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

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

ISSN 0973-2136

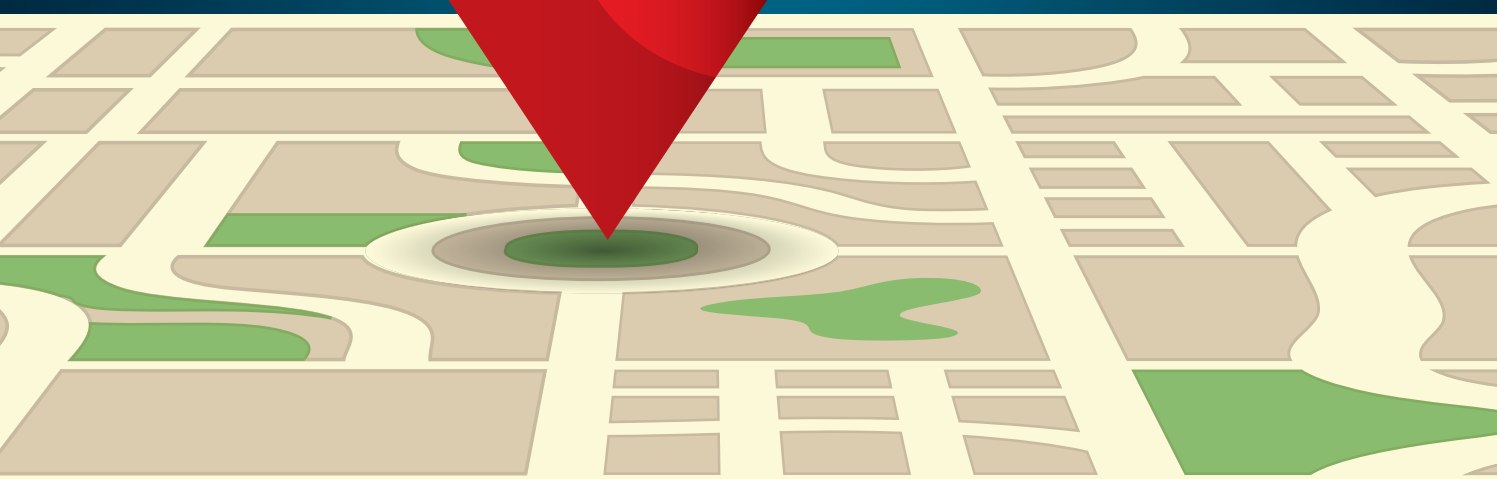
www.mycoordinates.org

Coordinates

Volume XVI, Issue 8, August 2020

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

A Map is a Living Structure with the Recurring Notion of *far more Smalls than Larges*



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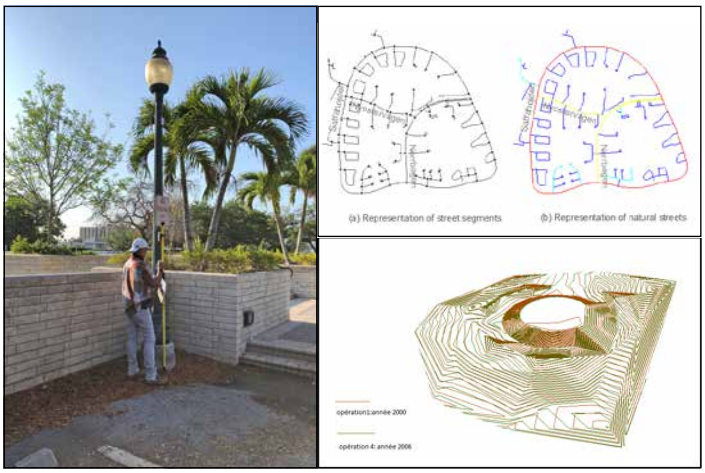

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Columns

This issue has been made possible by the support and good wishes of the following individuals and companies
Aicha Derkaoui, Bin Jiang, Chris Rizos, Sarah Alban and Terry Slocum; Labsat, Laser Technology, SBG System, and many others.

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Web www.mycoordinates.org

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

Printed and published by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
Published at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.

Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)

The rush

Several vaccines for Covid-19 are on the anvil.

A few are launched, and some in trial phase.

China, Russia, USA, UK, India and so on…

There is a need, a dire need.

And hence is the rush,

More so, when it is to be to be the first

To capture the market and the share.

There are issues,

Issues of credentials and credibility both.

Protocols cannot simply be compromised.

Though the rush is understandable,

It simply cannot be rushed through.

Bal Krishna, Editor
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Impact of COVID-19 on GNSS

The impact of COVID-19 is most dramatic in the slow down of workforce training, education, and research at universities

Chris Rizos
Emeritus Professor in the School of Civil and Environmental Engineering and a co-director of the Satellite Navigation and Positioning (SNAP) Lab at UNSW. Chris is president-elect of the International Union of Geodesy & Geophysics (IUGG)

At first I was trying to determine how there many be (positive or negative) impacts of COVID-19 on GNSS applications. I went down a checklist. Would it impact science? No. Would there be less construction or surveying? No, perhaps an emphasis on infrastructure spending to rebuild economies would increase GNSS use. Would there be less precision agriculture or automated mining activities? No. Less personal/mobilephone applications? I doubt it. Less R&D into future driverless vehicles? No. Less use in aviation (including drones)? Maybe, but this is a tiny market. Less maritime users? No. Less interest in "smart weapons" by defence or security agencies? Definitely No. Less interest in addressing vulnerabilities of GNSS due to jamming or spoofing threats? No. Less investment in regional satellite-based augmentation systems? No. The list goes on….

The conclusions I drew were that there would be almost no negative impacts of COVID-19 on the production or deployment of GNSS products and services. That in fact the pre-COVID-19 market predictions of double-digit growth in the value of GNSS equipment and applications over the coming decade are valid (of course assuming that their original assumptions about the growth of GNSS-supported applications were correct).

Then I realised that the greatest impact of COVID-19 would be on the GNSS workforce. In particular universities are teaching using online methods. How does that impact on the numbers of students being educated in GNSS principles and practices? No more "hands-on" labs. Our research (PhD) students are not mixing with other students (and getting cross-fertilisation of ideas). They are not meeting as often with their thesis supervisors. Most seriously for many western countries, the number of graduate students from China, India and other countries, coming to their universities to do their PhD studies has dried up! Western universities are (for the most part) the institutions that train (i.e. train to undertake research) the highly qualified workforce that GNSS industries need for product development and service operations. (Of course, Chinese universities are still producing large numbers of graduates, but there will be a lag of several years before these are recruited to non-Chinese GNSS companies.)

Furthermore with the cancellation of many conferences, there are currently no opportunities for early career researchers and graduate students to present the results of their research before their peers and obtain valuable feedback. It is possible to run conferences in "virtual" mode, but there is no substitute for face-to-face meetings over coffee or social events to engage in networking. This "networking" is the primary means by which academics and students discuss their work, identify new research challenges, find employment, and generally ensure the education sector remains dynamic. Even seasoned academics like myself feel cut off. We are not able to meet colleagues to discuss wider issues regarding GNSS, especially the many issues related to multi-constellation GNSS, alternative PNT technologies, national and international policy development, latest industry trends, new GNSS/PNT applications, defence vis-a-vis civilian GNSS issues, and new space-based PNT concepts (such as high performance clocks, possible use of LEO satellites, new signals and frequencies, and so on). It is impossible to quantify the impacts of such loss of intellectual interaction.

In short, I believe the impact of COVID-19 is most dramatic in the slow down of workforce training, education, and research at universities. There may then be a knock-on impact on GNSS industries and user communities in general.

There would be almost no negative impacts of COVID-19 on the production or deployment of GNSS products and services. That in fact the pre-COVID-19 market predictions of double-digit growth in the value of GNSS equipment and applications over the coming decade are valid

A Map Is a Living Structure with the Recurring Notion of Far More Smalls than Larges

This paper is intended to establish living structure – a physical phenomenon and mathematical concept – as a formal concept or foundation for maps and mapping

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

Terry Slocum
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[Maps] are no longer merely considered as aids…, but as products of scientific research which, being complete in themselves, convey their message by means of their own signs and symbols and through these furnish the basis for further geographic deduction. … . [the subjectivity] must not predominate: the dictates of science will prevent any erratic flight of the imagination and impact to the map a fundamentally objective character in spite of all subjective impulses.

