks themselves warm the peaches on the tree. It has a slightly dozy quality. The

The phenomenon of living structure exists not only in human-made or -built things, but also in nature. Alexander's approach to architecture is very much commonsense and humane. More importantly, he wanted to be inspired by nature and to make sure that what he observed from what humans built or made also applied to nature.

tree, carefully tied to grow flat against the wall; warming the bricks; the peaches growing in the sun; the wild grass growing around the roots of the tree, in the angle where the earth and roots and wall all meet." (Alexander 1979)

In this living structure of the garden corner, there are many interconnected living centers, such as the wall, the peach tree, the sun, the bricks, the wild grass, the roots of the tree, and even the garden. This is a very good example of Alexander's miniscule observations on nature and on our surroundings.

Considering another example of embryogenesis, a growing mouse foot is a living structure that comes from continuous differentiation and adaptation (Figure 2, Alexander 2005). In the course of the step-by-step development of the five days, many of the 15 structural properties can be observed, such as strong centers, thick boundaries, gradients, levels of scale, contrast, local symmetries, and finally, good shape of the whole. Alexander started his research on architecture – nearly from scratch – not only from traditional buildings and cities, but also from ancient artifacts such as carpets. Two of his books have accurately documented his miniscule observations: one on built environment (Alexander et al. 1977) – part of the trilogy with Alexander et al. (1975) and Alexander (1979) – and the other on carpets (Alexander 1993). His dream was to build beautiful buildings and cities, sharing the same order or beauty – or spirit – of nature, and his understanding of the kind of natural beauty that exists in deep structure rather than on the surface, such as thermal comfort, energy saving or illumination of surfaces. Nowadays, so-called "green" buildings are not really green according to Alexander, and "*a world built according to the present sustainable paradigm, the technical sustainability paradigm, would be quite a horrible place*". Instead, living structures "*represent true sustainability, they sustain the heart, and sustain the soul. They sustain the humanness of the person, and they sustain the Earth"* (Alexander 2004). When nature and the built environment are treated as one, when the physical world and our human's inner world are treated as one, and when the precious Earth's surface and our surroundings are treated as our garden, we will be able to reach the true sense of sustainability.

Back in the 1970s, when he was granted a project by National Institute of Mental Health in the United States to investigate on relationship between the built environment and human well-being, Alexander and his colleagues started learning what works and what does not. To a great extent, traditional buildings and artifacts were his great teacher. His research is not limited to a certain type, but all types of building – across all cultures and countries – that people know, deep in their heart, are universally beautiful or alive. For example, he noted that a waist-high shelf can be very convenient for people to leave things while searching for keys (Figure 3a), whereas a room with a sunbeam is more uplifting (Figure 3b). Thus, both the shelf and sunbeam are supportive to human well-being. It is these kinds of materials that constitute the major content of pattern language (Alexander et al. 1977).

Alexander describes his early work on pattern language as follows:

"To get my feet on the ground, and to have something solid that I could be sure of, I started by examining the smallest particles of functional effect, that I could discern in buildings, with small and sometimes barely significant aspects of the ways that buildings affect people. My purpose in doing this, was to focus on the smallest particles of fact that I could be certain of: something that was extraordinarily difficult when faced with the porridge of mush that then passed for architectural theory. In the early years my studies were based on the most ordinary, miniscule observations about usefulness and the effect of buildings on the people who lived in them, always keeping the observations modest, reliable -- small enough and solid enough so that I could be sure that they were true.

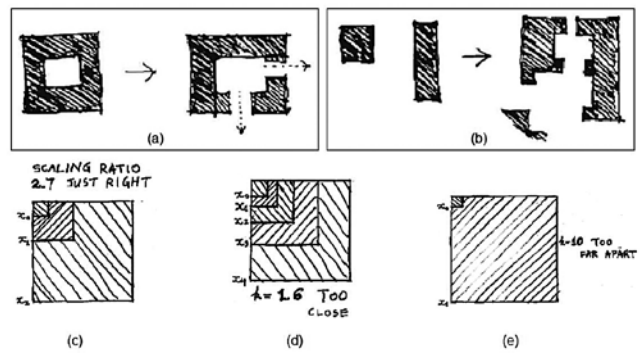


Figure 4: Good or bad as a matter of fact rather than an opinion (Note: A bad space – (a) too close or (b) too open – is transformed into a good space, creating a sense of belonging (Alexander et al. 1977). The scaling ratio is between 2 and 3, as observed by Alexander (2002–2005), tends to lead to a good design or structure, while the scaling ratios of 1.6 (d) or 10 (e) are either too close or too far apart (Salingaros 2006).)

Digital technology, particularly GIS, now provides enormous data about the Earth's surface, about cities, buildings, and about artifacts for revealing living structure in our surroundings.

At first I included very small particulars of functional effect in any matter that actually made a practical difference to daily life… a shelf besides the door where one could put a packet down while searching for ones keys, for instance, or the possibility of a sunbeam coming into a room and falling on the floor.

But I quickly realized that some of these details were very much more significant than others. Those like the first (the shelf) tended to be pedestrian, even though useful; while those like the second (the sunbeam) were more uplifting, and clearly mattered more in some obvious but profound sense. I began to focus on those miniscule points which mattered more, in the sense of the second example. Gradually, then, I was able to pave the way to the possibility of seeing how buildings support human well-being – not so much mechanical or material well-being, but rather the emotional well-being that makes a person feel deeply comfortable in himself. And as I studied these small effects carefully, gradually I was led to a conception of wholeness, wellness, and spiritual support that might, under ideal circumstances, be present between buildings and human beings." (Alexander 2007a)

Built on this earlier work of pattern language, Alexander realized that there are some structural aspects – the 15 properties – that are the most fundamental to human well-being. For example, the beauty of the blue sky and clouds comes from the property of positive space (Figure 3c); not only the white clouds but also the blue sky are well shaped. The same positive space appears between a tree's branches (as Alexander sketched himself in Figure 3d). This property of positive space is particularly important for urban environments. It implies that not only buildings, but also the space between buildings, should be well shaped like convex spaces, as we discussed with the living versus less-living structures presented in Figure 1.

Goodness of space is a matter of fact rather than opinion or personal preferences, and good space has a healing effect, sustaining and promoting health. For example, two spaces that are either too close or too open are transformed into positive spaces to which people can develop a sense of belonging (Figure 4 a and b). This sense of belonging further triggers human well-being, security, or safety. Well-being or comfort provided by environments or space is an important factor for human healing. In this regard, Ulrich (1984), an architect, found that the view from a window may influence a patient's recovery from surgery; that is, natural scenes are better than urban scenes for post-surgery recovery. Taylor (2006), a physicist, found that fractal patterns, if they are living structures, in nature and art have stress-reducing effect on people. Because both natural scenes and living structures are living rather than non-living, I conjecture that, essentially, it is living structures that have healing effects on people.

Alexander made another important discovery related to the property of levels of scale or scaling hierarchy. He found that the scaling ratio between two consecutive scales should be between 2 and 3; having it too close or too far apart would reduce the goodness or coherence of space or structure (Figure 4c, d and d). The major difference between fractal geometry (Mandelbrot 1983) and Alexander's work – or living geometry (Alexander et al. 2012) – is that the former is largely for understanding complexity of fractals. Although fractal geometry is able to create artificial fractals, it often ends with *"pretty pictures, pretty useless"* (Mandelbrot 1983). By contrast, living geometry aims not only to understand complexity, but also to create organized complexity, or beautiful or living structures, which are able to trigger a sense of beauty or life. The creation or the making of living structures is what makes Alexander (2003) differ from other pioneers in complexity science.

The following quote shows how Alexander explained the property of the levels of scale or scaling hierarchy pervasively seen in nature and in what we make and build, and how it triggers the feeling of life in our hearts:

"I would like to summarize the content of this new kind of empirical complex in the following way. In any part of what we call nature, or any part of a building, we see, at many levels of scale, coherent entities or centers, nested in each other, and overlapping each other. These coherent entities all have, in varying degree, some quality of "life."

For any given center, this quality of life comes about as a result of cooperation between the other living centers at several scales, which surround it, which contain it, and which appear within it. The degree of life any one center has, depends directly on the degree of life that is in its associated centers at these different scales. In short, I had identified a kind of wholeness: in which the life of any given entity depended on the extent to which that entity had unfolded from the wholeness." (Alexander 2007a)

In addition to what is summarized above, there are many other empirical findings (Alexander 2007b) that support living structure as a physical phenomenon, as well as a well-defined mathematical concept. In following section, we will carry out some case studies to support living structure is not only a phenomenon and concept, but also can be used to objectively judge quality of things.

4. Case studies on living structure

Digital technology, particularly geographic information systems, now provides enormous data about the Earth's surface,

about cities, buildings, and about artifacts for revealing living structure in our surroundings. This section reports several case studies for revealing ubiquitous living structure. To make this paper more readable, we do not use the mathematical model of wholeness for computing the degree of wholeness (Jiang 2015b, Jiang 2016). Instead, the case studies do no more than count the number of centers, and compute scaling hierarchy of "far more small centers than large ones". Previous studies have illustrated that this simple way of computing degree of wholeness is good enough in particular for comparison purposes (Jiang 2018, Jiang and Ren 2018). Anyone who is able to count can easily follow the case studies. Before the case studies, it is necessary to first introduce head/tail breaks (Jiang 2013, 2015a), which helps compute the scaling hierarchy of "far more smalls than larges". The scaling hierarchy is visualized by a series of spectrum colors ranging from blue for the lowest to red for the highest; the more colors, the more levels of scale, the more beautiful or living. Through the coloring, the notion of "far more smalls than larges" is equivalent to "far more blues than reds"; see Figure 5d, 5e, 6, 7 and 8 for the coloring.

4.1 Head/tail breaks for calculating scaling hierarchy

Given a dataset with a heavy tailed distribution or with "far more smalls than larges", head/tail breaks can help obtain the inherent scaling hierarchy by recursively breaking the dataset into two parts (the head and the tail) around the mean (Jiang 2013, 2015a). Those greater than the mean are called the head, and those less than the mean are called the tail. To illustrate the head/tail breaks, consider the 10 numbers – 1, 1/2, 1/3, …, and 1/10 – that exactly follow Zipf's law (1949) as a working example. These 10 numbers are already ranked from the biggest to the smallest. Their mean is ~0.29, which partitions the 10 numbers into two groups: the biggest three as the head, and the smallest seven as the tail. The mean of the biggest three is ~0.61, which further partitions the largest three into two groups again: the biggest 1 as the head, and the smallest two 1/2 and 1/3 as the tail. The notion of "far more smalls than larges" recurs twice, so the scaling hierarchy is three (or, in other words, three levels of scale). In general, the head/tail breaks is formatted as a recursive function as follows:

```
Recursive function Head/tail Breaks:
   Rank the input data values from
     the biggest to the smallest;
   Compute the mean value of the data
   Break the data (around the mean)
     into the head and the tail;
   // the head for the data values
     greater than the mean
   // the tail for the data values
     less than the mean
   while (length(head)/length(data)<=40%):
   Head/tail Breaks(head);
End Function
```

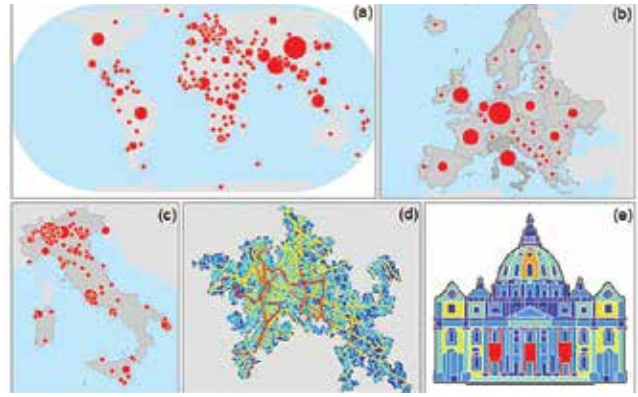


Figure 5: (Color online) The Earth's surface as a coherent whole, being a living structure

(Note: The living structure – scaling hierarchy of "far more smalls than larges" – recurs at different levels of scale of the Earth's surface from (a) the global scale, (b) the European scale, (c) the country scale of Italy, (d) the city scale of Rome, and to (e) the building scale of St. Peter's Basilica. For panels (d) and (e), the blue indicates the least-connected or smallest, red indicates the most-connected or the largest, and other colors are between the smallest and largest.)

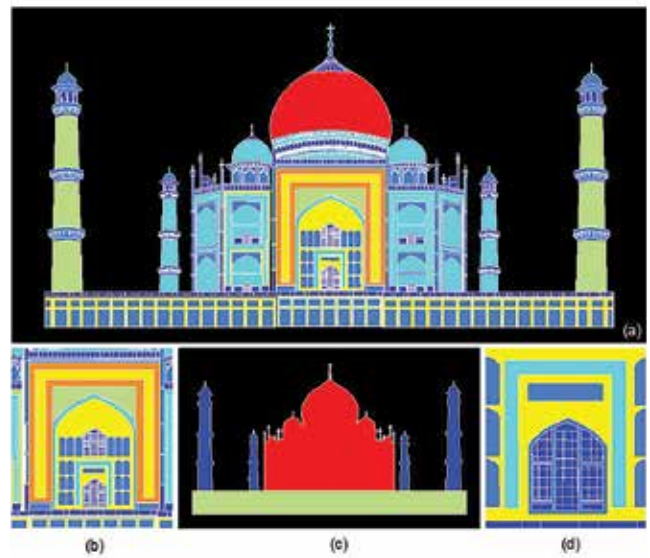


Figure 6: (Color online) The Taj Mahal as a living structure from the façade perspective

(Note: There are "far more small centers than larges" in the façade (a) with blue being the smallest, red being the largest, and other colors in between the smallest and largest. This is the essence of objective beauty or life. The scaling hierarchy of "far more smalls than larges" recurs six times; for example, (b), (c), and (d) each indicate an occurrence. The notion of "far more smalls than larges" is more powerful than the concept of self-similarity of fractal geometry (Mandelbrot 1983), because the former enables anyone – experts or laymen – to see fractals or living structures not only in nature, but also in what we build and make, such as buildings, art, and designs.)

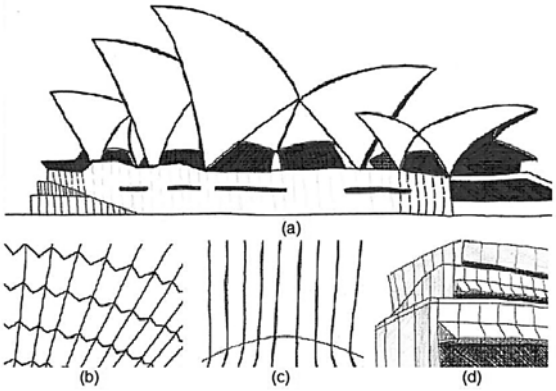


Figure 7: The Sydney Opera House as a less-living structure
(Note: The scaling hierarchy of "far more smalls than larges" occurs only once (a), and the opera house shows monotonic repetition at many levels of scale or on each scale (b), (c), (d). The drawing is by Celine Hedin.)