Max Eckert (1908)

Abstract

The Earth's surface or any territory is a coherent whole or subwhole, in which the notion of *"far more small things than large ones"* recurs at different levels of scale ranging from the smallest of a couple of meters to the largest of the Earth's surface or that of the territory. The coherent whole has the underlying character called wholeness or living structure, which is a physical phenomenon pervasively existing in our environment and can be defined mathematically under the new third view of space conceived and advocated by Christopher Alexander: space is neither lifeless nor neutral, but a living structure capable of being more alive or less alive. This paper argues that both the map and the territory are a living structure, and that it is the inherent hierarchy of *"far more smalls than larges"* that constitutes the foundation of maps and mapping. It is the underlying living structure of geographic space or geographic features that makes maps or mapping possible, i.e., larges to be retained, while smalls to be omitted in a recursive manner (Note: larges and smalls should be understood broadly, in terms of not only sizes, but also topological connectivity and semantic meaning). Thus, map making is largely an objective undertaking governed by the underlying living structure, and maps portray the truth of the living structure. Based on the notion of living structure, a map can be considered to be an iterative system, which means that the map is the map of the map of the map, and so on endlessly. The word endlessly means continuous map scales between two discrete ones, just as there are endless real numbers between 1 and 2. The iterated map system implies that each of the subsequent small-scale maps is a subset of the single large-scale map, not a simple subset but with various constraints to make all geographic features topologically correct.

1. Introduction

The Polish mathematician Alfred Korzybski (1933) first introduced the mantra *"a map is not the territory"* which points out two important facts about maps: (1) a map has a similar structure to the territory, and (2) a map is the map of the map of the map, and so on endlessly. This similar structure is actually living structure (Alexander 2002–2005) that possesses – in a recursive manner – far more small things than large ones. For example, a green tree with leaves is a living structure,

because it has far more small branches than large ones, and importantly small branches are embedded in large ones. The notion of *"far more smalls than larges"* differs fundamentally from that of "more smalls than larges", as *"far"* indicates the distinct disproportionality between smalls and larges. This disproportionality is what underlies the 80/20 Rule or Pareto Principle (Koch 1998). The second fact is essentially derived from the first one, i.e., a map – due to the living structure of the territory – is considered to be the map of the map of the map, and so on endlessly. This is a recursive perspective through which all small-scale maps are subsets of the single large-scale map, and they all retain the underlying living structure. Motivated by the mantra *"a map is not the territory"* or more specifically by the two facts about maps, this paper argues that not only a territory but also its associated maps are a living structure, and it is the living structure of the Earth's surface or of a territory that makes maps and mapping possible.

Living structure is essentially a recursive and holistic view of looking at space or things in our environment. A living structure consists of only one type of recursively defined entities called centers, so centers are made of centers of centers and so on, with far more small centers than large ones. For a street network, the individual junctions or street segments are not centers, but individual natural streets are centers; for a cartographic curve, its segments are not centers, but its bends are centers (see Figure 1 for illustration). Thus, the street network is a non-living structure when seen from the perspective of street junctions and segments, but it is a living structure when seen from the perspective of natural streets. In the same vein, the cartographic curve is non-living when seen from the perspective of individual line segments, but it is living when seen from the perspective of recursively defined bends. This living structure view of space is not typical of either Newtonian absolute space (the first view of space), Leibnizian relational space (the second view of space) or quantum mechanical space (Alexander 2002–2005). Under the new third view of space conceived by Whitehead (1938) and further developed by Alexander (2002–2005), space is considered to be neither lifeless nor neutral, but a living structure capable of being more alive or less alive. For example, a tree is more alive than its branches, and large branches are more alive than small branches. Importantly, the aliveness of a space is not determined by the space itself, but by those smaller spaces contained in it and the larger space that contains the particular space. In other words, the aliveness of space cannot be understood as a property of the space itself, or merely in terms of its own structure or shape. This is the essence of living structure.

It should be noted that the aliveness of a space has an iterative or accumulative property; this is essentially equivalent to the aphorism: "the rich get richer and the poor get poorer". This paper is intended to reach a wide audience of both academics and laypersons, and thus we will not get into the iterative or accumulative nature of life (as shown in Figure 2), but rather focus on how a space is conceived as a coherent whole consisting of far more smalls than larges. The Earth's surface as a living structure is composed of far more ocean than land or far more small countries than large ones; a country is composed of far more small settlements than large ones (Zipf 1949, Christaller 1933, 1961); a settlement is composed of far more short (or less-connected) streets than long (or well-connected) ones; and a street is composed of far more small bends than large ones. It is this recursively defined space and importantly its inherent hierarchy of far more smalls than larges that makes maps and mapping possible.

This paper is further motivated by some fundamental questions on maps and mapping: What is the nature of maps? How do maps work? What does the image of the map look like? The third question is inspired by Lynch (1965), and refers to the kind of mental image after one is exposed to a map rather than an actual city. This paper argues that the current state of the art of mapping practice or geographic representation is (mis-) guided by focusing largely on the notion of more or less similar things, although cartographers are guided – subconsciously or unconsciously – by living structure or its inherent hierarchy. For example, both raster and vector representations are not based on living centers; instead these representations are essentially nonliving or *"cold and dry"*, a term often used by Mandelbrot (1983) to refer to Euclidean geometric shapes such as circles, rectangles and straight lines. In a vector representation, geometric primitives such as points, lines and polygons are fairly good for computing processes and storages, but they are mechanistically imposed and are treated as fragmented pieces rather than living centers that can be well perceived as meaningful entities by human beings. Geographic features such as mountain ranges, river basins, settlements, street networks, and coastlines are actually meaningful entities, full of far more smalls than larges, so maps should be considered to be an iterative system, in which all subsequent small-scale maps can be automatically derived from a single large-scale map or database.

This paper is intended to establish living structure – a physical phenomenon and mathematical concept – as a formal concept or foundation for maps and mapping. More specifically, the contributions of this paper can be highlighted as follows: Firstly, it is argued that not only the territory but also the maps are a living structure with the recurring notion of far more smalls than larges; second, it is demonstrated that the map is an iterative system, being the map of the map of the map, and so on endlessly; third, it is demonstrated how data classification and map generalization – or mapping in general – can be considered to be a head/tail breaks process; finally, it is argued that objectivity should be favoured over subjectivity in maps and mapping, and maps are largely about truth of the underlying living structure of the territory or the data.

The remainder of this paper is organized as follows. Section 2 examines the state

of the art of maps and mapping in the field of geographic information science (GIScience) and how it is misguided by focusing largely on the notion of more or less similar things. Section 3 introduces the notion of living structure via four simple examples and its two fundamental laws. Section 4 demonstrates how maps – through data classification and map generalization – can be considered to be an iterative system. In Section 5, we further discuss the implications of living structure on maps and art. Finally, Section 6 draws a conclusion and points to future work.

2. The state of the art of maps and mapping

Over a long history of mapping practices, cartographers have been guided by living structure, not explicitly or consciously but implicitly or subconsciously. That is why geographic features represented at different scales of the map look very similar not only to each other but also to the territory. This similarity is obvious across a wide range of map scales even when geographic features are represented by abstract symbols. For example, as map scale is reduced, city boundaries are represented in some gradually simplified manner, so the boundaries in small-scale maps are simplified versions of those in a large-scale map. As map scale is further reduced, all cities are collapsed into single dots, and only largest cities are retained in the smallest-scale maps. Despite the cartographers' instinct, living structure has not been well established as a formal concept in cartography and GIScience. Instead, in the current state of the art of maps and mapping or under the current mode of thinking, map making is constrained by a desire to portray geometric details of locations, sizes, and directions rather than the overall character of the territory being mapped. It was found that 85% people tend to see things sequentially or analytically by focusing on these details, while only 15% people see things figuratively or holistically (Alexander 2002–2005, Alexander and Carey 1968, Alexander and Huggins 1964). Thus, there is little wonder that the current GIS representations focus on geometric details while miss the overall character. However, the figurative or holistic way is the right way to see the underlying character or living structure, which will be further discussed below.

Given their major concern with the location, size, and direction of geographic features, current geographic information systems (GIS) represent these features by geometric primitives such as points, lines, and polygons (e.g., Clarke 1995, Kraak and Ormeling 1996, Chrisman 2001, Bian 2007, Longley et al. 2015). Focusing on geometric primitives or geometric details tends to overlook the underlying living structure: the inherent hierarchy of *"far more smalls than larges"*. In current GIS, a street network is considered to be a collection of more or less similar junctions or a set of more or less similar street segments between the junctions (Figure 1a). And a curvilinear feature on a map is considered to be composed of a set of more or less similar line segments (Figure 1c). Instead, a street network should be considered as a set of far more less-connected streets than well-connected ones from the topological view of streets (Figure 1b). Equally, a curvilinear feature should be considered as a set of far more small bends than large ones (Figure 1d), recursively defined at different levels of scale. It should be noted that the non-living structure view (i.e., street segments and line segments), and the living structure view (i.e., streets and bends) are not contradictory but rather complementary to each other, with the former providing the geometric details, while the latter providing the overall character. As briefly mentioned above, the former view is under Newtonian and Leibnizian views of space (the first two views of space) being mechanistic (Descartes 1637, 1954),

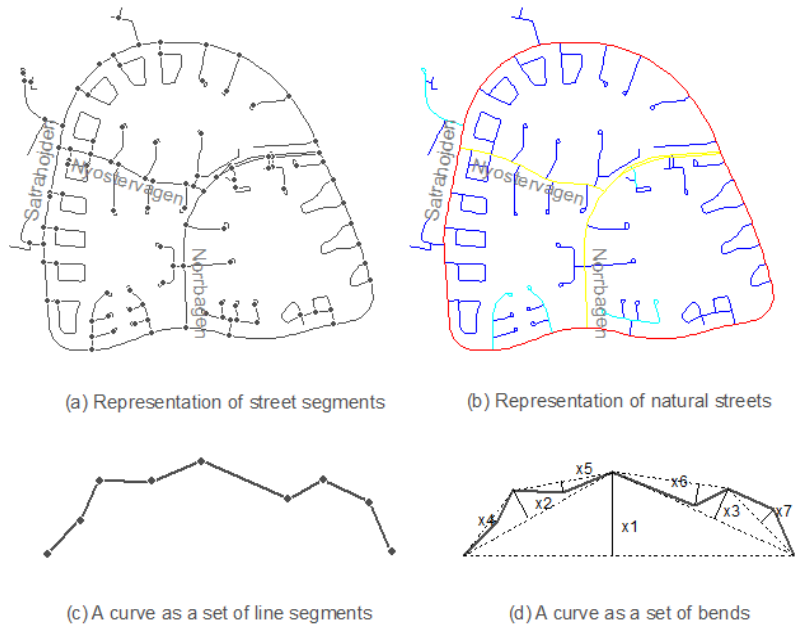


Figure 1: (color online) Geometric primitives versus geometrically meaningful entities (Note: A street network is represented as a set of junctions or street segments (geometric primitives, which are not centers) (a), whereas it is more correctly perceived as a collection of named streets (geometrically meaningful entities, which are centers) (b), each of which is colored as one of four hierarchical levels: blue for the least connected streets, red for the most connected street (only one), and yellow and turquoise for those between the most and the least connected. A curvilinear feature is usually represented as a set of line segments (geometric primitives, which are not centers) (c), but it is more correctly perceived as a collection of far more small bends than large ones (geometrically meaningful entities, which are centers) (d), because the notion of far more small bends than large ones occurs twice: (1) $x_1 + x_2 + x_3 > x_4 + x_5 + x_6 + x_7$, and (2) $x_1 > x_2 + x_3$.)

while the latter view is under the third view of space – being organic (Whitehead 1938) – advocated by Alexander (2002–2005): space is neither lifeless nor neutral, but a living structure capable of being more living or less living.

The perspective on geometric primitives is essentially a Euclidean geometric view, because it focuses on elements individually rather than on "far more smalls than larges" holistically, and on scales individually rather than on scaling collectively. The Euclidean geometric view enables us to see more or less similar things, e.g., more or less similar junctions (or equivalently more or less similar street segments) of a street network, or more or less similar line segments of a curvilinear feature (Figure 1a, 1c). This notion of more or less similar implies that there exists a characteristic mean for these things. More or less similar things are what underlies not only Gaussian statistics, but also the first law of geography: *"everything is related to everything else, but near things are more related than distant things"* (Tobler 1970). The first law of geography or Tobler's law was formulated out of the notion of spatial dependency or autocorrelation. For example, your housing price is more or less similar to those of your neighbors, and today's weather is more or less similar to that of yesterday. Spatial dependency indicates a local fact, i.e., spatial events are not random, but autocorrelated. Tobler's law is what underlies many mapping activities, e.g., spatial interpolation for creating a smooth surface, and the kernel density estimation to create hotspot maps. Many geographic phenomena are indeed dependent on each other, so there are more or less similar things nearby or locally, but globally there are far more smalls than larges. For example, there are far more low-housing prices than high-housing prices. And there are far more ordinary weather conditions than extraordinary weather conditions. This notion of far more smalls than larges has been formulated as the scaling law (Jiang 2015a, see Section 3 for more details). However, under the current mode of thinking on the assumption of more or less similar things, we have paid little attention to the notion of far more smalls than larges in maps and mapping. This situation is clearly reflected in data classification methods.

Natural breaks is commonly used to classify data for maps and mapping, and it is based on the principle that variation within classes should be minimized, while the variation between classes should be maximized (Jenks 1967). This principle is essentially based on the assumption that all classes have characteristic means. This is the same for the k-means clustering algorithm (Steinhaus 1956) commonly referred to in computer science. This assumption does not hold for many real-world data, because they are heavy tailed or long tailed, like city sizes that follow a so-called rank-size distribution (Zipf 1949). For such data that have far more smalls than larges, it is wise to ask how many times the notion of far more smalls than larges recurs based on the data's inherent hierarchy. This is what motivated the head/tail breaks (Jiang 2013) classification method for data with a heavy-tailed distribution, which has deep implications for living structure, as we will see in the next sections.

3. Living structure of centers and its two fundamental laws

All space and matter (either organic or inorganic) have some degree of life in it – *"every brick, every stone, every person, every physical structure of any kind at all"* (Alexander 2002–2005) – according to its underlying structure and arrangement. The phenomenon that all space has some degree of life has been extensively studied in computer science, architecture and urban science (e.g., Gabriel 1998, Salingaros 2014, Jiang 2016, Mehaffy 2017, Gabriel and Quillien 2019). If the degree of life is too low, the structure is called a dead or nonliving structure; otherwise, it is called a living structure. Beyond the conventional notion of biological life as being self-producing (Schrödinger 1944), the term life – also called wholeness – refers to the structural property of far more small centers than large ones. Here center refers to only one type of entity within a living structure, so centers are made of other centers recursively. There are far more small centers than large ones in any living structure in general. According to the definition of wholeness and centers, not only organic or alive things but also biologically dead things can have a living structure, as long as there is the recurring notion of far more small centers than large ones. For example, not only an alive tree, but also a dead tree is a living structure as long as the recurring notion of far more small branches than large ones remains. In one of his earlier works, Alexander (1979, p. ix) referred to life (or wholeness) as a quality without a name, being *"the root criterion of life and spirit in a man, a town, a building, or a wilderness"*. Living structure pervasively exists in our environment, but the degree of living structure may not be so obvious. Let's look at some typical examples of living structure:

Example 1: A green tree with leaves

A tree is made of far more small branches than large ones, out of which are made far more small branches than large ones, ..., and so on. Thus, the tree is a living structure with the recurring notion of far more small branches than large ones. This is an alive tree, but its living structure remains even after it becomes dead, for the recurrent notion of far more smalls than larges remains unchanged.

Example 2: The English country garden corner where a peach tree grows against a wall (Alexander 1979)

The wall runs east to west; the peach tree grows flat against its 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 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 angles where the earth and roots and wall all meet.

Example 3: The Berkeley street corner at the intersection of Hearst and Euclid (Alexander 1965)

In Berkeley at the corner of Hearst and Euclid, there is a drugstore, and outside the drugstore a traffic light. In the entrance to the drugstore there is a newsrack where the day's papers are displayed. When the light is red, people who are waiting to cross the street stand idly by the light; and since they have nothing to do, they look at the papers displayed on the newsrack which they can see from where they stand. Some of them just read the headlines, others actually buy a paper while they wait. This effect makes the newsrack and the traffic light interactive; the newsrack, the newspapers on it, the money going from people's pockets to the dime slot, the people who stop at the light and read papers, the traffic light, the electric impulses which make the lights change, and the sidewalk which the people stand on form a system - they all work together.

Among the above three examples, the first one is the most obvious, while the other two may seem a bit obscure. In the first example, the tree is considered to be the living center, consisting of far more small centers (actually branches) than large ones, which further consist of far more small centers than large ones, and so on. The tree can be considered the center of the center of the center, and so on. The country garden corner is the first place where Alexander (1979) was pondering on the phenomenon of life and struggling with its naming as the quality without a name, the precursor of living structure. The garden corner as a living center consists of many centers, among which the most salient include the peach tree, the wall that is composed of many bricks, the wild grasses, the earth and the sun. All these living centers, which are certainly living structures, constitute mutual supporting relationships, e.g., the light shines on the wall, warming the bricks and dead leaves, and grasses nourish the earth and the tree, forming a coherent whole or ecological system. The corner is a living center of the larger center (e.g., the garden), which is a center of an even larger center (e.g., the neighborhood) of an even larger center (e.g., the city), and so on endlessly towards the entire universe.