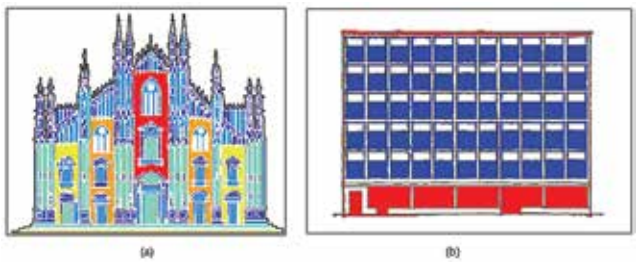


Figure 8: (Color online) Two building façades with different degrees of life or beauty
(Note: The façade on the left (a) has a steep scaling hierarchy with six levels of scale (the six colors), whereas the one on the right (b) has a very flat scaling hierarchy with only two levels of scale (the two colors). More importantly, all blue centers of the right façade are exactly the same without any variation. Beauty or life is determined (1) by the number of centers – the more centers, the more beautiful – and (2) by the scaling hierarchy – the more levels of scale, the more beautiful structurally.) Source: This figure is created by the author based on the scanned black and white images from Kleineisel (1970).

Note that 40% is the threshold for the condition of whether to continue partitioning for the head. In other words, if the head percentage is greater than the set threshold, the function will stop. However, for many real-world data, this 40% threshold for every head can be relaxed to 40% on average for all the heads. This implies that, for some iterations, we can break up the 40% as long as, on average, the head percentage is equal to or less than 40%. The relaxed version of head/tail breaks is called head/tail breaks 2.0 (Jiang 2019b), while the above version is called head/tail breaks 1.0.

4.2 The Earth's surface as a living structure from the globe to the building façade

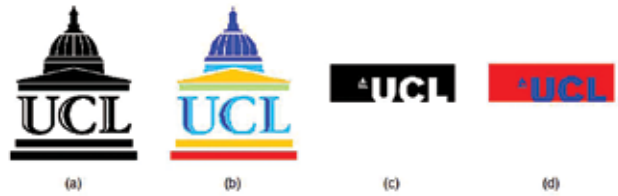


Figure 9: (Color online) Two UCL logos with different degrees of beauty or life
(Note: The old logo (the left, panel a and b) is more beautiful or more living than the new one (the right, panel c and d). This is because the old one has at least 19 centers with a scaling hierarchy of 5 by the five colors, whereas the new one has a maximum of six centers with a scaling hierarchy of only 2 by blue and red. Beauty or life is determined (1) by the number of centers – the more centers, the more beautiful – and (2) by the scaling hierarchy – the more levels of scale, the more beautiful structurally.)

The Earth's surface is a living structure, seen from the global scale, down to the continent, to the country, to the city, and to the building façade, as shown in Figure 5. At every scale, there are "far more smalls than larges". For example, at both the global and continental scales, there are "far more small countries than large ones" in terms of their population (Figure 5a, 5b). At the country scale, there are "far more small cities than large ones" (Figure 5c). At the city scale, there are "far more less-connected streets (by cold colors) than well-connected ones (by warm colors)", with blues being the least-connected, reds being the most-connected, and other colors between the least- and most-connected. At the building scale, the façade of St. Peter's Basilica contains "far more small centers than large ones". It is important to note that, across the scales ranging from the globe to the city, there is no global symmetry, but there are full of local symmetries that make the Earth's surface beautiful or alive. There are "far more smalls than larges" globally, yet at each scale, things are "more or less similar". It is scaling law and Tobler's law that govern the Earth's surface as a living structure, being beautiful and alive.

Unlike many larger scales, building façades usually maintain their global symmetry, just as carpets must (Alexander 1993). However, for building plans, there is no need to retain the global symmetry, like the plan of the Alhambra (Alexander 2002–2005, Jiang 2015b), and the Eishin campus (Alexander et al. 2012, Guttmann et al. 2019). The Taj Mahal is undoubtedly a living structure, and it holds seven hierarchical levels of scale, some of which are illustrated in Figure 6. In this figure, we show different scales down to centimeters, but it can actually be shown down to millimeters, or the scale of an ornament. It should be noted that the Taj Mahal's facade is probably too symmetric or too restrict in terms of scaling ratio. The Taj Mahal is indeed living, but can become more living if some of the 15 properties – for example, alternating repetition – can be introduced, just as the Koch curve is indeed living, but it is less living than the coastline, as remarked in Section 2. Essentially, the Earth's surface in the wide range of 10^{-3} up to 10^{7}

is a living structure. This is the general conclusion drawn from the case studies.

Based on the Taj Mahal study, we can draw another (potentially controversial) conclusion that the Sydney Opera House is a less-living structure, for it clearly misses this kind of steep scaling hierarchy that we see in the Taj Mahal. Instead, the Sydney Opera House shows a very flat scaling hierarchy if any. The opera house may look a "good shape" on the surface, for it looks like a series of gleaming white sail-shaped shells. Seen from kilometers away, there are indeed "far more small shells than large ones", which occurs just once or at one scale rather than across scales, and monotonic repetition rather than "more or less similar" which recurs on each scale (Figure 7). The property of good shape does not necessarily imply any biological shapes, as seen on the surface (Thompson 1917), but something in far deep under the surface, the recurring scaling hierarchy of "far more smalls than larges". This is a misperception on good architecture by many of experts and the general public, just as the Golden Ratio is misunderstood as any shape with a ratio of ~1.618 (Salingaros 2018). To paraphrase Alexander, beauty is not skin-deep, but lies deep in the fine structure, or in the scaling hierarchy of "far more smalls than larges". Despite missing the scaling hierarchy, the opera house exhibits some of the 15 properties, so it cannot be said to be ugly when compared to many modernist buildings. For example, seen from kilometers away under the blue sky and white clouds, it looks really beautiful; Or seen from kilometers away under the background of the deadly boring tall buildings, it looks really living. Here we are talking about the property of not separateness. Therefore, living or less-living is relative rather than absolute, very much like the feeling of warmness.

4.3 Comparison study on living structure

This comparison study aims to prove that the modernist architecture and design usually fail to create living structure, whereas traditional buildings and designs are usually living structures. The study is constrained to building façades and all their identified centers, which are shown as individual polygons (Figure 8). The cathedral façade (Figure 8a) contains over 500 centers, whereas the modernist one (Figure 8b) contains only a bit over 50 centers. From these two numbers, we can judge that the left (Figure 8a) is more living than the right (Figure 8b). Secondly, the cathedral façade has six hierarchical levels indicated by the six colors (Figure 8a), whereas the modernist façade has only two levels represented by blue and red (Figure 8b). In addition, all of the blue pieces on the modernist building façade are exactly the same size, so look boring without any variation. There is little doubt that the left is more beautiful or living than the right.

The second comparison study applies to the two logos of University College

Despite the high correlation between living structure and the selfness, it is impossible – under the current mode of Cartesian thought – to set up the causation between the living structure and our inner world; that is, how the living physical world is reflected as our feeling of beauty and life. We know from statistics that correlation does not mean causation, and it has to be established scientifically. To address the question of why the feeling of life and beauty can be triggered by living structure.

London (UCL) (Figure 9). The new logo (http://tiny.cc/jpgxaz) was adopted in 2005, but it is far less-living than the old one (http://tiny.cc/81gxaz). Now let's examine the number of centers and the scaling hierarchy they hold. The old logo has at least 19 centers, which hold five hierarchical levels (Figure 9a and 9b), whereas the new logo has a maximum of six centers, which can be put at only two hierarchical levels: the five centers as the figure, and the one center as the ground (Figure 9c and 9d). In fact, two of the six centers are a bit too small to recognize when the logo is small enough. It is clear that the old logo is more living or more beautiful than the new one. Even by assessing the three letters U, C, L, we can conclude that the old one is more beautiful or more living than the new one, based on the fact that serif letters in general have more centers – thus more beautiful – than sans-serif ones. To this point, the more-living and less-living logos can really be said to a fact rather than an opinion.

4.4 Discussion on the case studies

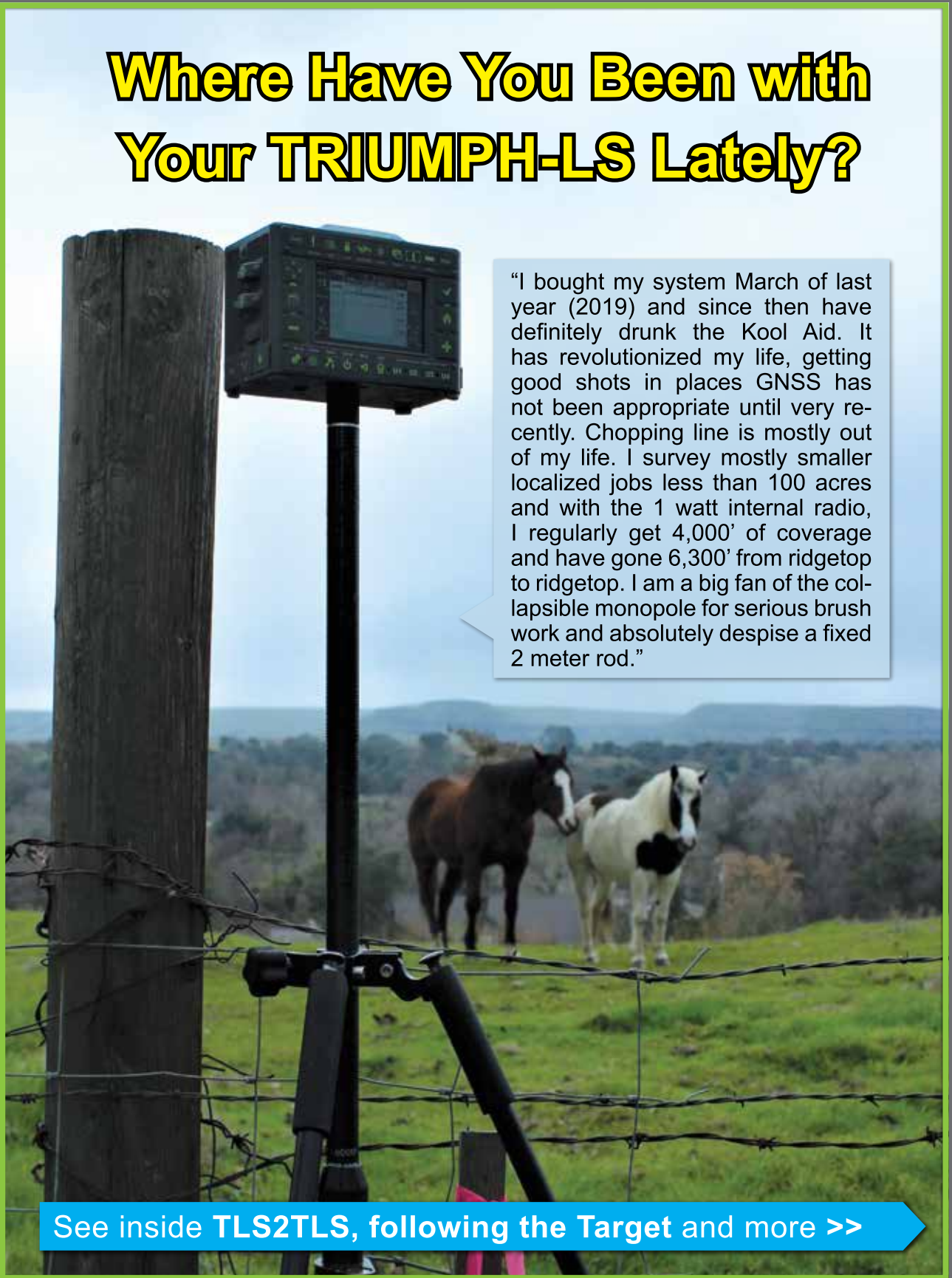
The case studies demonstrate that living structure meets both the scaling law and Tobler's law, whereas dead structure violates these two laws. For example, the two bad designs – the modernist façade and logo – are considered to be dead structures, for they have only two hierarchical levels (indicated by red and blue). It should be noted that these two bad designs are, by far, not the worst. All those buildings labeled by such names as modernism, postmodernism, and deconstructionism belong to so-called dead structures or disorganized complexity (Jacobs 1961). In this connection. we found no better paper than the one by Salingaros (2014) that illustrates vividly complexity in architecture and design; essentially, living structure is organized complexity, while dead structure is disorganized complexity. Dead structure or disorganized complexity violates scaling law across scales or Tobler's law on each scale, and is not created by differentiation and adaptation through the 15 structural properties. Ironically, all these dead structures were mistakenly claimed to be inspired by new complexity science such as fractal geometry and chaos theory by Jencks (2002), which mistakenly confused fractals with fragmented and disorganized things. The world of architecture needs a new paradigm, built on the phenomenon of living structure (Grabow 1983). Although this paradigm was put forward a long time ago, mainstream architecture is still very much dominated by some wrong ways of thinking.

Structure with different degrees of scaling hierarchy can evoke different senses of feeling: *"To the extent they are alive, they let our inner forces loose, and set us free; but when they are dead they keep us locked in inner conflict"* (Alexander 1979). This feeling that sets us free or the correlation between living structure and human's selfness can be revealed by the mirror-of-the-self experiment (Alexander 2002–2005, Wu 2015, Rofé 2016). Two things or their pictures are put side by side, and the human subject is asked to pick the one that best reflects oneself. Most of time and for most people, the one with a higher degree of wholeness was picked with a high degree of agreement. However, unlike many human experiments in psychology for seeking an inter-subjective agreement, the mirror-of-the-self experiment seeks the true feeling of wholeness. This kind of experiment is able to capture the genuine or objective feeling of wholeness inside the human beings, if questions about inner nature of wholeness are asked carefully and in the right way. In other words, a human being is a reliable measuring instrument for wholeness, leading to reliable and shared results. However, the question is, why can living structure trigger the feeling of beauty or life in human minds?

Despite the high correlation between living structure and the selfness, it is impossible – under the current mode of Cartesian thought – to set up the causation between the living structure and our inner world; that is, how the living physical world is reflected as our feeling of beauty and life. We know from statistics that correlation does not mean causation, and it has to be established scientifically. To address the question of why the feeling of life and beauty can be triggered by living structure, Alexander put forward an I-hypothesis or a new cosmology (Alexander 2002–2005, Book 4, p. 23), *"one in which the idea of great art is possible – even necessary – as something which connects us to the universe, something which can provide a proper underpinning for the art of building"*. The next section will concentrate on the I-hypothesis and new cosmology.

To be concluded in April issue.

Where Have You Been with Your TRIUMPH-LS Lately?

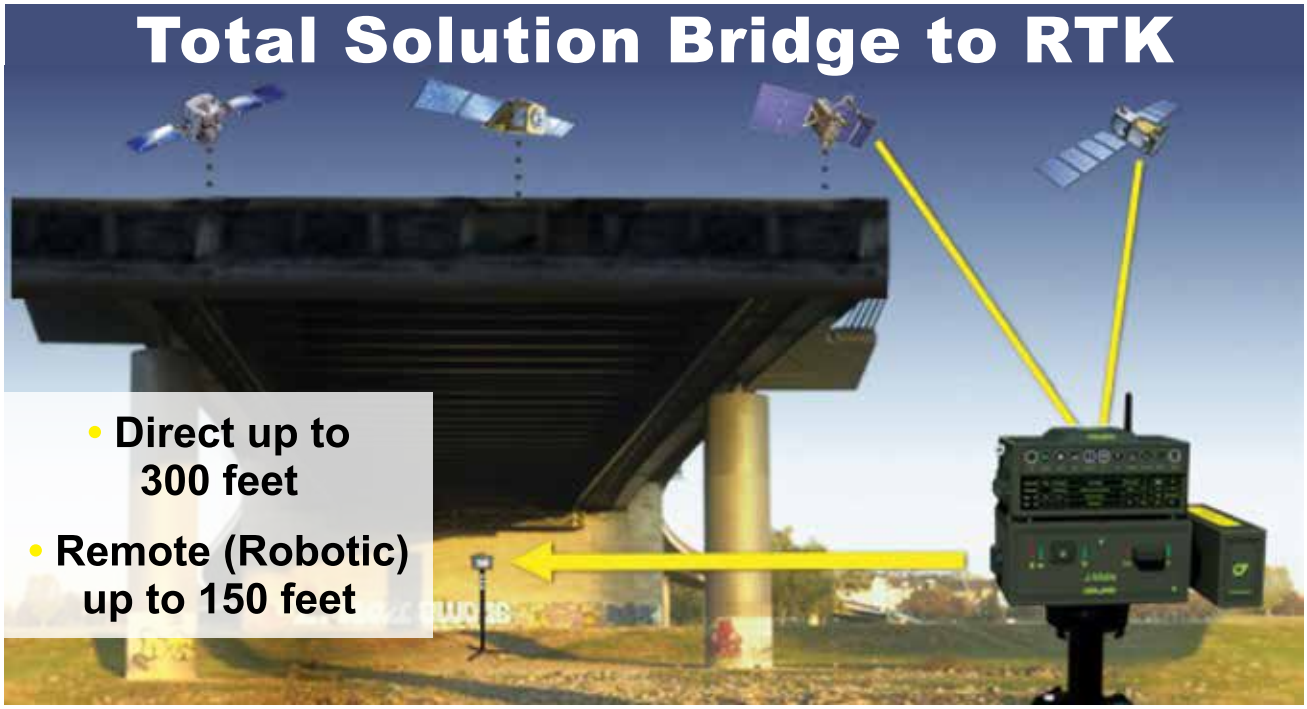


"I bought my system March of last year (2019) and since then have definitely drunk the Kool Aid. It has revolutionized my life, getting good shots in places GNSS has not been appropriate until very recently. Chopping line is mostly out of my life. I survey mostly smaller localized jobs less than 100 acres and with the 1 watt internal radio, I regularly get 4,000' of coverage and have gone 6,300' from ridgetop to ridgetop. I am a big fan of the collapsible monopole for serious brush work and absolutely despise a fixed 2 meter rod."

See inside **TLS2TLS, following the Target** and more **>>**

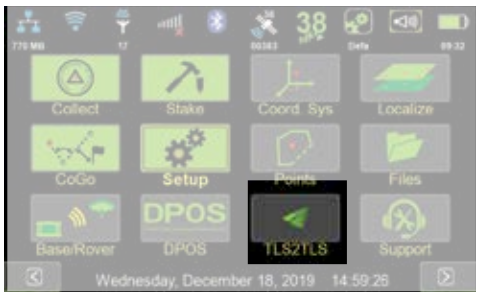
JAVAD

www.javad.com

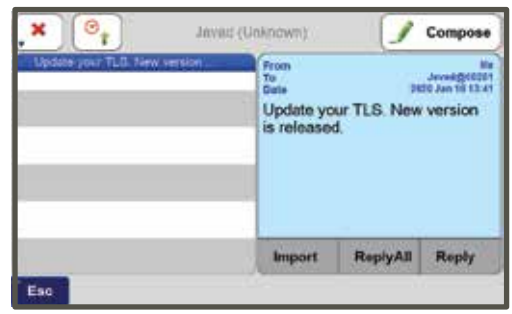


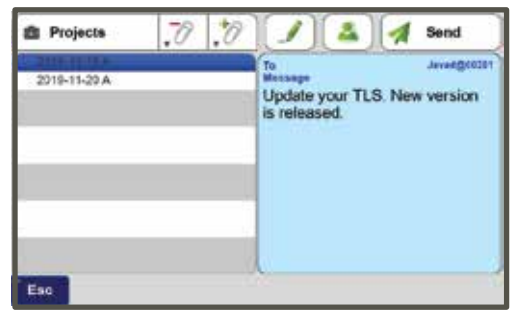
J-Mate is a bridge between RTK and areas that GNSS signal is not available.

TLS2TLS



You can send and receive text messages and files from and to other TRIUMPH-LS units. In the Main screen click TLS2TLS and then in the “Compose” screen, click and enter names and serial numbers of the TRIUMPH-LS units that you want to communicate with. You can attach Projects, Screenshots, Images, Audio, GNSS RAW files to your text messages and send to the selected TRIUMPH-LS units.





The received messages are shown in the first screen. You can “Import” the attached files, if any, to your local unit. Click “Reply” to reply to a message.

You can reply to received messages by clicking the “Reply” (only to sender) or “ReplyAll” (to all recipients) buttons.

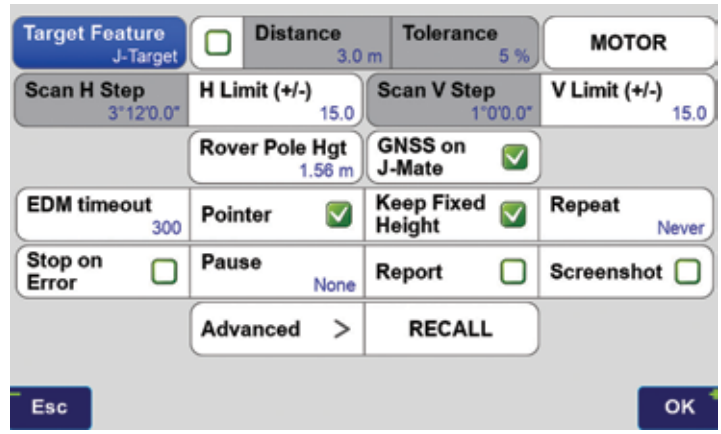
You may receive “Public” messages from JAVAD GNSS team. You do not to reply to them.

As with the TRIUMPH-LS, with the J-Mate we also provide software improvement updates regularly and free of charge. Download the J-Mate update in your TRIUMPH-LS and then inject it to the J-Mate.

Searching and finding objects by laser and by Optics

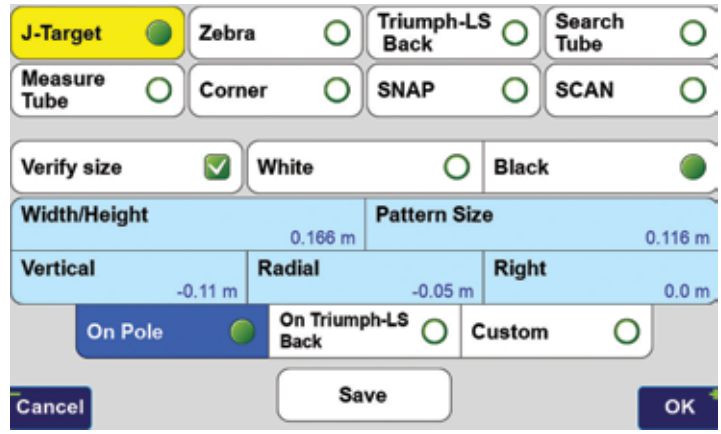
J-Mate has the unique feature of searching for objects by laser and by optics (camera).

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.

TRIUMPH-LS New Options

Integrated J-Target painted on the back of TRIUMPH-LS

Little heads-up on what is coming for TRIUMPH-LS

Soon will be an 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.**
- **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.**

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.

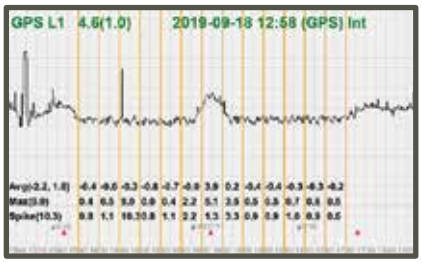
Zebra

Zebra is a pattern of black and white rings around the pole. Zebra can be searched only by optical search.

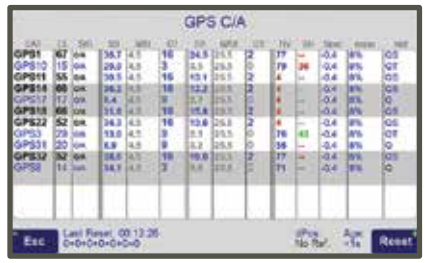
We added the "Aim" option for stake-out.

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

RTK Engines

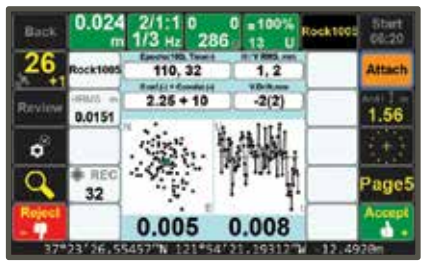


30 MHz-wide spectrum of the signal.

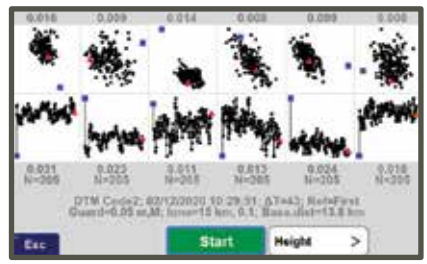


Two-peak information and spoofer.

Noise and spoofed signals.



Status of RTK survey collection.



Horizontal and vertical result of each engine.

New feature

There are three types or RTK engines:

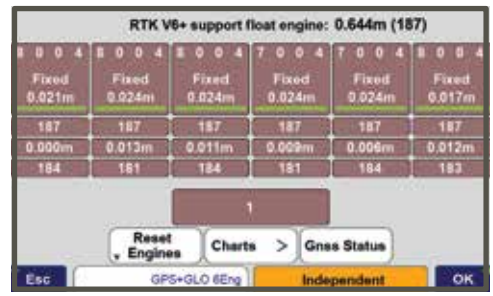
1) 6 engine GPS + GLONASS;

2) 6-engine multi constellation, and

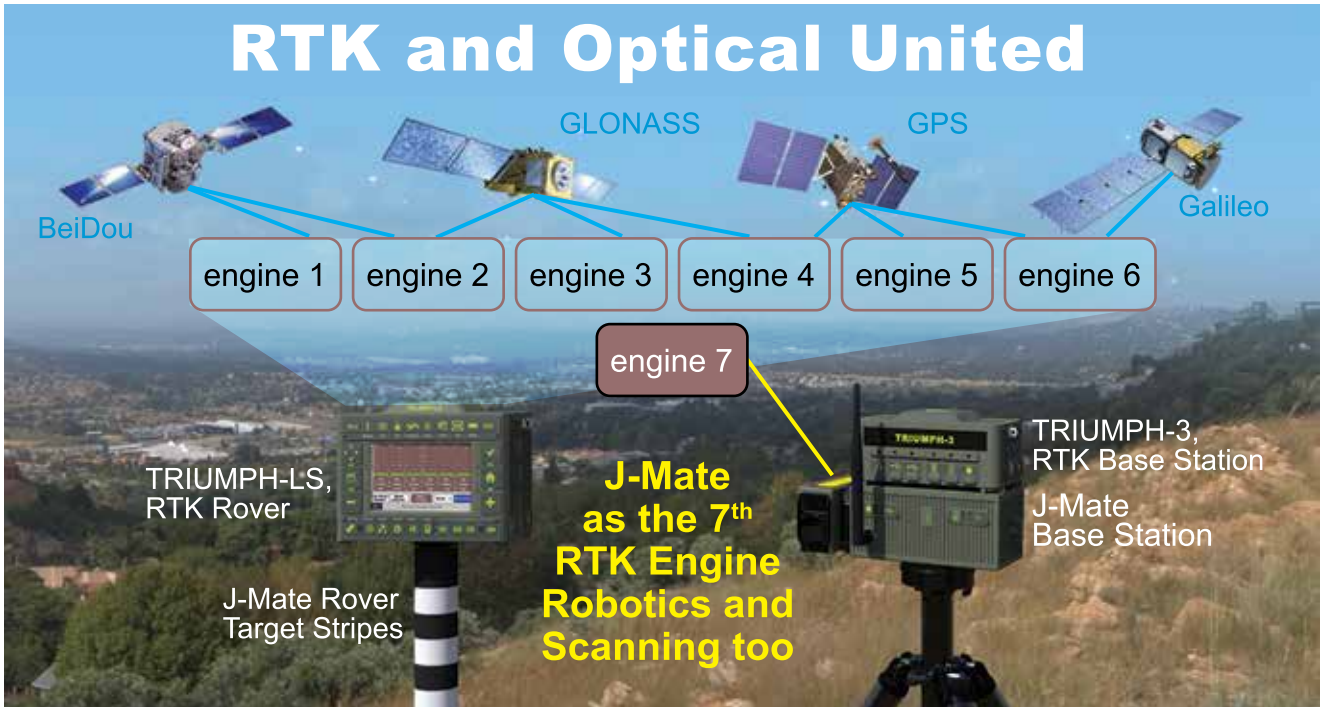
3) 2-engine multi constellation.

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 re-boot.

“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.



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

Connecting the TRIUMPH-LS to the J-Mate

Let's set the record straight: 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**.

TRIUMPH-LS communicates with the J-Mate through Wi-Fi. Turn on both the TRIUMPH-LS and the J-Mate.

Click the Setup icon on the TRIUMPH-LS Home screen and click "J-Mate" to connect to J-Mate.

The J-Mate SSID will be in JMatexxxxx format, where xxxxx is your J-Mate's serial number. After Wi-Fi connection is established, click the "Collect" or "Stake" icons according to your job.