The notion of far more smalls than larges can be rephrased in some situations as that of far more less-used locations than well-used ones, or far more meaningless locations than meaningful ones. The street corner scene consists of a few well-used locations (the newsrack, the traffic light and the pavement between them) and many remaining less-used locations that hold together as a coherent living structure. The well-used locations occupy a small amount of space but receive far more attention than the less-used locations; thus, there are far more smalls than larges in terms of how much space is used, or how meaningful semantically space is perceived. In other words, the small amount of space is well-used or more meaningful, whereas the large amount of space is less-used or less meaningful: this is truly a living structure. These well-used locations can be compared to the eyes, nose and mouth of a human face, which is surely a living structure; the eyes, the nose and the mouth occupy a small amount of space, but they receive a large amount of attention, whereas the remaining parts of the face occupy a large amount of space, but receive a small amount of attention as shown by eye-tracking experiments (Yarbus 1967). In any living structure, there is a recurring notion of far more low-intensity centers than large ones. To make this point clear, let's now look at a fourth example.

Example 4: A ten-city cluster as a living structure (Figure 2a)

A ten-city cluster within a square space in which there is one largest city (red, Figure 2b), two middle-sized cities (green, Figure 2c), and seven smallest cities (blue, Figure 2d). There are three hierarchical levels among the ten cities indicated by the three different colors. In other words, the notion of far more smalls than larges recurs twice, so it is a living structure. The nested and mutual relationship among the ten cities constitutes a complex network (Figure 2e); note that the relationship at the same level is undirected, while the relationship between different levels is directed. The degree of life can be computed relying on Google's PageRank (Page and Brin 1998, Jiang 2015b), leading to far more low-life centers than high-life ones (Figure 2f). The PageRank way of computing the degree of life of a center can be compared to assessing how important a person is, for which we should ask how important not only his/her friends are, but also the friends of the friends of the friends, and so on virtually for all people on the planet. In this sense, note that the small northcentral city has a higher degree of life than other small cities because of the more links it receives and the few links it gives out. In the same vein, the right green city has a higher degree of life than that of the left one.

In considering these examples (in particular examples 2 and 3), the reader may be thinking that the living structure approach is subjective, as people may have different thoughts about these situations, but Alexander (1979, 2002–2005) argued that the approach is largely objective and is not just a matter of personal opinion and taste. This situation may be compared to the situation when asking a group of people about the temperature of a piece of ice and a glass of hot water; there is little doubt that the hot water has a higher degree of temperature than the ice, although people may disagree on the exact temperature of the hot water.

Living structure is not only objective and precise, but also reflected in the human mind and heart. It was found through the mirror-of-the-self experiment (Alexander 2002–2005, Wu 2015) that living structure correlates with very personal questions such as whether I feel myself whole, or whether my spirit is lifted up in the presence of living structure. Although there is indeed some personal opinion and human taste involved in interpreting living structure, the mirror-of-the-self experiment showed that living structure is a shared notion among a majority of people regardless of their faiths, cultures, and ethics.

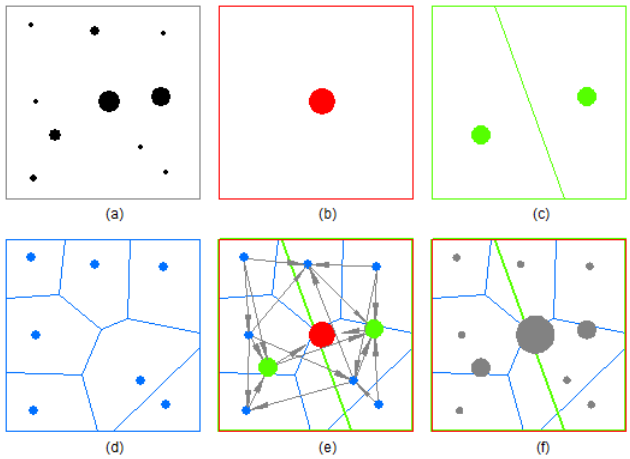


Figure 2: (Color online) The ten fictitious cities and their interrelationship constitute a living structure

(Note: As a structural invariant of the central place theory model (Christaller 1933, 1966), the cluster of the ten cities (a) is composed of the largest city (b) bounded by the red square, surrounded by two second largest cities (c) separated by the green line and bounded by the green box, and further surrounded by seven third largest cities (d) separated by blue lines and bounded by the blue box, thus with three hierarchical levels, indicated by dot sizes and colors. Because of mutual relationship among the ten cities (e), each city has different degree of life, as indicated by the dot sizes (f).)

Table 1: Two fundamental laws of living structure

(Note: These two laws – scaling law and Tobler's law – complement each other and recur at different levels of scale of living structure.)

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

Underlying any living structure there are two governing laws: the scaling law across all scales (Jiang 2015a) and Tobler's law at each scale (Tobler 1970) (Table 1). According to the scaling law, there are far more low-life centers than high-life ones across all scales ranging from the lowest to the highest. It is important to note that the scaling law is a relaxed version of other long-standing laws or rules such as Zipf's law (1949) and the universal rule (Salingaros and West 1999), which all require a power law distribution.

Instead, the scaling law requires only that far more smalls than larges recurs at least twice with the ht-index being at least three. From a dynamic point of view, the ht-index of a living structure usually will increase as time goes by, and when it reaches to 6 or 7, the data distribution may demonstrate a power law. While the scaling law applies to all scales, Tobler's law applies to each scale, i.e., centers tend to be more or less similar on each scale. These two laws characterize living structure from both global and local perspectives. However, the scaling law is primary and global, while Tobler's law is secondary and local. Any structure with more or less similar centers globally tends to be uninteresting or less-living. As we have shown in Figure 1, a street network if seen from the perspective of individual street segments – the geometric view – tends to be uninteresting or less-living, but it is a living structure if seen from the topological perspective of connected streets, and a curvilinear feature when seen from the perspective of segments tends to be uninteresting or less-living, but it is a living structure when seen from the perspective of the recursively defined bends.

It should be noted that the scaling law or scaling hierarchy is what underlies many natural and societal phenomena such as coastlines, terrain ranges, earth quakes, and financial markets. They are also called complex systems which demonstrate non-equilibrium character (e.g., Simon 1962, Zipf 1949, Mandelbrot 1983, Bak 1996). Complex systems appear complex and non-equilibrium at the global scale, but they may demonstrate simple and equilibrium character at a local scale. Climate is essentially a complex system, so it is unpredictable essentially; there are far more ordinary weather conditions than extraordinary ones globally, but locally, today's weather is more or less similar to that of yesterday. It should be also noted that the notion of far more smalls than larges relies on its *recurring* nature. In other words, the notion must recur at least twice rather than just once. There are three different perspectives to assess whether there are far more smalls than larges: topological, geometrical, and semantic. Among the three perspectives, the topological is primary because it specifies the spatial configuration or the underlying structure that determines the degree of life. For example, a tiny city in the middle of a set of cities may look extremely small, but it tends to have a high degree of life because of its many connections. Herewith it is not geometric size, but the topological connection that essentially determines the degree of life, as we can see for the small northcentral city in Figure 2.

4. Mapping as the head/tail breaks process: data classification and map generalization

We contend in this paper that both maps of different scales and the territory are living structures with the inherent hierarchy of far more smalls than larges. Map making essentially depicts the inherent hierarchy or the recurrent notion of far more smalls than larges. Let us now illustrate how data classification and map generalization – or mapping in general – can be conducted as a head/tail breaks process relying on two simple examples.

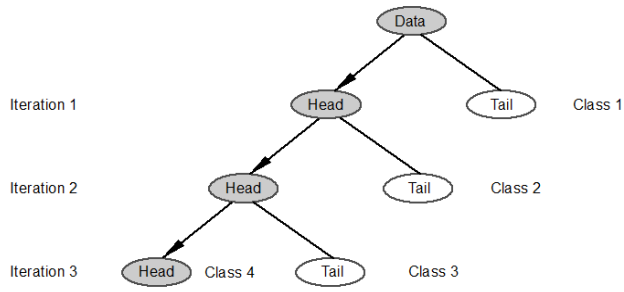


Figure 3: Illustration of the head/tail breaks as an iterative function
(Note: The data as a whole is recursively divided into the head (for those greater than the average) and the tail (for those less than the average). The whole or data is seen as an iterated system, i.e., the head of the head of the head and so on. For the sake of simplicity, we illustrate three iterations or four classes.)

Table 2: Statistics of the head/tail breaks process of the 39 numbers

Number	Mean	# head	# tail	% head	% tail
39	0.11	9	30	23%	77%
9	0.31	3	6	33%	67%
3	0.61	1	2	33%	67%

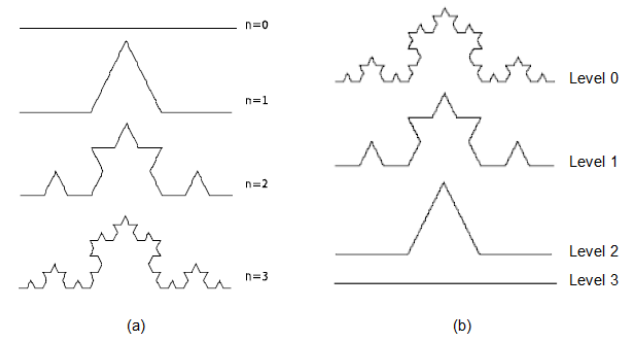


Figure 4: Generation (a) and generalization (b) of the Koch curve with the first four iterations
(Note: Beginning with a segment of scale 1 (n = 0), it is divided into thirds, and the middle third is replaced by two equilaterals of a triangle, leading to four segments of scale 1/3 (n = 1). This division and replacement process continues for scales 1/9, and 1/27, leading respectively to 16 segments, and 64 segments (n = 2, and 3). This is the generation of the Koch curve, as shown in panel (a). On the other hand, the Koch curve (Level 0) can be generalized in a step-by-step fashion, as shown in Table 3, resulting in the outcome in panel (b).)

Table 3: The four iterations of the Koch curve as shown in Figure 4a

Iteration	Scale	#Segment
0	1	1
1	1/3	4
2	1/9	16
3	1/27	64

Let's first look at a set of 39 data values: (1, 1/2, 1/3, 1/4, …, 1/39), which follow exactly a rank-size distribution (Zipf 1949), which means the first largest city is twice as big as the second largest city, three times as big as the third largest city, and so on. This dataset has four inherent hierarchical levels, for the notion of far more smalls than larges recurs three times as shown in Table 2. More specifically, the average of the 39 values is ~0.11, which partitions these values into two groups: those greater than the average is called the head: (1, 1/2, 1/3, …, 1/9), and those less than the average is called the tail: (1/10, …, 1/39). In this case, we can see in Table 2 that the head has nine large values and the tail has far more small values (thirty). Among the nine in the head, their average is ~0.31, which further partitions these nine into two groups: three large in the head: (1, 1/2, and 1/3), and six small in the tail (1/4, 1/5, …, 1/9). For the three in the head, their average is ~0.61, which further partitions the three into two groups: one large (1) for the head, and two small (1/2, 1/3) for the tail. This iterated head/tail breaks process relies on the data itself to partition the data; thus, the resulting classes or hierarchical levels are determined from the bottom up rather than imposed from the top down or by cartographers. In other words, head/tail breaks lets the data determine classes, in terms of not only how many classes, but also how to set class intervals. Real world datasets are often much larger or more complex than this simple dataset, but the underlying data classification approach remains the same in order to uncover the inherent hierarchy of data for mapping. Figure 3 illustrates the head/tail breaks classification for the dataset with four inherent hierarchies.

The reader may wonder at what time or under what condition, the iteration process should stop. This is a valid question. Roughly put, head/tail breaks has to ensure – at each iteration – that the head percentage is far smaller than that of the tail, to reflect the desire for "far more smalls than larges". One reasonable solution based on the first author's experience is that the number in the head should be less than 40%. However, with many real-world data, the first iterations may end up with more than 40% for the head, but for all subsequent iterations the head percentages are all around 20%. Therefore, there are two different ending conditions for head/tail breaks: 1) the head percentage must be less than 40% for every iteration, and 2) the *average* head percentage for all iterations must be less than 40%. Given the complexity of the real-world data, the second is more preferred, for it is less restrictive than the first.

Slocum et al. (2008) discuss numerous criteria for determining an appropriate method of classification. From the above computations, we can see that head/tail breaks does an excellent job of meeting two key criteria. First, by iteratively assigning "far more smalls" at each step of the classification, head/tail breaks pays careful attention to the graphical distribution of the data along the number line (e.g. expressed as either a dot plot or a rank-size plot). Second, the method provides an objective approach for stopping the classification process. The latter is in contrast to the natural breaks method, which generally

determines the number of classes through a visual examination of a graph of the number of classes plotted against a goodness-of-variance fit measure.

Having discussed data classification, let us showcase how map generalization can be conducted through head/tail breaks. We will use the Koch curve (Figure 4a, Koch 1904) as a working example. Let's first consider how the Koch curve can be generated as an iterative function. A segment of unit 1 is divided equally into thirds, with the middle third replaced by two sides of an equilateral triangle. This process can be repeated until the scale is infinitely small. To illustrate, we show the first four iterations in Figure 4a and Table 3. This is one of the first classic fractals based on a rigorous definition. The reader may argue that cartographic objects do not exhibit the regularity of the Koch curve, as cartographic objects have a much more random character. However, the notion of far more smalls than larges remains for both the classic and randomized Koch curve. For this reason, and for the sake of simplicity, we use the classic Koch curve for illustration of our ideas in this paper. The Koch curve is a deterministic process of creating fractals: as the scale drops by 1/3, the number of segments increases by 4 times, and the direction of the little bump is always in the same direction. When this deterministic process changes to a non-deterministic one, the Koch curves would look like coastlines, clouds, or city skylines. However, the notion of far more smalls than larges would remain unchanged.

Let's take the Koch curve at the fourth iteration (n=3 in Figure 4a or Level 0 in Figure 4b) to see how it can be generalized or simplified at the different levels of detail. It is very important to realize that the Koch curve is not just a collection of 64 segments with the size of 1/27 (or ~0.04). It is a wrong way of thinking based on Euclidean geometry. The right way of thinking – or being recursive or the way of living structure – is that it is a collection of 64 segments of size 1/27 (or ~0.04), plus 16 segments of size 1/9 (or ~0.11), plus 4 segments of size 1/3 (or ~0.33), plus 1 segment of size 1, i.e., 64 + 16 + 4 + 1 = 85 segments. In other words, all large sizes (1, 1/3, and 1/9) are embedded in the small one (1/27) in a recursive manner. Now let's calculate the average length of these 85 segments, which is ~0.08. Clearly, there are 16 + 4 + 1 = 21 long segments (longer than the average) and 64 short segments (shorter than the average), implying far more short segments than long ones. For the purpose of generalization, we retain the long ones, and we have a result of level 1 in Figure 4b. For level 1, there are 21 segments, and their average length is ~0.20. There are five segments greater than this average ~0.20, and thus we have a level 2 generalization (Figure 4b). For level 2, there are 5 segments, and their average length is ~0.47. There is only one segment greater than this average ~0.47, and the result is level 3 (Figure 4b). From this generalization process, we can remark that the curve is the bump of the bump, the bump of the bump, and the bump of the bump (actually the last iteration is no longer a bump, but a straight line).

Seen from the working example of the Koch curve, map generalization is no more than retaining large things, while eliminating small things in a recursive manner to get different levels of detail. Geographic features like coastlines may look much more complicated than the Koch curve, but the head/tail breaks principle remains the same. A cartographic curve may be represented as a set of bends, recursively defined by three points as illustrated in Figure 1d. The largest bend x_1 is followed by the second largest bends x_2 and x_3, and third largest bends x_4, x_5, x_6 and x_7. From the point of view of the recursively defined bends, there are three inherent hierarchical levels. Thus, the simplification of the line can be carried out in a similar manner as that of the Koch curve. However, there is one potential problem in the course of line simplification or generalization: The simplified curve may create intersections either with the curve itself or with other geographic features, the so-called "self-intersection" or "intersection with others", which produces topologically incorrect geographic features. The solution to this problem is simple (Jiang 2017 and related references therein); whenever intersections occur with a simplified curve, that part of the curve has to go back to the previous iteration, or a few trivial points have to be added to avoid the intersection, but all other parts without conflicts remain unchanged.