See details at www.javad.com

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

Smart total stations in land surveying

The technological modernization and operational benefits offered by Total Stations make it the foremost preferred; they add ease and accuracy to the surveying process

Glenford V. D'Souza
Senior-General Manager and Spokesperson, LYNX: Lawrence & Mayo, India

Making decisions based on geography is basic to human thinking. Primary decisions such as our style of living, daily commute or the infrastructural planning of a city is totally co-dependent on our geographic and architectural limitations.

Today, everything has the word 'smart' associated with it. Be it smartphones, cars, homes, applications. It's all watered down to make every item and process 'smart' and technology-friendly. The concept of 'Smart Cities' continues to evolve as the human population keeps migrating to urban areas, leading to existing infrastructure undergoing radical changes.

Previously, surveying, mapping and record-keeping systems were sufficient for the needs of that time. However, these historical data points were nearly impossible to place into a single database simply because of one factor: geo-referencing. Thanks to the population explosion, sturdy and reliable infrastructure are the need of the hour.

Surveyors play a major role in the development, installation and maintenance of these cities. They assist citizens and engineers to understand the geographical situation and thus make informed decisions. Technology integrated with land surveying has been instrumental in making it all possible.

With modern times, we have seen the introduction of many new and innovative instruments for land surveying, the demand for secure measurements have been a key element for driving the expansion of 'Smart Total Stations' market.

There has been a clear shift in the land surveying process, with the introduction of various instruments for the same. Demand for fast and accurate measurements has been a key element for driving the expansion of the 'Smart Total Stations' market. It is clear that in an infrastructure-driven economy, Smart Total Stations are bringing about a transformation in this field.

The Global "Total Station Instrument Market" report 2020 highlights key points of the industry which include market dynamics and the growth of the Total Station Instrument industry in upcoming years, a market valued at millions in 2018 and it is estimated to grow further by the end of 2025.

Total Stations combine electronic distance measurement and the angle measuring capabilities of theodolites in one unit. These instruments are used to measure horizontal positions in relation to established control networks. The technological modernization and operational benefits offered by Total Stations make it the foremost preferred; they add ease and accuracy to the surveying process.

Total Station surveys are a widely used method to survey topography. With applications ranging from traditional land surveying, landform evolution monitoring, to land use monitoring. In geosciences and biological sciences, Total Stations are now becoming standard tools in monitoring geomorphic change detection of rivers, streams, beaches and more.

Conflicts have been eliminated due to advanced development. As a civilization, we have evolved in the past two decades and made more effective use of our land resources for better infrastructure and green spaces. The smart-cities, metro-cities, roadways, railways and any other form of architecture that we witness today is a testament of accurate and efficient land surveying powered by the Total Smart Stations.

These Smart Total Stations consist of high-precision, intuitive software coupled with lenses for the accurate measurement of land. The salient features of these smart stations are a significant leap in the use of technology in modern land surveys when compared to its previous versions. Therefore, it brings us to the conclusion that 'Smart Total Stations' indeed offer no gross errors, providing accuracy in better infrastructure planning.

The technology sector will continue to push the limits of computing speed, physical size and data capacity looking for the "next big thing." The surveying profession has enjoyed many of the fruits of that success, so one has to simply imagine that many more advances will soon arrive to add value to the horizon of Smart Total Stations.

In Coordinates

10 years before...

mycoordinates.org/vol-6-issue-3-March -10

The GNSS race

There are some countries trying to develop their own GNSS system. Is there any race? If yes, how appropriate and where would it lead to? Here are some views

What race?

Chris Rizos
Vice President of the International Association of Geodesy (IAG)

There is a great potential for international cooperation

Sergej G Revnivych
Deputy Director General Central Research Institute of Machine Building, leading institute of Federal Space Agency

Not appropriate to encourage unnecessary competition in the development of global public infrastructure

David A Turner
Deputy Director Space and Advanced Technology US Department of State

Every country has the legal right to build its own satellite navigation system

Bernd Eissfeller
Faculty of Aerospace Engineering University of the Armed Forces Munich, Germany

The ultimate goal of ICG is to build a GNSS system of systems

Sharafat Gadimova
Programme Offi cer ICG Executive Secretariat UNOOSA, Vienna

Complementary relationship will grow stronger in the future

Hiroaki Tateshita
Satellite Application and Promotion Center, Space Applications Mission Directorate, Japan

GAGAN signal in space-validation and utilization

The paper covers the validation and utilization of GAGAN-TDS SIS through various static and dynamic tests

Rajneesh Gupta, A S Ganeshan
ISRO, India

A synchronisation approach to automate spatial metadata updating process

This paper presents a new approach to automate spatial metadata updating process, by which dataset properties are read from the dataset fi le and written into its metadata fi le automatically

Hamed Olfat
Centre for SDIs and Land Administration Department of Geomatics, The University of Melbourne, Australia

Abbas Rajabifard
Centre for SDIs and Land Administration Department of Geomatics, The University of Melbourne, Australia

Dr Mohsen Kalantari
Centre for SDIs and Land Administration Department of Geomatics, The University of Melbourne, Australia

Fourteenth meeting of the ICG

We present here the joint statement issued at Fourteenth meeting of the International Committee on Global Navigation Satellite Systems (ICG) held at Bengaluru, India during 8 - 13 December 2019

ICG adopted by consensus the following joint statement:

1. The fourteenth meeting of the International Committee on Global Navigation Satellite Systems (ICG) was held in Bengaluru, India, from 9 to 13 December 2019 to continue reviewing and discussing developments in the field of global navigation satellite systems (GNSS) and to allow ICG members, associate members and observers to address recent developments in their countries, organizations and associations regarding GNSS services and applications.

2. On behalf of the Government of India, K. Sivan, Chairman of the Indian Space Research Organization (ISRO) and Secretary of the Department of Space presided over the inauguration of the fourteenth meeting of ICG and delivered a keynote address. Senior representatives of ISRO, including the Scientific Secretary and the Directors of the U R Rao Satellite Centre and the Space Applications Centre, the ISRO centres that are the key contributors to the navigation programme, addressed the meeting. The representative of the Office for Outer Space Affairs also addressed the meeting. The inaugural event concluded with an expression of thanks offered by the Director of the Satellite Navigation Programme Office of ISRO headquarters.

3. The meeting was attended by representatives of Australia, China, India, Japan, Nigeria, the Russian Federation, the United Arab Emirates, the United States of America and the European Union, as well as the following intergovernmental and non-governmental organizations: Arab Institute of Navigation, Asia-Pacific Space Cooperation Organization, Civil Global Positioning System Service Interface Committee, European Space Agency (ESA), Interagency Operations Advisory Group (IOAG), International Bureau of Weights and Measures (BIPM), International Federation of Surveyors and International GNSS Service (IGS). Representatives of the Office for Outer Space Affairs and the International Telecommunication Union (ITU) also participated. New Zealand and the Republic of Korea were invited to attend as observers. New Zealand was recognized by ICG as a new member.

4. ICG conducted a seminar focusing on the contributions of GNSS for societal and developmental purposes. Presentations were made on the use of satellite navigation in terrestrial and maritime transportation, timing applications, use of pseudolites for aircraft approach and unmanned aerial vehicle guidance, environmental observations and the introduction of the use of NavIC positioning data in mobile phones.

5. ICG noted that the working groups had focused on the following issues: systems, signals and services; enhancement of GNSS performance, new services and capabilities; information dissemination and capacity- building; and reference frames, timing and applications.

6. The Working Group on Systems, Signals and Services (Working Group S), through its subgroups and task forces, advanced all aspects of its workplan in the intersessional period between the thirteenth and fourteenth meetings of ICG. Under the leadership of the subgroup on compatibility and spectrum protection, an eighth GNSS interference detection and mitigation workshop was conducted in May 2019, for the third time in conjunction with the annual conference in Baška, Croatia. At the workshop, a number of concepts and ideas were presented on interference detection and mitigation capabilities and methodologies. The Working Group continued its campaign to promote adequate protection of the GNSS spectrum through education and outreach by conducting a fourth seminar on spectrum protection and interference detection and mitigation, in conjunction with a regional workshop on the applications of GNSS, held in Suva from 24 to 28 June 2019 (see A/AC.105/1216). On the basis of the positive feedback received about the success of that outreach effort, the Working Group submitted a recommendation to ICG to create a booklet addressing the importance of GNSS spectrum protection and interference detection and mitigation. The recommendation was adopted at an ICG plenary session. The compatibility and spectrum protection subgroup also maintained a close watch on ITU activities, including preparations for the World Radiocommunication Conference 2019 (WRC-19), held in Egypt in November 2019. The Working Group members received an update on the outcomes related to the radio-navigation satellite service (RNSS) spectrum. As a result of the hard work done before and during WRC-19, there were no impacts on RNSS resulting from the ITU Radio Regulations.

7. The subgroup on interoperability and service standards held three workshops during the intersessional period, in Vienna in June 2019. A workshop on

defining guidelines for developing open service performance standards was held on 12 June 2019, led by a dedicated team of experts working under the auspices of the subgroup. The main emphasis was on defining and expanding the list of parameters beyond those in the initial performance standard guidelines adopted at the thirteenth meeting of ICG. On 12 and 13 June 2019, a workshop focused on international GNSS monitoring and assessment (IGMA) took place. The subgroup also organized a third workshop focused on GNSS system time interoperability, held on 14 June 2019, in conjunction with the meeting of Working Group D. The Working Group agreed to continue those discussions by holding another workshop in conjunction with meetings of Working Groups B and D in 2020, with a focus on input from GNSS receiver manufacturers and users of different categories. Finally, the Working Group participated in a workshop chaired by Working Groups B and D, focused on precise point positioning (PPP) services, which took place in conjunction with the regional workshop held in Suva in June 2019. Based on the outcome of the workshop, Working Group S recommended the establishment of a task force on PPP interoperability, which was adopted by ICG. The task force will be co-chaired by Australia, the European Union and Japan and will prepare a workshop in 2020 to continue the discussions and address the issues raised at the 2019 workshop.

8. The Working Group also highlighted the need for consultation with the Inter-Agency Space Debris Coordination Committee regarding implementation of the recommendation from the thirteenth meeting of ICG to study the issue of debris mitigation practices relevant to the medium Earth orbit and inclined geosynchronous orbit orbital regimes used for GNSS.

9. The Working Group on Enhancement of GNSS Performance, New Services and Capabilities (Working Group B) has progressed in its activities.

10. The space user subgroup informed the Working Group on the progress made since the thirteenth meeting of ICG, when the subgroup was established. The subgroup made major progress related to the updates for the next envisaged release of the GNSS space service volume (SSV) booklet, in line with its workplan for the period 2019–2020. The finalization of a video, produced to explain the basic concept of the GNSS SSV to the general public, was expected in the first quarter of 2020. It was envisaged that the name of that subgroup would be finalized in that same period. New activities had also been identified, including discussions on the need for user guidelines or standards for space usage of GNSS and the identification of space user needs related to timing aspects. The subgroup also proposed a recommendation related to the release of the GNSS transmit antenna patterns or equivalent representative modelling information, including the side lobes, by all GNSS service providers, in order to fully exploit the potential of GNSS for space users, including missions to the Moon and beyond.

11. The Working Group recognized the efforts made by its application subgroup on creating a user questionnaire and a GNSS catalogue, and a draft questionnaire and a draft structure of the application catalogue were distributed to the co-chairs and members of the Working Group. After reviewing the current status of the project, the Working Group recommended that the project should focus on specific areas. The focus areas were still to be identified, but suggested areas were user needs with respect to emerging scientific GNSS applications such as space weather, reflectometry, PPP and unmanned vehicles. All members of the Working Group were encouraged to take a more proactive role in the project.

12. The co-chairs of the application subgroup requested each contact point to report the topics of interest to the co-chairs and to identify potential additional members of the subgroup by the end of January 2020, as input for a meeting of the subgroup to be held in March 2020. The subgroup would select the topics of focus and develop a workplan to be submitted to the Working Group for the intersessional meeting to be held in June 2020, in preparation for the fifteenth meeting of ICG.

13. Working Group B, as part of its agenda, addressed additional aspects of GNSS usage in space, on the basis of presentations provided by the National Aeronautics and Space Administration (NASA) of the United States and by India and China. The Working Group was provided with updates on space missions using GNSS receivers based on the information recorded by IOAG. NASA shared new results of the navigation performance of the Magnetospheric Multiscale (MMS) mission and discussed plans and analyses related to the use of GNSS for its lunar exploration missions. NASA reported on the successful first operational use of the NASA Autonomous Flight Termination System using global positioning system during a launch on 6 December 2019. China reported a signal improvement method for cislunar space missions. India informed the Working Group about activities for orbit determination for Navigation with Indian Constellation (NavIC), including extended Kalman filter-based on-board orbit determination using GNSS and investigations on NavIC extended ephemerides, the efforts of India for SSV and lunar missions, as well as on pseudo-random noise number (PRN) code design for a future NavIC signal on the L1 band. China introduced a low Earth orbit (LEO) satellite-based augmentation system using 120 LEO satellites to provide global fast convergence high-accuracy

PPP, GNSS monitoring and integrity augmentation services. The Russian Federation made a presentation on developments relating to the module for real-time kinematic navigation, with respect to multi-GNSS and integration with inertial sensors.

14. As part of the scientific presentations, India provided details on many scientific investigations and research for future applications such as the following: a NeQuick model-based ionospheric corrections and solar flux estimation for NavIC, modelling of perturbations in the total electron content in the ionosphere for space weather studies, atmospheric water vapour detection using GNSS and its impact on weather prediction, the detection of seismic activities utilizing NavIC signals by identifying anomalies in the ionosphere, and the benefits of GNSS signals for weather monitoring employing GNSS reflectometry techniques.

15. China informed the Working Group about the BeiDou Navigation Satellite System (BDS-3) on board space weather payloads and the recent release of data on the BDS web page (http://en.beidou.gov.cn/). Since most GNSS satellites have space weather payloads, China suggested that GNSS providers share space weather data. Furthermore, China suggested that a correspondence group on this topic be established within the Working Group. This point will be addressed as part of the Working Group's activities leading to the fifteenth meeting of ICG.

16. Japan informed the Working Group on the progress of the emergency warning service of the Quasi-Zenith Satellite System (QZSS) and provided an update on the activities of the correspondence group on the emergency warning service. A draft message definition had been shared with the contact points of the correspondence group. Future work will focus on the definition of the technical specifications of emergency warning messages. More active response from each contact point was encouraged. China provided the Working Group with an update on the progress of the BDS synthetic aperture radar and the BDS return link service. India made a presentation on the results of a project for monitoring coastal rip currents and how those results had been used to improve safety on beaches along the Indian coastline.

17. The Working Group expressed its appreciation for the variety of the contributions and noted the growing importance of the scientific use of GNSS. In addition, the Working Group agreed to organize the joint session held with Working Groups S and D on the topics of PPP and timing interoperability.