Table 4: Statistics of the head/tail breaks process for the Koch curve

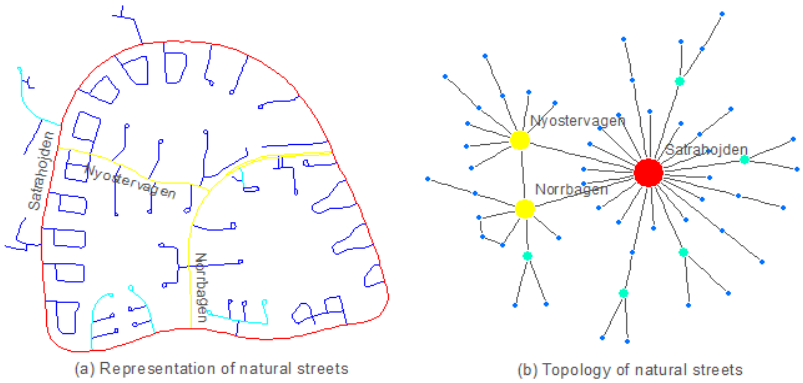
# Segment	Mean	# head	# tail	% head	% tail
85	0.08	21	64	25%	75%
21	0.20	5	16	24%	76%
5	0.47	1	4	20%	80%

Seen from these two examples, data classification and map generalization can be accomplished objectively, by applying head/tail breaks to the underling living structure. Since the resulting maps are automatically determined by head/tail breaks, we can say that the "data speak for itself". Under the current mapping paradigm, there are many parameters to be set carefully to fulfill automatic map generalization between two particular map scales (e.g. from 1:10K to 1:50K) (e.g., Stoter et al. 2014, Buttenfield et al. 2011). In contrast, under the living structure view, and relying on the head/tail breaks, there are few parameters to be set; if any parameters are set, the ideal is to let the data determine a meaningful cutoff rather than have cartographers make this decision. This opens up the possibility of automatic map generalization from a single large-scale database to create a large variety of small-scale maps.

5. Further discussions on living structure for maps and art

Maps are essentially about the truth of the territory or that of the Earth's surface, or more specifically the truth of the underlying living structure. There is little doubt that there are subjective factors involved in maps and mapping (Monmonier 1991, Wright 1942), but

maps are largely about truth, and an important component of this truth is the inherent hierarchy of far more smalls than larges. Objectivity is more important than subjectivity in the mapping process rather than the other way around. It is for sure that certain aspects are sometimes distorted or exaggerated. For example, for the purpose of navigation, the London Underground Map puts linkages and stops in the first and foremost priority of representation, while drastically simplifying locations, routes, and even orientations. The Underground Map, although drastically simplified, becomes far more informative for the purpose of navigation. As another example, Figure 5 shows the topology of underlying streets, indicating the living structure of far more less-connected streets than well-connected ones. Note that the graph in Figure 5b is not georeferenced at all, neither the nodes nor the links have any georeferenced information. Instead, the node sizes indicate the degree of connectivity of the corresponding streets in Figure 5a. With the graph, the underlying living structure of the street network becomes very striking. It helps to answer such a question as: how many intermediate streets does one have to pass through in order to go from location A to location B? Unfortunately, this question is virtually impossible to address with any conventional representation (e.g., Figure 1a). In this case Figure 5b provides a good example about the true living structure of the Earth's surface.



(a) Representation of natural streets (b) Topology of natural streets

Figure 5: (Color online) A living structure with four hierarchical levels of natural streets (Note: The natural streets that are represented – on the surface – by geometrical details of locations, sizes, and directions (a) are transformed into the topology of the streets or living structure – in the deep sense – with far more less-connected streets than well-connected ones (b).)

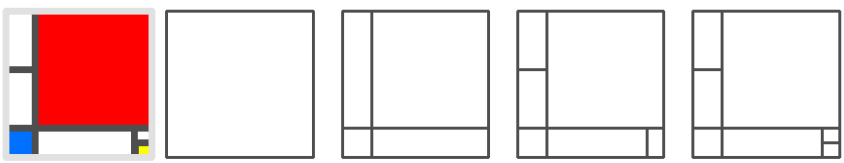


Figure 6: Composition II by Piet Mondrian (a) and its evolution from the empty square (Note: It meets the minimum condition of being a living structure, and it is simple enough to illustrate how it is differentiated in a step-by-step fashion in panels (b) to (e), thus with a gradually increasing degree of life or beauty; there are far more smalls (4) than larges (1) from (b) to (c), and again far more smalls (6) than larges (4) from (c) to (d), so the ht-index is 3, which meets the condition of being a living structure. Thus both (b) and (c) are non-living structure, for their ht-index is less than 3. In addition, there is a violation of far more smalls (7) than larges (6) from (d) to (e), for 6 and 7 are more or less similar. If we consider the evolution in the opposite direction (from (e) to (b)) then it can be viewed as a generalization process, very much like that of map generalization.)

The living structure view of maps and the territory or the Earth's surface in general is a powerful concept that has important implications for maps and mapping. The implications touch such issues as automatic mapping, the nature of maps, the mental image of maps, and how maps work. Although a large body of research has attempted to address these profound issues in the past century (e.g., Eckert 1908, Robinson 1952, MacEachren 1995, Wuppuluri and Doria 2018, Tversky 2019), such research has not considered the underlying living structure. It can be argued that the nature of maps depends to a considerable extent on the underlying living structure or the inherent hierarchy of far more smalls than larges; it is through the living structure or the inherent hierarchy that maps often convey useful information, and those largest and most connected and most meaningful things constitute the mental image of the map in the human mind. In this sense maps, in particular terrain maps or topographic maps, are not very different from products of art (like landscape paintings), because both tend to reflect the underlying living structure.

In addition to revealing the living structure of far more smalls than larges, another advantage of Alexander's approach is that the resulting maps should provide a sense of good feelings such as belonging, healing and well-being. This concept may seem foreign to cartographers, but it is integral to the concept of living structure. For example, Alexander (2002–2005) describes the good feelings that come from viewing architecture that is based on living structure principles. We conjecture that it is the underlying living structure of natural scenes that has the healing effect on patients' recovery from surgery (Ulrich 1984). In this sense, it also can be argued that there is little difference between when people are exposed to good maps and when people are exposed to good scenes (either landscapes or indigenous buildings). In other words, maps can be viewed as no different from landscapes and buildings, because they are all living structure. Also, in this connection, there

is little difference between maps and fine products of art, because both capture the underlying living structure. Actually, not only fine products of art, but also abstract paintings reflect the underlying living structure. For example, Jackson Pollock's epic painting *Blue Poles: Number 11, 1952* presents nothing more than the recurring notion of far more smalls than larges, which is the very essence of nature or of the Earth's surface in particular. The fractal or living nature of Jackson Pollock's drip paintings was verified by the physicist Taylor (2006), who discovered that those paintings with a fractal dimension around 1.3–1.5 tend to have the highest aesthetic appeal or the highest degree of beauty in the human mind or heart.

As another example of the relevance of art, Piet Mondrian's compositions of red, yellow and blue are living structures, although they are less living than those of Pollock's drip paintings. Mondrian's compositions present nothing more than the recurring notion of far more smalls than larges. Figure 6 presents one of Mondrian's compositions, consisting of only seven simple pieces. It does not exhibit extensive living structure, but we see clearly twice the recurring notion of far more smalls than larges. The composition painting can be viewed as the product of the differentiation process in a step-by-step fashion, i.e. the square space is continuously differentiated leading to far more smalls than larges. Viewed the other way around, the empty square can be viewed as the outcome of aggregating or clustering small pieces into large ones, also in a step-by-step process. In spirit, the aggregating process is actually the map generalization process, as small pieces are aggregated to large ones.

6. Conclusion

Beginning with the two basic facts about maps, we have attempted to argue that not only maps but also the territory is a living structure. The living structure exhibits the inherent hierarchy of far more smalls than larges, e.g., far more low peaks than high peaks over a terrain surface, far more small cities than large ones in a country, far more short streets than long ones in a city, and far more small bends than large ones over a coastline. Although cartographers have long been – subconsciously or unconsciously – guided by living structure for map making or map reading, this paper is intended to explicitly establish living structure as a formal concept of maps and mapping. We have argued and demonstrated that it is the inherent hierarchy or the recurring notion of far more smalls than larges that makes maps and mapping possible, and data classification and map generalization within map making can be accomplished through the head/tail breaks process. Viewed in the reverse sense, it is essentially the conventional mode of thinking based on Euclidean geometry and Gaussian statistics that makes automatic map generalization virtually impossible.

Maps can, should and must be treated as a scientific product, and their quality can be judged to a considerable extent by the underlying living structure. It can be argued that the more that maps reflect the underlying living structure, the better the quality of the maps. The iterative head/tail breaks method provides an objective method of determining an appropriate data classification or level of generalization, and can avoid some of the subjective issues associated with more traditional approaches. A map based on living structure can evoke a good sense of feeling in human beings in their deep psyche in terms of belonging, healing and well-being. This kind of good feeling can explain why many people love maps. Importantly this kind of feeling is shared. To paraphrase Alexander (2002–2005), a majority of our feelings are shared, and idiosyncratic feelings account for only a minority. Using Alexander's approach, objectivity is favored over subjectivity in maps and mapping, because maps and the territory share the same living structure. In this new way of mapping, there is a distinct attempt to design from the bottom up, i.e., let the geospatial data map or speak for itself. This new way of mapping departs radically from the current ways of mapping often involving many parameters imposed by techniques (e.g., natural breaks, Kernel density function) or by cartographers.