18. The Working Group on Information Dissemination and Capacity-building (Working Group C) considered, through its extensive deliberations, the outreach programmes and the capacity-building activities carried out by ESA, the University of Tokyo, the Tokyo University of Marine Science and Technology of Japan, Beihang University of China, the United Nations-affiliated Regional Centre for Space Science and Technology Education for Asia and the Pacific, ISRO of India, Moscow State University of Geodesy and Cartography of the Russian Federation, and the European Union. It was emphasized that those institutions could collaborate on future training curricula and opportunities.

19. The Working Group examined in depth certain points pertinent to offering superior quality of education on GNSS and building up sustainable cooperation. Those points included the exchange of faculty staff from different regional centres, approaches and methods for the dissemination of GNSS data and information about GNSS-related events, and encouraging the above-listed institutions participating in the Working Group to consider making online GNSS courses available.

20. The Working Group noted that a communication framework for the sharing of short-term training opportunities should be developed, enabling efficient use of programmes provided by the regional centres for space science and technology education, affiliated to the United Nations and other institutions. By virtue of the experience in conducting short-term training courses, the Regional Centre for Space Science and Technology Education for Asia and the Pacific in India could take a leading role in organizing such courses.

21. The Working Group on Reference Frames, Timing and Applications (Working Group D) noted the significant progress on the geodetic and timing references made by the GNSS providers. Specific progress was noted on: (a) the refinement of the alignment of GNSS reference frames with the International Terrestrial Reference Frame (ITRF); and (b) the information on the GNSS timing references and the inter-comparisons of GNSS time offsets. The Working Group noted that the templates on geodetic and timing references currently provided on the ICG information portal should be updated by the GNSS providers so that they contain the most current information.

22. It was noted that the work of ICG and the Working Group had resulted in significant progress in the realization of GNSS reference frames, and especially with regard to their alignment to ITRF. This progress included deformation of the terrestrial scale. As this work progressed into a high- accuracy positioning community service, participants were encouraged to consider how to address potential issues of reference frame interoperability.

23. Knowledge of satellite physical and geometrical properties related to the shape, mass, optical properties,

dimensions and locations of radiating antennas permits improved orbit modelling, which in turn increases the accuracy of satellite ephemerides and clock correction determination. The Working Group acknowledged that there had been some progress made in the provision of satellite properties by the GNSS providers, on the basis of ICG recommendation No. 23 and in accordance with the IGS white paper entitled "Satellite and operations information for generation of precise GNSS orbit and clock products". IGS collects and makes available GNSS satellite properties to the user community. Access to satellite metadata was essential for enabling scientific applications and for high-accuracy precise positioning. The Working Group also noted that providing GNSS satellite phase centre offsets made it possible to determine the ITRF scale using GNSS. The Working Group acknowledged the release of additional satellite metadata for QZSS, the European satellite navigation system (Galileo) and BDS.

24. The Working Group noted that there had been little progress on ICG recommendation No. 12. Some providers were providing GNSS data from their tracking stations to IGS. The Working Group will continue to monitor progress. The Working Group continued to contribute to the IGMA initiative, in particular through involvement in the IGMA Task Force IGS joint trial project.

25. The Working Group noted progress on ICG recommendation No. 21 on monitoring the offsets between GNSS times. Studies had been conducted by some providers and the timing community identifying several methods to improve their time offset determination and the impact on positioning. Additional work was necessary for the providers to assess the accuracy goals in the determination of the GNSS time offsets and the impact on positioning so as to specify a recommended method to determine and monitor time offsets. At the joint session of the Working Groups S and D, it was concluded that a further workshop should focus on addressing these questions in 2020 by inviting receiver manufacturers to discuss multi- GNSS positioning and interoperability.

26. The task force on timing references of the Working Group noted that there had been significant progress related to the ICG recommendation No. 20, as BIPM was on the verge of extending the provision of Coordinated Universal Time (UTC) – UTC(k)_GNSS to Galileo and BDS. The Working Group also noted the excellent performance of UTCr, in particular since July 2017. It was recalled that the creation of UTCr by BIPM was initiated subsequent to ICG recommendation No. 19.

27. The Working Group recognized the contributions from India and the presentations on the NavIC timescale, time transfer and space-based clock. The Working Group noted interest of NavIC in proposing an update regarding the ICG recommendation No. 20 at the next meeting of ICG.

28. With respect to education and capacity-building in developing countries, the Working Group members also participated in education, outreach and community engagement projects, in partnership with Working Group C. Linkages between ICG capacity-building initiatives and the Sendai Framework for Disaster Risk Reduction were also described.

29. The chairs of Working Groups C and D recognized the synergies that existed between the activities of the two working groups in the fields of GNSS, geodesy and reference frames. The two working groups therefore both agreed to continue to work together and contribute to capacity- building in the field of GNSS and the utilization of GNSS in geodesy and reference frames.

30. The Working Group held a joint meeting with the Working Groups B and S to discuss the Interoperability of GNSS PPP services. The discussions in the joint meeting highlighted the importance of harmonizing key aspects of system-provided PPP services, which subsequently led to a recommendation to establish a task force under the interoperability subgroup of Working Group S.

The detailed report can be accessed from

https://www.unoosa.org/oosa/en/ourwork/icg/meetings/ICG-2019.html

FORM IV

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I, Sanjay Malaviya, hereby declare that the particulars given above are true to the best of my knowledge and belief.

March 1, 2020 Signature of publisher

NCAER releases India's first Land Records and Services Index

National Council of Applied Economic Research (NCAER), released its new Land Records and Services Index (N-LRSI 2020), on Thursday, 27th February, 2020. The N-LRSI assesses the extent of digitisation of land records and the quality of these land records in the States and Union Territories of India. Madhya Pradesh, Odisha, Maharashtra, Chhattisgarh, and Tamil Nadu emerged as the top States in the N-LRSI 2020.

The N-LRSI is an integral part of the NCAER Land Policy Initiative (NLPI) launched in 2019 with the aim of filling the gaps in economic research, policy analysis, and systematic data on land. Access to land is a critical factor for economic growth and poverty reduction. For government, industry, and citizens to be able to use this asset effectively and to minimise disputes, it is important to have access to reliable land and property records. Over the years, different states have made significant progress in making their land records digitally available to citizens. The N-LRSI aims to understand the extent of this progress and existing gaps and to identify measures to improve land records in each state.

The 2020 N-LRSI is based on data collected over 2019-20 on two aspects of the supply of land records—the extent of digitisation of land records and the quality of these land records. The first component, which aims to assess whether a state has made all its land records digitally available to citizens, looks at three dimensions—the text of the land records (also called the record of rights), the official map associated with a land record (also called cadastral maps), and the property registration process.

The second component of the Index aims to assess if the land records are comprehensive and reliable–are ownership details updated as soon as a sale occurs, the extent of joint ownership, type of land use, land area on the record and on the map, and

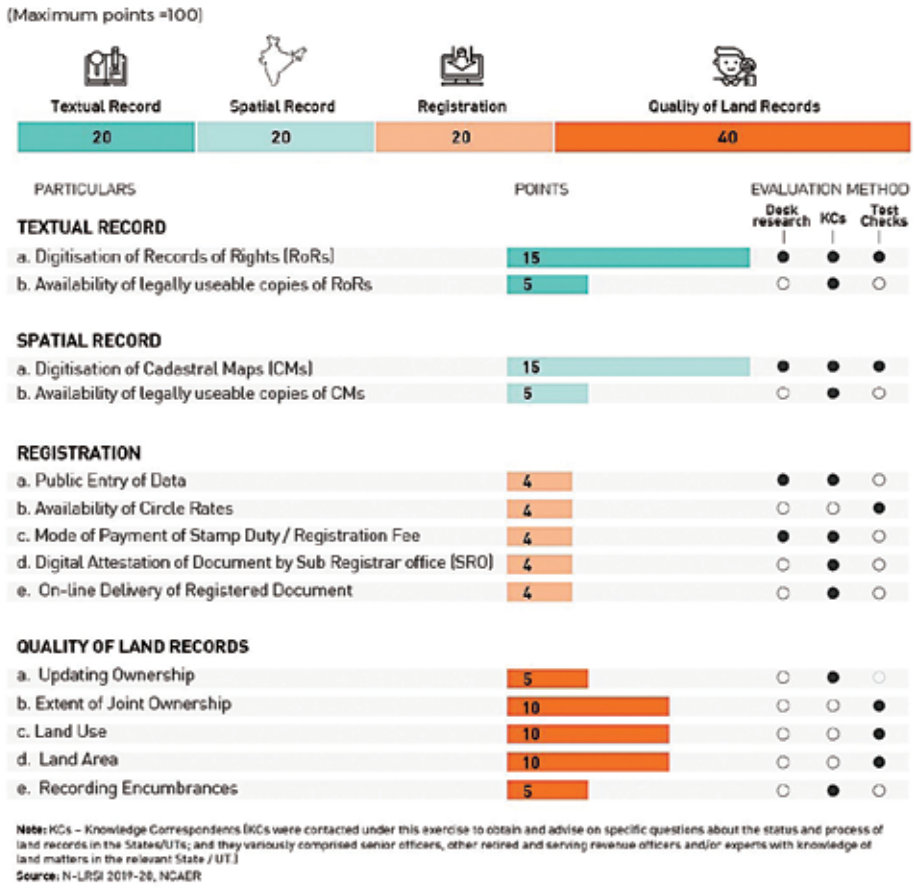

Figure 1: Structure of the N-LRSI

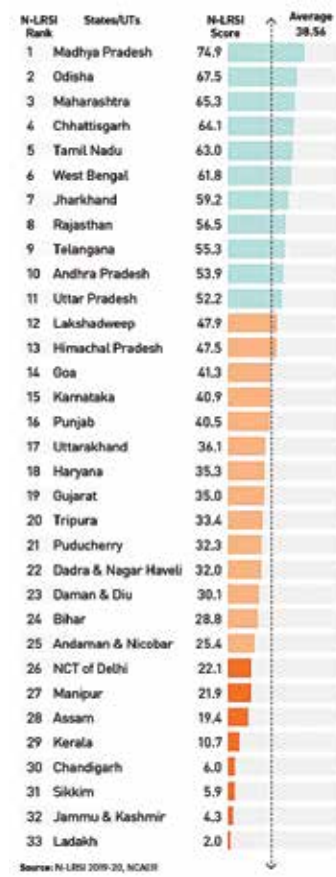

Figure 2: N-LRSI 2020 State Rankings

are encumbrances being recorded (other claims on the property such as mortgages and court cases). All these elements are closely connected to land disputes and to the ease with which transactions in land can be completed and legally recorded and then conveniently accessed. In his introductory remarks, Dr Shekhar Shah, Director General, NCAER, noted that "The N-LRSI is timely, pioneering work and is already attracting policymaker attention at the Central and State levels. The Index can serve at least three purposes. First, it will help formulate State action plans to attain the goal of secure, assured land records that mirror ground realities and are generated by efficient titling services. Second, the N-LRSI's comparative assessment of States and UTs will make it possible for the States to learn from each other, with the best performing States showing how the supply of good, reliable, accessible digital land records has been improved. Third, the Central Government can use the N-LRSI to reward and recognise States and UTs that perform better on the Index so that the others are encouraged to improve their standing."

Talking about the next steps for the N-LRSI, project co-leader Professor Devendra B Gupta said, "The first round construction of the N-LRSI primarily used supply-side data during 2019-20, including proxies for measuring access for citizens, for assessing the extent of digitisation and gauging the quality of land-records services offered. For the second round using data for 2020-21, a demand-side survey of citizens will be added to gauge the level of public awareness and satisfaction in using digital land records and associated services."

N-LRSI 2020 Findings

Scoring 60-75 points, Madhya Pradesh, Odisha, Maharashtra, Chhattisgarh, and Tamil Nadu are the five best-performing States on the N-LRSI. West Bengal, Jharkhand, Rajasthan, Telangana, Andhra Pradesh, and Uttar Pradesh are the six States in the 50-60 point category. Figure 1 shows the different components of the N-LRSI and their weights and method of evaluation. *www.ncaer.org*

GIS to be set up with mobile app for Haridwar Mahakumbh, India

Upcoming Mahakumbh in 2021 in Haridwar will be put on GIS to enable better management of the mega event along with developing an android mobile application for the pilgrims coming to the Mahakumbh.

MPS Bisht, director of USAC said, "we are set for application and integration of technological tools for the convenience of people and the government. High-quality pictures, maps, rods and other geographical data will be collated for use of the public as well as the authorities".

Uttarakhand Space Application Centre (USAC) has taken up the task which will be first of its kind effort to manage any of the Mahakumbhs in the country, claimed USAC officials. The setup will be using satellite imagery which would enable the authorities to have real-time data for monitoring of the event. After getting fully developed, USAC will launch to develop a mobile-based application or app to facilitate the pilgrims coming to the Mahakumbh. The plans are to integrate GIS-based data with the help of a dedicated support system to official website of the municipal corporation for accessibility of the same to government and public as per access rights. *www.newindianexpress.com*

Haulotte launches BIM library

Haulotte has set up a BIM (Building Information Modeling) library on its website. It means construction professionals can now incorporate computer generated versions of Haulotte's models in their design plans to provide an accurate picture of what equipment is required. *www.haulotte.in*

Esri partners with Saint Louis University

Esri has entered into an official partnership with Saint Louis University, well-known for its commitment to geospatial research and application. The university recently founded the Geospatial Institute, also known as GeoSLU. The institute encourages students and staff from a variety of areas to explore ways that GIS technology can provide insight into issues affecting the world today, including climate change, access to food and clean water, and economic stability.

Esri will collaborate with Saint Louis University to advance programs focused on these and other areas of global concern. *www.esri.com*

SSC and Geo-Insights sign MoU

Swedish Space Corporation (SSC) and Geo-Insights (GI) have signed a memorandum of understanding (MoU) for collaborative activities regarding satellite ground station services on the Asia-Pacific market, ultimately expanding their businesses in the region.

The agreement will provide new possibilities for SSC and GI to serve their existing and future customers in Asia-Pacific, currently the fastest growing space market globally. The partners will co-operate to expand satellite ground systems and services in the region by sharing capacity and competence. *geo-insights.ai*

Urban Links Africa project in Cape Town

Connected Places Catapult has announced the launch of its Urban Links Africa project at an event in Cape Town, South Africa. This flagship project will see joint UK and African innovations deployed to solve pressing challenges in Africa's rapidly growing cities.

The project's goal is to facilitate a sustainable collaboration between the UK, South Africa and Kenya by bringing together cities and tech ecosystems through equitable partnerships and industry investment, to address African cities' key challenges and improve life for citizens.

Funded by Innovate UK, Urban Links Africa (ULA) – which began in September 2019 and will run until April 2021 – will pilot market-led solutions to key urban challenges in Nairobi, Mombasa and Kisumu in Kenya; and Cape Town, Johannesburg and Durban in South Africa. *cp.catapult.org.uk*

World's largest platform for air quality data launched

The United Nations Environment Programme (UNEP), together with UN-Habitat and IQAir, a Swiss air quality technology company, have launched the world's largest air quality data platform, bringing together real-time air pollution data from over 4,000 contributors, including citizens, communities, governments and the private sector to work towards healthier, more sustainable cities.