Acknowledgement

This paper is a reprint of the recent paper (Jiang and Slocum 2020), and it grows out of collaboration between the two authors on an AutoCarto 2020 Workshop on Living Structure as a Scientific Foundation of Maps and Mapping. The workshop has been delayed due to the COVID-19 pandemic. During the preparation of the workshop, the two authors have exchanged numerous emails discussing the two tools Axwoman and head/tail breaks. One of the fruits of the collaboration is this paper, arguing for establishing living structure as a formal concept or foundation of maps and mapping. The paper was partially supported by the Swedish Research Council FORMAS through the ALEXANDER project with grant number FR-2017/0009.

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Astronauts to fly on SpaceX Crew-2 mission

NASA and its international partners have assigned crew members for Crew-2, which will be the second operational SpaceX Crew Dragon flight to the International Space Station as part of NASA's Commercial Crew Program.

NASA astronauts Shane Kimbrough and Megan McArthur will serve as spacecraft commander and pilot, respectively, for the mission. JAXA (Japan Aerospace Exploration Agency) astronaut Akihiko Hoshide and ESA (European Space Agency) astronaut Thomas Pesquet will join as mission specialists.

Crew-2 is targeted to launch in spring 2021, following the successful completion of both NASA's SpaceX Demo-2 test flight mission, which is expected to return to Earth Aug. 2, and the launch of NASA's SpaceX Crew-1 mission, which is targeted for late September.

The Crew-2 astronauts will remain aboard the space station for approximately six months as expedition crew members, along with three crewmates who will launch via a Russian Soyuz spacecraft. The increase of the full space station crew complement to seven members – over the previous six – will allow NASA to effectively double the amount of science that can be conducted in space.

NASA's Commercial Crew Program is working with the American aerospace industry as companies develop and operate a new generation of spacecraft and launch systems capable of carrying crews to low-Earth orbit and the space station. Commercial transportation to and from the station will provide expanded utility, additional research time, and broader opportunities for discovery on the orbital outpost. *www.nasa.gov*

In Coordinates

10 years before...

mycoordinates.org/vol-6-issue-8-August -2010

Phase centre determination on the basis of far-field measurements

Nikola Basta, Andriy Konovaltsev and Lukasz A Greda
DLR, German Aerospace Center, Germany

The phase front curves obtained in the simulations are much less distorted than the measured ones, thus introducing less error in the least square estimation. Therewith calculated PC positions are stable with respect to the zenith angle (Fig. 4). The proposed method allows for estimation of the phase centre variations.

GPR data georeferencing using photogrammetry and digital maps

Barzaghi Riccardo, Carrion Daniela, Cazzaniga Noemi Emanuela and Forlani Gianfranco
DIIAR, Politecnico di Milano, Milan, Italy

The results obtained from this three simulations suggest that the objective can be achieved, provided that GCP can be recognized on images at intervals not much larger than 200- 250 m, with precisions below 10 cm. Preliminary tests with real image sequences show that automatic image orientation can deal with sequences of 30-40 images without problems.

GEO-spatial data accuracy and its legal implications

Adibah Awang and Shahidah Mohd Ariff
Geo Law Research Group Faculty of Geoinformation Science and Engineering Universiti Teknologi Malaysia

Ahmad Fauzi Bin Nordin Deputy Director General of Survey and Mapping Department of Survey and Mapping, Malaysia

The paper reflects on the law and standards pertaining to data accuracy and its legal implication due to the lack of accuracy by tracing the source or basis of data inaccuracy i.e. primary data source, processing of the data and the human factor.

"Eventually all receivers will be multi-GNSS"

Says John Pottle Marketing Director, Spirent Communications, Positioning Group

Solutions that combine multi-GNSS, low cost inertial sensors and wi-fi positioning are becoming a very strong solution for consumers. More generally, inertial navigation is an excellent compliment to GNSS, in that inertial continues to work well where GNSS is not available. I think the frontrunners will combine symbiotic technologies like GPS and inertial to provide the best performance for customers, whatever the application.

Decision support system for engineering structure supervision

The work presented in this article is through the integration of multidimensional and spatial analysis in the management of a network of auscultation for monitoring structures

Aicha Derkaoui
Teacher-researcher
Abou Bekr Belkaid University in Tlemcen, Algeria

The safety of engineering structures requires periodic inspection. Assessing the condition of the structure and its behavior cannot be done without a regular and frequent monitoring by establishing a network of geometric auscultation. The contribution of an analytical tool in the management of this network is the purpose of this work.

The idea is to propose an interactive decision support system by integrating GIS and OLAP technology to take advantage of each to ensure better multidimensional and space analysis to facilitate decision making. It will therefore be to combine the technology of geographic information systems for the treatment of geographic data and map viewing with exploration and analysis tools OLAP, this achievement involves many concepts and techniques. The practical application of our work is in the field of engineering structure supervision. The data used to illustrate our contribution concerns the geometric auscultation network of the GL4Z storage tank.

Introduction

Engineering structures such as storage tanks are constantly prone to deformations and displacements under the constraints of internal and external loads acting on structures. To ensure safety, prevent costly damage, check the criteria of construction and follow their behavior in general, an accurate assessment of their travel time is needed for this, the basic geodetic measurements that are the determination on a given date, the position of points in a network established on the study site is applied. Thus, their relative displacements are used to define the deformations of the ground. The framework put in place for periodic monitoring of tanks, is presented as a tool for monitoring and prevention of risks that might arise while determining the positions of the targets to quantify their movements compared to a known initial position to reach a decision.

The effectiveness of decision-making depends on the provision of relevant information and appropriate tools. Management systems of traditional data will be inappropriate for the activity of decision making. To overcome this drawback, systems decision supports have been developed and whose main objective is to allow a user to access data simply and enhance the information retrieved.

The objective of this work is to propose a decision-making approach to surveillance (geometric auscultation) work of art based on the concept SOLAP (Spatial On Line Analytical Processing), which opens up new possibilities for managing and exploring data.

The work presented in this article is through the integration of multidimensional and spatial analysis in the management of a network of auscultation for monitoring structures.

Auscultation

Auscultation includes all devices for measuring physical quantities may change in time, so as to highlight its behavior and the evolutionary significant aging. To do this, we proceed to measure displacements, strains, stresses, pressures, flow rates ... etc. Among these methods, we find the geometric auscultation.

Measures auscultation structures are of great importance. They have in fact two main goals:

- Check the stability of the structure and prevent major risks trained by his break.
- Track the behavior of the structure in time, i.e. quantify the displacements and deformations of parts or all of the item.

Based on the geometric elements of auscultation as place on the ground, we proposed decision model shown in Figure (1). This model follows the steps of the decision-making approach of Pictet. Figure (2) summarizes the different steps of the structuring phase, operation and implementation.

Structuring phase model

In this phase, the surveillance data from different observing campaigns undergo a series of treatments in a process data warehouse ETL (Extract, Transform, Load) and then integrated into a single data warehouse.

The relational database is structured according to a particular model called star model which takes its name from the configuration object containing a central fact table named connected to a number of objects radially called dimension tables that contain attributes defining each dimension members. The data store is a Data Mart or localized implantation of a data warehouse for single use. Its dimensions are chosen according to the needs of our application and the desired measurements and included in the client application.

Operational phase of the model

The data are presented as a multidimensional view before presenting them to the client module with different display modes:

- Graph: tabular, histograms or pie;
- Cartography by a geographic information system.

The OLAP tool used for navigation in the data warehouse. In the OLAP tool, data is imported from transactional systems and restructured into a cube, through dimensions. The imported data stores must be organized in a model facilitating the decision and suitable for analysis tools.