Launched at the Tenth World Urban Forum in Abu Dhabi, this partnership – currently reaching over 15 million users and covering more than 7,000 cities worldwide – aims to sustain and grow the world's foremost air quality databank.

The data, shared on a single, UN-coordinated platform, will empower governments to take action to improve policy, allow citizens to make more informed health choices and demand action from their governments, while giving businesses the ability to make investment decisions that promote a cleaner, greener environment.

The need to act is urgent. Globally, 7 million people die each year because of air pollution; 650,000 of these are children. Air pollutants not only affect our health, they also affect ecosystems and food production; air pollution is also linked to climate change. Despite this, most citizens don't have access to real-time air quality data.

The UNEP platform builds upon IQAir's technology to aggregate, validate and calibrate air quality data that up until now was either restricted to individually-run websites or apps, or not shared publicly. UN-Habitat helps cities to develop plans that can reduce air pollution, including better public transport and waste management interventions. *iqair.com*

Collaborative cloud construction intelligence management platform by Yovza

Yovza Technologies FZ-LLC, UAE's most economical Construction Technology solution provider, launched its state-of-the-art construction intelligence management platform Yovza.com in Dubai. It is positioned to be an integrated solution that will connect businesses within the construction industry across the segments of four key project stakeholders taking their operations completely paperless. Starting from Engineering Consultants, Main-Contractors, Sub-Contractors and Material Suppliers. The solution will bind together project information and project controls on a single cloud-based collaborative intelligence management platform. *yovza.com*

Geospatial eXploitation products software with industrial intelligence data

Industrial Info Resources (IIR), provider of worldwide, accurate, and continuously updated industrial facility and infrastructure intelligence and information, has announced that it is providing a global Industrial Intelligence database for integration into BAE Systems' Geospatial eXploitation Products™ (GXP®) software. Integrated as an image overlay, this database represents the collection, validation, and categorization of human-sourced industrial intelligence acquired over three decades from vital industries such as energy, materials, chemicals, manufacturing, pharmaceuticals, food and beverage, as well as supporting infrastructure. *www.industrialinfo.com*

1Spatial announces new mobile platform for spatial data collection

1Spatial has announced an exciting evolution to its product range. The new Location Mobile App Platform (LMAP) enables easy and flexible spatial data collection whilst in the field. Leveraging existing expertise in data management and data quality into a mobile app platform delivers an easy to use UI, complete flexibility in integration and in-built validation based upon business rules. *www.1spatial.com*

Fugro selected for Australian Government

The Australian Government has selected Fugro to join the HydroScheme Industry Partnership Program (HIPP) to increase Australia's hydrographic industry capability. The panel of industry partners was chosen as part of a long-term strategy to ensure safe shipping routes, commercial ports and maritime approaches within the Australian Charting Area. Panel members will acquire marine environmental data to produce digital maps of Australia's sea and coastal areas that will improve the safety of maritime vessels operating in Australia's sea charting area, which covers 10 % of the earth's surface. *www.fugro.com*

SBG Systems strengthens its presence in Asia

SBG Systems has announced the opening of its new subsidiary in Singapore. Located in the center of the city, this new office brings sales and technical support to the Asian region. *www.sbg-systems.com*

Doka launches software for formwork planning in BIM

Doka has launched DokaCAD for Revit, its software for automated formwork planning. Efficient formwork systems influence the success of a shell construction project, which requires correct and reliable formwork planning and optimal cycle planning.

The use of building information modelling (BIM) in construction design is a key factor in productivity gains, and BIM models are increasingly used as the basis for formwork planning. *www.doka.com*

Next generation platform "Medallion GPS PRO" for Light-commercial fleets

IGEN Networks Corporation a leading innovator of cloud-based and Internet of Things (IoT) solutions for the protection and management of mobile assets, has announced its launch of its Next Generation "Medallion GPS PRO" product line targeted for Light Commercial Fleets for US markets. It is a Commercial Fleet Management Platform designed for the Light Commercial Fleet owner, with compelling features and services at lower costs and emphasis on ease-of-use. The system is organized around both asset and driver with dispatch capabilities, automated reporting, maintenance and diagnostics reporting, driver behavior scoring, and video tutorials on demand that are built on AWS Cloud-based infrastructure. The Sprint IoT Factory platform is enabled through a strategic relationship with myDevices, the Internet of Things (IoT) solutions company that "simplifies the connected world" to accelerate the development and sales of finished IoT solutions. *www.igennetworks.net*

Inpixon releases new features for indoor mapping platform

Inpixon, a leading indoor data company that specializes in delivering indoor intelligence, has released its latest mapping platform, Jibestream 4.12. The update delivers a number of new and enhanced features to streamline the creation, management and delivery of indoor maps. The release also includes support for point labels and new capabilities for integrating outdoor and indoor maps into a single application.

This release's Outdoor-Indoor Kit for Google Maps allows customers to utilize Google Maps' SDK along with the Jibestream SDKs to deliver outdoor/indoor experiences in a single app. For instance, an app user in their home can enter a specific destination within a target facility and be guided through the outdoor portion of their journey to the best building entrance using the Google map, and then be guided within the building to their indoor destination using the Inpixon map. Optional integration with smart parking systems can guide users to open parking spaces or to their parked vehicle.

Latin American farmers to increase crop yields by 12%

Rezatec, a leading provider of geospatial data analytics, has launched a free smartphone app which acts as a portal for farmers to record their agricultural activities and provides recommendations for optimal sowing and irrigation scheduling. Based on preliminary results from the experimental stations, the app has demonstrated the potential to increase wheat yields by up to 12%.

COMPASS v2.0 provides decisions based on Earth observation satellite data, in-situ field data captured by farmers, and a sophisticated crop model, to identify factors that might cause lower crop performance. In the Yaqui Valley in Mexico, a region that relies on irrigation due to varying climatic conditions, water security is a serious challenge. With general circulation models predicting less water availability in the future, farmers must be very precise in their irrigation management. The technology will track crop growth performance allowing farmers to make more informed decisions about crop management. *www.rezatec.com*

GPS tracking devices receive Verizon LTE-M certification

Digital Matter, a leading global developer of battery powered GPS asset tracking devices has announced that Verizon has officially certified the Oyster2 and Yabby 4G LTE-M GPS devices to operate on the most reliable wireless data network in the United States.

Designed for tracking any non-powered asset for extended periods of time, common applications of the Oyster2 and Yabby battery powered tracking devices include tracking trailers, containers, bins, bikes, scooters, pallets, livestock and more. *www.digitalmatter.com.*

Galileo gives major backing to SuperHalfs Series

The European GNSS Agency (GSA) and SuperHalfs have announced that Galileo has thrown its support behind the international half marathon series and will become the Presenting Partner. The news comes as thousands prepare to plot their running journey across the continent.

Galileo is Europe's independent, civilian and free system behind the location services that billions use every day in smartphones, cars, planes, fitness trackers and various other devices. *superhalfs.com*

Tesla to add third-party charging stations to its in-car navigation

Tesla is starting to add third-party charging stations to its in-car navigation on top of its own Superchargers and Destination chargers.

While there are several other growing third-party charging networks, most Tesla owners never have to use them as Tesla's own networks cover a large part of almost all the markets where it sells its vehicles. These chargers are all listed in Tesla's in-car navigation system, which is going to route you directly to a Supercharger station if your final destination cannot be reached based on your current state-of-charge. Now Tesla is starting to add third-party stations to its maps and navigation, which should help owners make use of the station *https://electrek.co*

COAST autonomous and DG cities collaboration

COAST Autonomous has signed a Memorandum of Understanding ("MOU") with DG Cities, an expert in smart city development that is a subsidiary of the Royal Borough of Greenwich in London. Both will work together to provide consultancy services related to the design and implementation of transportation for people and/or goods using Autonomous Vehicles ("AVs"). Complementary skills of both will offer cities a path to a sustainable and more livable future. *www.coastautonomous.com*

The ION releases the GNSS Software Defined Radio (SDR) metadata standard

The Institute of Navigation's (ION) GNSS Software Defined Radio Metadata Standard document has been published and is available at sdr.ion.org.

The Global Navigation Satellite Systems Software Defined Radio Sample Data Metadata Standard is the product of a three year long effort of the ION GNSS SDR Standard Working Group and defines parameters and schema to express the contents of SDR sample data files. The standard promotes the interoperability of GNSS SDR data collection systems and processors.

In recent years there has been a proliferation of software defined radio (SDR) data collection systems and processing platforms designed for Global Navigation Satellite System (GNSS) receiver applications or those that support GNSS bands. For post-processing, correctly interpreting the GNSS SDR sampled datasets produced or consumed by these systems has historically been a cumbersome and error-prone process. This is because these systems necessarily produce datasets of various formats, the subtleties of which are often lost in translation when communicating between the producer and consumer of these datasets. This specification standardizes the metadata associated with GNSS SDR sampled data files and the layout of the binary sample files.T he formal standards document is free and available at *sdr.ion.org*.

Third GPS III Satellite delivered

Lockheed Martin in Denver has shipped its third GPS III satellite to Cape Canaveral for the U.S. Space Force's "first" GPS III launch in April. GPS III Space Vehicle 03 (GPS III SV03), nicknamed "Columbus" by the GPS III government-industry team, shipped out of Buckley Air Force base on Feb. 5. Meanwhile, the first GPS III satellite (GPS III SV01) was declared operational in January; GPS III SV02, launched in August, has completed on-orbit testing, and is ready and waiting to join the GPS constellation; and, also in January, GPS III SV04 was declared "Available for Launch."

Centimetre-level positioning for autonomous vehicles

A multi-partner European project has achieved positioning accuracy for an autonomous truck using data from the Galileo GNSS, in combination with other positioning and sensor technologies.

Autonomous vehicles and their advanced driver assistance systems need robust and precise positioning information to enable reliable operations, which will be particularly important during the early transitional phase of the technology, when other vehicles around them will not be automated. The new and innovative positioning solution was developed in the European PRoPART (Precise and Robust Positioning for Automated Road Transports) project, which has involved Swedish truck maker Scania and six other partners. The project team believes the centimetre-level positioning system could be a key enabler for autonomous transport in the future.

The solution was demonstrated in a recreated motorway situation at the AstaZero test facility in Sweden, with a connected autonomous truck and two unconnected manned cars. As part of the test, a Scania self-driving truck executed a safe and efficient lane change in traffic. The manoeuvre was managed by the new system, relying on centimetre-level positioning combined with collaborative perception sensor data.

The project demonstrated that it was possible to pinpoint the position with 10cm (4-inch) accuracy. The truck could execute the manoeuvre due to the precise positioning and an accurate representation of the whole surrounding environment. This was achieved by fusing data from the truck's camera and front and side radars combined with radars mounted on roadside units (RSUs).*www.traffictechnologytoday.com*

Turkish satnav station opens in Antarctica

Turkish specialists have opened a GNSS base station in Antarctica, Turkish Industry and Technology Minister Mustafa Varank said.

The Fourth Antarctic Expedition of Turkey began on Feb. 9 under the coordination of the Scientific and Technological Research Council (TUBITAK) Polar Research Institute. The GNSS station operates on Dismal Island, 73 kilometres (45 miles) from Horseshoe Island, where the temporary Turkish science base is located.

The 24-member Turkish research team joins 15 scientific projects in the Earth, life, and marine sciences. The expedition is being conducted under the auspices of the Turkish Presidential Administration and the Ministry of Industry and Technology and coordinated by the TUBITAK. *https://sputniknews.com*

Russia to launch 9 Glonass-K Navigation Satellites by 2022

Russian satellite maker ISS-Reshetnev will add nine next-generation Glonass-K satellites to the constellation of the global navigation satellite system by 2022, the firm›s spokesman said.

At the moment, the group consists of 26 Glonass-M satellites and two test variants of the next-generation Glonass-K. New variant, Glonass-K2, will be introduced in 2023. www.*urdupoint.com*

Four new Chinese Beidou GNSS satellites declared operational

Four new satellites for the Chinese BeiDou Navigation Satellite System (BDS) recently passed technical and system tests and checks in orbit, and have started operations within the BeiDou global navigation satellite servive (GNSS) network, according to China's Satellite

Navigation System Management Office. The four new satellites are the 41st, 49th, 50th, and 51st satellites within the BDS GNSS constrellation. *https://spacewatch.global/2020/02/four-new-chinese-beidou-gnss-satellites-declared-operational/*

Trump demands protection for GPS-based transportation

President of the USA, Donald Trump issued an executive order aimed at protecting and promoting GPS for positioning, navigation and timing (PNT) services used in transportation systems.

"Because of the widespread adoption of PNT services, the disruption or manipulation of these services has the potential to adversely affect the national and economic security of the United States," the order states. «To strengthen national resilience, the Federal Government must foster the responsible use of PNT services by critical infrastructure owners and operators.»

The order requires that within 180 days the Secretary of Transportation, along with other cabinet agency heads, is to develop a pilot program to evaluate the responsible use of PNT services with infrastructure owners and operators. The pilot is to be completed within one year of creating an initial plan, with results used to develop a "PNT profile" and to inform opportunities for research and development.

"PNT services, such as [GPS], are critical to the safe and efficient use of the national transportation system by the traveling public, the freight community, other commercial and private entities," the U.S. Department of Transportation said in a statement.

"The Department is committed to working with industry, as well as the other departments and agencies, to ensure expeditious implementation of the framework and resulting transportation PNT profiles. Our challenge is to enable increased resilience across our transportation systems and ensure the traveling public and freight transporters experience an increased level of safety and efficiency without the possibility of interference caused by loss or manipulation of PNT."

Because trucking is relying increasingly on GPS to improve efficiency and reduce costs, the new policy is likely to draw the attention of technology developers.

A study commissioned by the U.S. Commerce Department's National Institute of Standards and Technology found that GPS-based PNT services have led to over $1.4 trillion in U.S. economic benefits since GPS became available in the 1980s, according to the agency. It pointed out that the same study estimates a hypothetical disruption to GPS could result in $30 billion-$45 billion in economic losses over a 30-day period. *https://finance.yahoo.com*

Apple applies for machine learning GNSS device

Earlier this month, Apple applied to the Federal Communications Commission for to a license to install GPS testing equipment on its headquarters campus.

This may be related to an application filed by Apple Inc. with the U.S. Patent Office in August 2019, which describes the company's "Machine Learning Assisted Satellite Based Positioning."

A device implementing a system for estimating device location includes at least one processor configured to receive an estimated position based on a positioning system comprising a Global Navigation Satellite System (GNSS) satellite, and receive a set of parameters associated with the estimated position.

The processor is further configured to apply the set of parameters and the estimated position to a machine learning model, the machine learning model having been trained based at least on a position of a receiving device relative to the GNSS satellite.

The processor is further configured to provide the estimated position and an output of the machine learning model to a Kalman filter, and provide an estimated device location based on an output of the Kalman filter.

In 2015, Apple acquired the small enhanced-GPS company Coherent to aid the speed and accuracy of its devices' location services. Presumably, Apple intends to incorporate its machine-learning positioning method into its navigation software.

ESA's Galileo satnav system can now reply to SOS signalsVIEW 6 IMAGES

Galileo satellite navigation system can now not only receive, relay, and locate distress beacon signals, it can also respond to the SOS, sending back an acknowledgement to those awaiting rescue that their location and call for help has been received and search and rescue services are responding. The new function became operational during the 12th European Space Conference in Brussels, which ran from January 21 to 22, 2020.

The Cospas-Sarsat, as it is currently configured, is a compromise between the original deployment of low-Earth-orbit satellites, which accurately pinpointed distress signals by measuring their Doppler shift but could only see small areas, and later payloads in geosynchronous orbit, where the system could see larger areas but couldn't measure Doppler shifts.

However, the Galileo constellation is composed of medium-orbiting satellites at an altitude of 23,222 km (14,429 mi) – high enough to see large areas of the Earth's surface, but low enough to locate an object within five minutes to within as little as a kilometer (0.6 mi). Distress signals are relayed to Medium-Earth Orbit Local User Terminals (MEOLUT) in the Spitsbergen Islands, Cyprus, and the Canary Islands under the coordination of a control center in Toulouse. The signals are then relayed to local search and rescue authorities.

Now, the system has a "return link" function that can send an acknowledgment back to the beacon transmitting the SOS in under a maximum of 30 minutes and in as little as one or two minutes.

NAV CANADA signs strategic agreement with Unifly

Canada's civil air navigation service provider, NAV CANADA, has entered into an agreement with Japan-based Terra Drone Corporation's portfolio company, Unifly, to help drone pilots plan future missions. As a strategic technology partner to NAV CANADA, Unifly will facilitate the deployment of a national system that would provide digital services for safely operating and managing drones in the Canadian airspace.

UAV Navigation is compatible with Trimble UAS1

UAV Navigation has announced that its flight control solutions for Remotely Piloted Air Systems/Unmanned Aerial Vehicles (RPAS/UAVs) are compatible with the Trimble UAS1, a high-precision GNSS receiver. The core benefits of Trimble's GNSS solution include centimeter-level precision and easy integration.

ideaForge and L&T Ink MoU for Unmanned Aerial Systems

ideaForge, India's largest manufacturer of Unmanned Aerial Vehicles (UAVs) and Larsen and Toubro (L&T), India's multinational engineering conglomerate and the largest private sector defence company have entered an MoU to offer drones and allied systems for defence use.

Both the companies will combine their strengths to offer hi-tech, integrated drone solutions to enhance security and surveillance. They will also offer anti-drone solutions to counter the threat of malicious or unintended usage of drones. *www.ideaforge.co.in*

First BVLOS Drone Waiver In South Africa

Iris Automation announced that customer United Drone Holdings (UDH) has been granted the first Beyond-Visual-Line-of-Sight (BVLOS) flight approval by the South African Civil Aviation Authority (SACAA) to conduct long-range commercial flights with vertical take-off and landing (VTOL) aircraft.

The SACAA's approval for the flight was granted based on the utilization of the Iris Automation Casia onboard detect-and-avoid system, which was demonstrated during live flight operations that included the Casia system making automated maneuvers to avoid collisions with manned aircraft. The approval from the SACAA requires no visual observers or ground-based radars, enabling BVLOS flights with only two crew members. *www.irisonboard.com*

GarudaUAV Expands Service Coverage to the Entire Delhi Region

GarudaUAV has announced the expansion of its operations and maintenance (O&M) services to the whole of Delhi distribution region. The company now counts Tata Power-DDL, BSES Delhi's Yamuna Power and Rajdhani Power as its clients for drone-based O&M services.

GarudaUAV helps the distribution companies to pre-empt faults by conducting drone-based maintenance and repair tasks. It creates thermal maps of and geo-tags various transmission and distribution assets like poles, pylons, overhead wires, grid sub-stations, transformers, switches and capacitors.

Using its AI-powered enterprise drone platform, it helps with timely detection of asset deterioration, corrosion, vegetation encroachment, plinth conditions and wear and tear of various components which, if undetected, could cause power outages. *garudauav.com*

New drone-powered haul router tool by TraceAir

TraceAir, a construction management platform powered by drone data, has announced the launch of the new drone-powered Haul Router tool, developed together with Independent Construction, the owner of one of the largest dirt moving fleets in the United States. The tool helps foremen to make data-driven decisions with regard to new or existing haul roads.

Moving dirt on a mass grading job can cost anywhere from $2.5 to $5 per cubic yard, depending on the haul road used. Even a small deviation from the optimal path can cost contractors a fortune in lost margins. For example, moving just 10% of 1mil CY dirt not in an optimal way will lead to losing $250k or more. It takes at least three experienced field employees to design and agree on a new haul road on a hilly job site.

Haul Router provides the best mathematically objective hauls for each given drone scan. Any employee can use the tool to design a haul road and export the results to feed into grading equipment. While developing the tool, TraceAir conducted multiple in-field interviews and grading site observations to understand how haul roads were designed, and their impact on various projects. Independent Construction also offered their expertise, sharing feedback on prototypes and co-executing numerous field tests.

Remote sensing to monitor forest encroachments in J&K, India

After starting the cancellation of illegal entries on forest land, the Jammu and Kashmir Union Territory (UT) is using remote sensing technology and GIS to prepare vulnerability maps in all 30 forest divisions to track encroachments and map forest fire susceptible zones.

The encroachment of forests, especially in the Jammu division, has reached an alarming situation with hundreds of acres being illegally entered in the revenue records as private land. The plan will cover the Shivaliks, Pir Panjal range and the high Himalayan mountains in Kashmir. *www.tribuneindia.com*

Ecometrica to provide platform for NASA's latest Earth images

Sustainability and space data company Ecometrica is to help disseminate data from NASA's latest 'Global Ecosystem Dynamics Investigation' (GEDI) LiDAR instrument, thanks to a new contract with the University of Maryland (UMD). The firm's Ecometrica Platform will make processed maps more widely available to end users and reduce the need for additional processing of highly technical remote sensing LiDAR data.

GEDI is led by the UMD, in collaboration with NASA Goddard Spaceflight Center, and deploys a multibeam LiDAR instrument onboard the International Space Station to measure the forest vertical structure and biomass. Carried from Earth to the International Space Station atop a reusable SpaceX Falcon 9 rocket, it is already providing valuable raw data, which will be crucial in better understanding climate change and the Earth's ecosystems. The data has global potential but needs to be interpreted. Ecometrica's Platform will display key findings on rapidly updating maps, allowing conservation organisations and government agencies around the world to tap into the findings and use the real-time data to monitor forest canopies and cover. *www.ecometrica.com*

NRL's remote sensing division analyzes ground characteristics in Australia

U.S. Naval Research Laboratory physical scientists, engineers, and principal investigator Andrei Abelev visited Australia in May 2019 to validate their techniques for terrain characterization.

Using multiple types of sensors to gain understanding of different soils, the team used the trip to see how their models performed with the soils Down Under, digging into the homes of some of the most dangerous animals in the world.

To collect soil data, NRL researchers use multiple kinds of sophisticated sensors, also known as modalities, on the ground and in the air, including radar, hyperspectral instruments, and lidar. *www.dvidshub.net*

Image processing technology using sensor fusion for air- and space-based remote sensing

U.S. intelligence experts approaching industry for a image-processing project to blend data from satellite- and aircraft-based multispectral imaging sensors and visible-light sensors to detect activities like heavy building projects and highway construction.

Officials of the U.S. Intelligence Advanced Projects Agency (IARPA) in Washington issued a broad agency announcement last week (IARPA-BAA-19-04) for the Space-based Machine Automated Recognition Technique (SMART) project.

SMART seeks to use sensor fusionto enable automated broad-area search, monitoring, and characterization the progression of natural or man-made activities using time-series spectral imagery from several different satellite- or aircraft-based electro-optical sensors. Examples include heavy construction, real estate or urban development, crop disease propagation, forest fire, flooding and mud slides, insect or battle damage, human migration, mining, logging, farming, earthquakes. SMART applications potentially could include geospatial intelligence, disaster recovery, humanitarian aid, and automated assessment of land-use trending. *https://iarpa-ideas.gov*

Vexcel Imaging unlocks new business With HPE And Qumulo

Qumulo, the leading provider of enterprise-proven hybrid cloud file storage, has announced that Vexcel Imaging chose Qumulo and HPE to store massive amounts of large-format digital images on a powerful hybrid cloud infrastructure.

In 2018, Vexcel launched the Vexcel Data Program (VDP), a cloud-based aerial imagery and data library covering entire states and countries. The VDP leverages the company's advanced UltraCam aerial sensors and UltraMap software to allow organizations to make better strategic decisions through intelligent imagery in order to uncover crucial location insights.

In addition to "blue sky" data sets, Vexcel collects aerial imagery after catastrophic events such as floods, tornadoes or hurricanes as part of its "gray sky" program. Provided in collaboration with the Geospatial Intelligence Center (GIC), the imagery is made available within 24-hours after collecting to government organizations, rescue services and insurance companies.

Laser scanning in space utilization and facilities management

Pointfuse has launched a new toolkit specifically designed to make it easier to adopt laser scanning within space management, planning and utilization workflows. Pointfuse Space Creator automates the conversion of features such as walls, doors and windows to BIM LOD 200, and is compatible with the latest mobile mapping systems that are increasingly being used for as-built and as-used surveys within the facilities management sector. Pointfuse software converts the millions of individual measurements captured by laser scanning and photogrammetry into useable 3D models. poin*tfuse.com*

Pléiades Neo well on track for launch mid-2020

The first two Airbus-built Pléiades Neo imaging satellites have started comprehensive environmental testing, to ensure they are ready for in-orbit operation.

During the tests, the satellites are subjected to extreme temperatures and vacuum, vibration and acoustic noise, as well as electromagnetic interference. This will ensure they can withstand the harsh conditions they will experience during launch and their mission in orbit. These first two new generation very high-resolution satellites are on schedule for launch as planned in mid-2020. They will join the already world leading Airbus constellation of optical and radar satellites, improving both the revisit and resolution capacities.*www.airbus.com*

Shom to renew its entire fleet of inertial navigation systems

Shom, the French national hydrographic and oceanographic office selected SBG Systems' inertial navigation sytems to renew their whole fleet of INS. They chose the cost-effective and easy-to-use Navsight Apogee INS for their speedboats and survey vessels for both shallow and deep-water real-time bathymetric surveys and Qinertia PPK software for post-processing tasks.

Shom, the French national hydrographic and oceanographic office

Shom, as a public institution, has 3 major objectives: national hydrography and cartography, defense support in hydro-oceanographic fields, and support in maritime geospatial products and services for public policies on the sea and the coast. The fleet used by Shom is based in Brest and is composed of eleven boats, including seven speedboats, and three 59-meter long BH2 survey vessels. They operate on shallow and deep water in France, Africa, the Indian Ocean and in the Caribbean Sea. Shom also uses a fleet based in New Caledonia composed of two boats, one speedboat and a buoy-laying Vessel used part of the time for hydrographic surveys.

Renewing the fleet of Inertial Navigation Systems with SBG

When it came to renewing the fleet of inertial navigation systems (INS), the Shom looked at INS complying with IHO standards for bathymetric surveys, with a focus on roll and heave that have the biggest impact on the multibeam echo sounder data compensation.

After having conducted several tests in their official test zone where each element's location is strictly and precisely known, Shom selected SBG Systems for the replacement of inertial navigation systems. If at first, they acquired a Navsight Ekinox grade (0.02° roll) for shallow water survey in New Caledonia, they then decided to move the fleet in Brest with Apogee grade INS solutions (0.008° roll). "The Apogee is highly versatile; it fits both deep and shallow water requirements. Having a homogenized fleet of sensors for speedboats and BH2 is easier to maintain, like the number of spare equipment, for example," explains Rémi Labonde, in charge of Positioning and Hydrographic Equipment at Shom. Designed for hydrographers, Navsight Apogee grade is composed of a GNSS receiver and a processing unit enabling the real-time fusion of inertial and navigation data. Navsight provides connections to several external equipment such as echo sounders, computers, etc. With its titanium enclosure, the Apogee sensor could be installed in the floodable engine compartment, close to the multibeam echo sounder.

Navsight Apogee INS: Choosing Simplicity and Best Price/Performance Ratio

Navsight Apogee solution is a high performance cost-effective inertial navigation system based on state-of-the-art MEMS technology; it, therefore, requires no annual maintenance. The SBG solution includes free unlimited firmware updates and technical support. "We have selected SBG for the good performance/price ratio and the high level of service. The SBG technical support team is available, reactive, and committed," adds the Shom professional. Another key factor when choosing the INS solution was the ease of use. Once connected through Ethernet, the Navsight inner web interface guides the user during the installation phase. For example, a 3D view of the boat shows the entered parameters so that the user can check the installation in real-time. The embedded filter also controls and validates lever arms and antenna alignment during this procedure, which can be a plus if the Shom needs to calibrate a new system abroad. "We are big fans of SBG's web interface. It is modern, extremely clear, and easy to use; it really makes a difference in our team's work," to conclude Rémi Labonde.

Saving the Day with Qinertia Post-processing Software

Navsight Apogee INS accepts real-time corrections from Real Time Kinematic (RTK) or Precise Point Positioning (PPP). In their daily surveys, the Shom uses PPP positioning for its big advantage of not requiring any installation compared to RTK. It also allows surveying offshore, or even near shore when no RTK correction is available. If most of their data is collected in real-time, Shom hydrographers employ SBG Systems' in-house post-processing software called Qinertia to understand and fix data issues due to communication cuts. At the end of the day, the onboard team checks the data and corrects them with Qinertia if needed. The PPK software is known to be intuitive and Rémi Labonde confirms this: "It's nice to have a software that is clear and easy-to-handle." *www.sbg-systems.com*

Leica Geosystems brings the world's first MultiStation to the next level

New Leica Nova MS60 MultiStation brings sensor fusion to the next level by combining upgraded faster 3D laser scanning capabilities, GNSS connectivity and digital imaging with a highest-end total station. It features several laser scanning updates, including an incredibly fast scanning speed of up to 30,000 points per second, optimised scan area definitions, adapted scan managements, and an improved scanning path for zenith scans.

The MS60 is also equipped with the unique AutoHeight feature, enabling users to save time by automatically measuring the instrument's height with a simple button press. Measurement professionals can make decisions directly in the field performing point cloud analysis, such as flatness analysis and as-built checks in the Inspect Surface app of the MS60.

Gexcel announces RECONSTRUCTOR® 4.2

New release of Reconstructor by Gexcel introduces some very interesting improvements for mining, tunneling, construction, and infrastructure applications thanks to new strategic workflows designed to easily guide customers to final deliverables from the surveying data.

Reconstructor 4.2 makes a step forward into the processing of large datasets from various 3D sensors and in particular from Mobile Mapping Systems. Reconstructor 4.2 increases the capability to manage data from tunnels, underground and open-pit mines 3D surveys, thanks to new and improved tools that help users get the result done by a smart process.

Casablanca's Medina buildings monitored during tunnel construction

Vibrations during the construction of a new 1,890-meter tunnel adjacent to Casablanca's Old Medina, the 250-year-old section of the famed Moroccan city, challenged the stability of its historically important buildings.

To monitor in real time the effects on the Medina's aging buildings and to confirm that the construction work meets all engineering standards and guidelines, ETAFAT, a geospatial information acquisition and processing company, used the Nikon XF Total Station to perform more than 100 daily inspections. The ETAFAT team relied on optical targets placed on building facades whose coordinates were determined by forced centering to complete the inspections.

The Nikon XF 1" with its fast autofocus function, saved considerable field time. It enabled very fast collection of highly accurate observations throughout the monitoring and control of the planimetric and altimetric locations of the structure. The monitoring of the buildings during the various phases of the tunnel's construction generated a large amount of data essential for understanding the consequences of the work and defining any necessary corrective measures. *www.trimble.com*

Teledyne CARIS' HIPS and SIPS 11.3 release

Teledyne CARIS released HIPS and SIPSTM 11.3. This new software upgrade will introduce the first-ever COTS (commercial-off-the-shelf) release of an AI solution for classifying and cleaning sonar noise. Teledyne CARIS seeks to reduce significantly the need for manual cleaning and to move data swiftly from acquisition to review. The Sonar Noise Classifier automatically identifies the vast majority of sonar noise, resulting in a reduction of manual cleaning effort by a factor of up to 10x at an accuracy of 95%. This allows the hydrographer to focus more time on other important aspects of the survey and processing workflow. tele*dyne.com*

Sonardyne instruments to support pioneering tsunami research

High-accuracy, long-endurance underwater instrumentation from Sonardyne Inc. is set to play a major role in helping scientists across the US better understand and possibly predict earthquake and tsunami risk at a far greater scale than has been possible before. Scripps Institution of Oceanography, through a US$5.5 million grant from the US National Science Foundation (NSF), is procuring equipment to be used by the broader scientific community to study seafloor deformation. Comprising of more than 50 Sonardyne Fetch subsea sensor logging nodes, this major new equipment pool will also include Sonardyne's advanced acoustic positioning modules fitted to three Liquid Robotics Wave Gliders. These will, for the first time, make highly precise seabed monitoring capability – at scale – available to the entire US earth science community using a technique known as GNSS-A. so*nardyne.com*

ADVA tackles GNSS jamming and spoofing

ADVA has launched the industry's first centralized GNSS monitoring and assurance tool. Using artificial intelligence (AI) and machine learning (ML) for comprehensive predictive maintenance, it addresses the key concerns of GNSS users around the globe. The new customer-owned tool enables users to collect and analyze huge amounts of information from across the network to remotely identify issues and protect networks from GNSS vulnerabilities, including jamming and spoofing attacks.

It also helps to identify GNSS obstruction issues, detect blind/poor spots that appear over time and enable optimal antenna positioning. Built into ADVA's Ensemble Controller network management suite with Sync Director, the solution enables customers to detect potential problems in advance, maintain the highest quality of network synchronization and significantly reduce opex. By complementing today's limited distributed approach to GNSS assurance with a centralized-global system, it offers a major boost to critical infrastructure dependent on satellite-based timing. *www.adva.com*

U.S. Navy awards Booz Allen $178M GPS contract

The U.S. Navy's Naval Information Warfare Center (NIWC Pacific), in partnership with the U.S. Air Force Space and Missile Systems Center (SMC), has awarded Booz Allen Hamilton (NYSE: BAH) a $178 million contract to provide technical engineering services toward the modernization of advanced Global Positioning System (GPS) systems. The NIWC Pacific Positioning, Navigation and Timing (PNT) Division is the Navy's principal research and development center for navigation sensors and systems. SMC is the center of technical excellence for developing, acquiring, fielding, and sustaining resilient and affordable military space systems. *BoozAllen.com*

Sapcorda releases Unique Data Service for High Precision GNSS

Sapcorda Services GmbH has announced the release of the unique SAPA (Safe And Precise Augmentation) Premium GNSS positioning service. It enables mass-market GNSS devices to operate with unprecedented accuracy and reliability across Europe and the Continental United States. The service›s cutting-edge technology unlocks advanced performance with instantaneous sub-decimeter position accuracy for devices used in all market applications. *www.sapcorda.com*

GNSS/INS Localization Solution

Designed to replace expensive and bulky precision RTK/INS systems, this compact navigation solution meets the needs of automotive, robot, drone, construction and agriculture systems. The system includes a triple-band RTK/GNSS receiver coupled with redundant inertial sensor arrays to provide cm-level accuracy, enhanced reliability, and superior performance during GNSS outages. The system integrates a very precise 2 Degree/Hour IMU to offer ten to thirty seconds of high accuracy localization during full GNSS denial. This enables autonomous system developers to safely deliver highly accurate localization and position capabilities in their vehicles at prices that meet their budgets. The unit's embedded Ethernet interface allows easy and direct connection to GNSS correction networks around the world, and its CAN bus interface allows simple integration into existing vehicle architectures. *www.aceinna.com*

Leica Geosystems announces new most accurate total station

The new Leica Nova TS60, said to be the most accurate total station, with newly integrated DynamicLock and AutoHeight features. It is now equipped with DynamicLock, allowing the instrument to lock onto a moving prism, and devised with AutoHeight, enabling users to get the instrument's height with a simple button press. With these new integrated capabilities and sub-second and sub-millimetre accuracy, the TS60 is the most accurate total station for minimising risks of downtime and unexpected costs and delays. The TS60 is the only total station in the market that enables users to work with an angular accuracy of 0.5" and a distance accuracy of 0.6mm + 1ppm. Designed and manufactured to the highest levels of quality, this high-end total station is the best fit for most demanding projects due to its reliability even in the harshest conditions. *leica-geosystems.com*

Development of NTS-3 navigation satellite

An experimental navigation satellite being developed by L3Harris for the U.S. Air Force has passed a preliminary design review, clearing the way for the program to move forward. The Navigation Technology Satellite-3 (NTS-3) is an experiment to show that a layer of smaller satellites in geosynchronous Earth orbit could be deployed to supplement the medium Earth orbiting GPS constellation and improve the resiliency of the military's positioning, navigation and timing capabilities. The Air Force Research Laboratory plans to launch NTS-3 in 2022.

NTS-3 also will be used to develop technologies such as experimental antennas, flexible and secure signals, automation and use of commercial command and control systems. If successful, these technologies would transition to the GPS 3F satellites made by Lockheed Martin, the Air Force said. In September 2018, the Air Force awarded Lockheed Martin a contract for up to 22 GPS 3F satellites. L3Harris in January 2019 received a $243 million award to provide the navigation signals for the first two GPS 3F spacecraft. *https://spacenews.com*

HERE unveils geodata models

HERE has unveiled HERE Geodata Models to help accelerate the telecommunications industry's planning and deployment of 5G wireless networks while reducing network planning operational expenses.

It is a highly precise and scalable 3D digital representation of the buildings, trees and roadside objects (e.g. streetlights, utility poles, overpasses, billboards, etc.) making up the physical environment surrounding 5G antennas. The 3D digital representations provide 5G network planners and radio frequency (RF) engineers with the ability to remotely conduct field surveys and precisely plan where to locate 5G antennas in order to create optimal signal coverage. HERE is partnering with multiple industry leaders, including Nokia and Kinetica, to integrate this 3D data into their network planning and design solutions. *www.here.com*

Juniper systems limited expands to India

Juniper Systems Limited has announced its expansion into India via a new partnership with Elkay India. The alliance fills a need in the Indian surveying, industrial, and energy markets for data loggers and receivers that continue operating in harsh weather conditions.

India is a prime marketplace for Juniper's products, which continue operating in extreme weather conditions. *www.junipersys.com*

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www.beidou.org

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Boston, USA
www.xponential.org

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

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

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

14th RIN Baška GNSS Conference
17-19 May
Baška, Croatia
https://rin.org.uk

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

1st Workshop on Smart Blue and Green Maritime Technologies
20-21 May
Baška, Croatia
https://rin.org.uk

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

June2020

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

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

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

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

July 2020

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

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

September 2020

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

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

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

October 2020

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

International Symposium on Satellite Navigation (ISSN 2020)
21-24 October, 2020
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

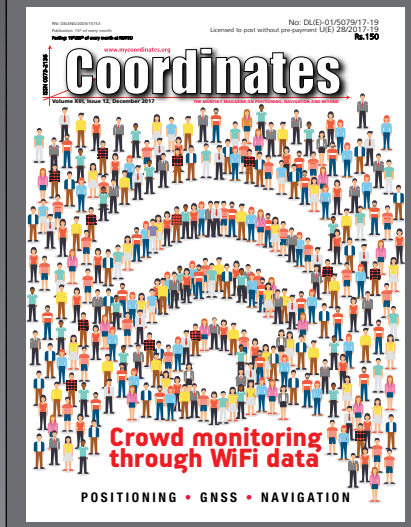
AARSE2020
26-30 October
Kigali, Rwanda
https://aarse2020.org

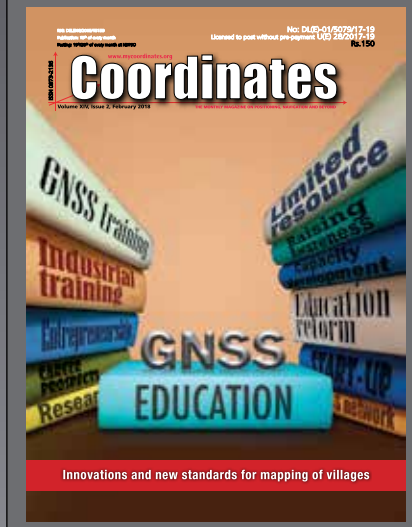
November 2020

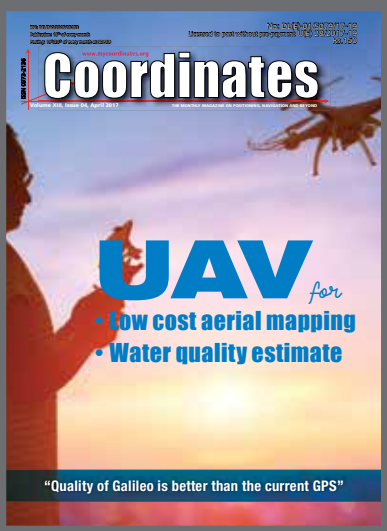
Trimble Dimensions 2020
2 - 4 November
Nashville, USA
www.trimbledimensions.com

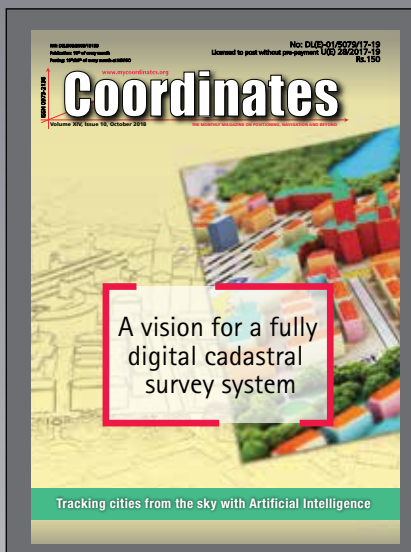
December 2020

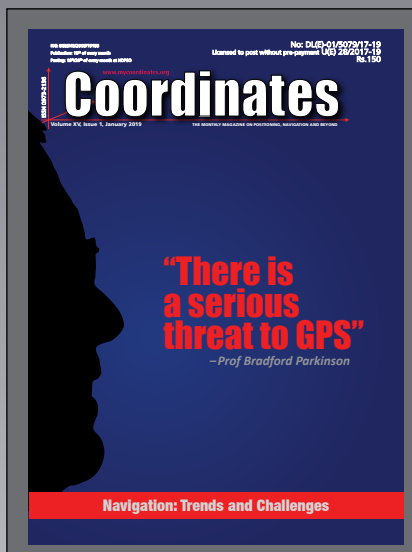
Amsterdam Drone Week & UAM Summit
December 2-4
www.amsterdamdroneweek.com

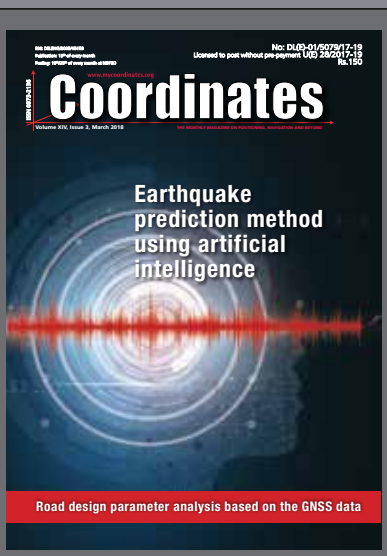


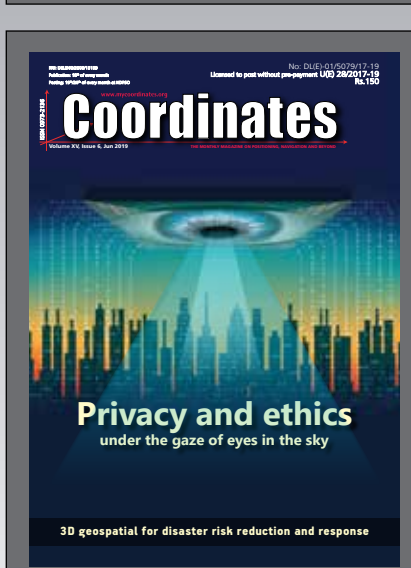


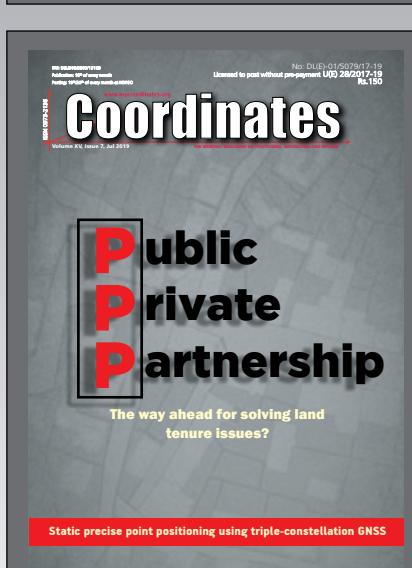












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