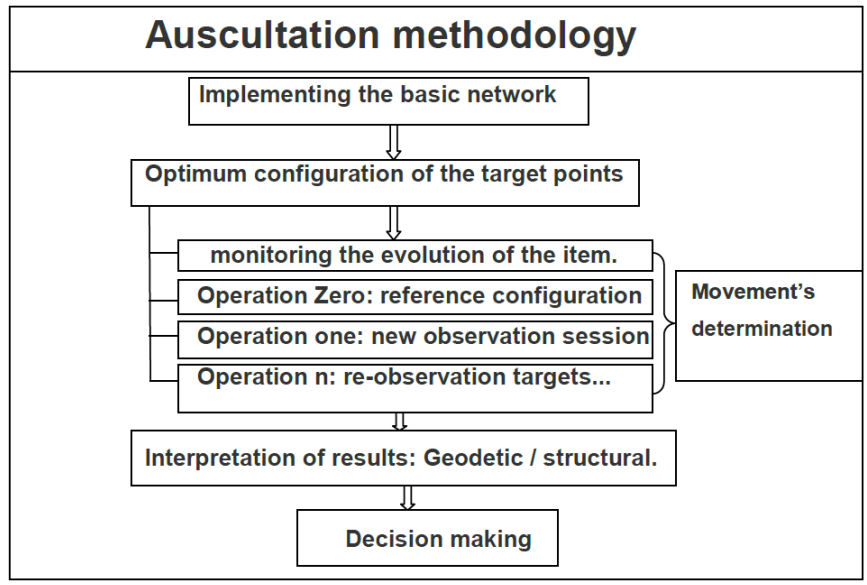

Figure 1: Auscultation Méthodology

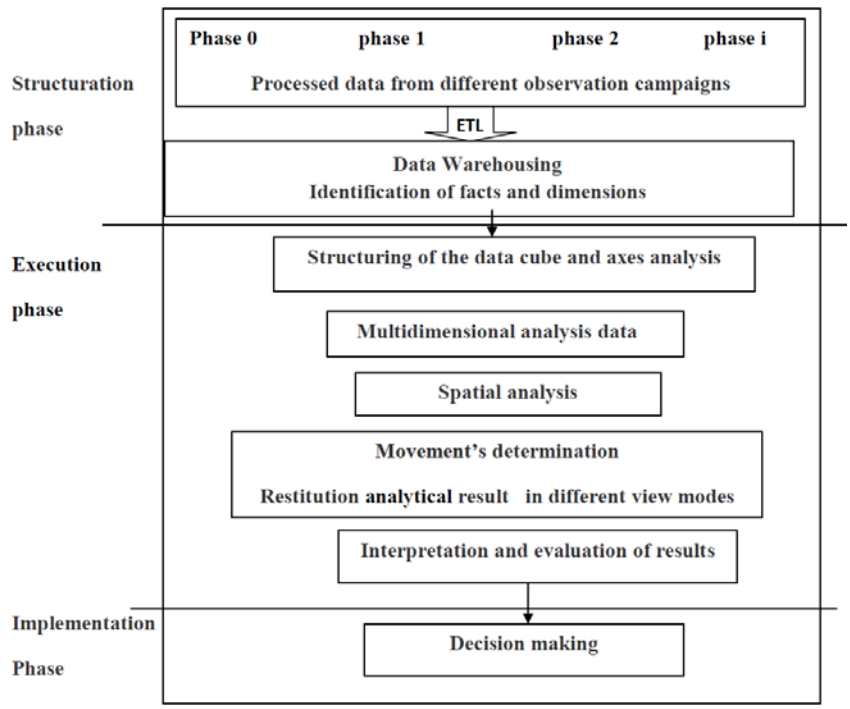

Figure 2: Decision Support Model for geometric auscultation

The multivariate analysis allows knowing, measure and forecast (decision) through the manipulation of data store. We can consider several handling operations:

- Consultation of table data and generate graphs;
- Requestgraph on a database;
- Application of multidimensional operators. Spatial analysis is an essential activity for mapping and decision making. GIS used for spatial analysis. It remains a tool in the decision making process and it becomes a tool integrator providing clear and accurate information to decision makers to make a more just and enlightened. GIS is currently the best tool for digital geographic information and definition, especially as this analysis tools.

Phase of implementation of the results

This phase focuses on the interpretation of results of analysis and knowledge discovery in order to facilitate the taking of the decision.

Figure (2) presents an overview of the proposed decision-making process for inspecting geometric aims to facilitate decision making. System of Interactive Decision Support (DSS) adopted this approach based on OLAP engine which is the center of the model and gives back the tables and charts, as well as results from mapping the spatial analysis.

The suggested approach to decision making is structured according to the three stages of Pictet, namely the step of structuring, operating and implementation.

The proposed decision model will serve as a monitoring system for the interpretation of geodetic results following trends deformations and displacements using geo-technologies more advanced decision (Datawarehouse, Data mart, GIS OLAP cube and SOLAP).

Case study

Our model monitoring work of art oriented solution SOLAP belongs to the whole vast field of applications of decision support, particularly from the field of Business Intelligence.

Indeed, the architecture of our system decision support is that of a purely OLAP architecture while integrating spatially referenced data at different levels of application components.

The decision model proposed allows the exploitation of the data cube for spatio-temporal analysis based on the different dimensions temporal, geographical and thematic.

Presentation of the tank frozen ground

The tank frozen ground LNG terminal complex SONATRACH GL/4Z Arzew was built in 1964 and has a capacity of about 38,000 m3. It accounted for the complex more than 50% of its storage capacity. The tank has a diameter of 37.20 meters and a depth of 36 meters and is situated 100 meters from the sea. The main characteristic of this type of storage is the lack of insulation and moisture barrier on the vertical walls and the bottom. Only the gel of the water contained in the soil ensures impermeability. This type of storage can be heated without destroying itself. Problems encountered in the operation of this type of storage are of different types: natural

- Problems (deformations of the tank and its immediate vicinity).
- Structural problems (disorders at the structure supporting the roof of the tank).

The origins of these problems are mainly related to the nature of the soil, the proximity of the sea and the progression of freezing front.

Methodology of the tank auscultation

This type of tank is well suited to auscultation GPS where all the precision of this technique standard (SD = 5mm ± 1 ppm) can be exploited. Auscultation methodology for this type of tray is as follows:

Implementation of basic network choice points near the work sites and stable materialization terminals concrete. The altitude of the base stations was chosen almost identical to that of the tank to minimize the influence of the troposphere.

- Optimal targets:
  - Number and homogeneous distribution of target points: according to the shape and type of structure by a suitable mesh (structural mechanics).
  - Sustainable Materialization points.
- Monitoring the evolution or stability of the structure:
  - Operation 0: observation in static or rapid static and determining the coordinates of the target points. The positions of these points from the backbone are the reference pattern. - Operation i: determining the positions of target points from a new campaign GPS observation to quantify the displacements of the structure relative to the reference configuration. The new configuration thus determined (step i) serve as a reference

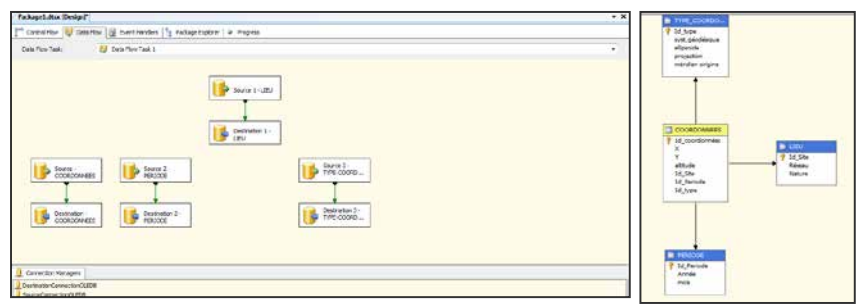

Figure 3: data Integration & data cube.

configuration for the next operation auscultation (i +1). The frequency response varies the amplitude of the deformations, the speed of movement of the tray and in response to events (such as earthquakes, landslides ...).

- Interpreting results:
  - Geodetic Interpretations: following trends deformations and displacements.
  - Structural Interpretations: integrate other data (permeability, soil consolidation pressure, isotherms, internal inspection of the tank by endoscopy, etc.)...

Structuring phase

This first phase goes into the process of data warehousing (datawarhousing). We adopt in the following decision-making approach to monitoring by auscultation geometric proposed in the case of storage tank excavation of LNG. Informational part of our study is represented by data from 04 observational campaigns.

Microsoft Integration Services is a platform that allows you to create high-performance solutions for data integration, including extraction, transformation and loading (ETL) packages for data warehousing (Data Warehousing).

Through a process of data warehouse ETL (Extract, Transform, Load), data will undergo a series of treatments before stored in a single data warehouse: Data will first be extracted from each data source to be cleaned and homogenized. These data will become, therefore, the same target format to be finally loaded into the ED.

Operational phase

Multidimensional analysis

- Browsing the Cube

Once the cube is deployed, it is possible to display the data cube tab Browser (Browser) Designer cube and dimension data browser tab of Dimension Designer.

Navigation is a term used to describe the process used to explore a cube interactively, usually by using a graphical OLAP client connected to an OLAP server. The process for user interactive multidimensional query is called "slicing" and "dicing". The result of a query is either a multidimensional cell, a "slice" two-dimensional or multi-dimensional subcube.

- Determining the displacements of the network

The MDX language, developed in the laboratories Microsoft is a query language for multidimensional databases more suitable than conventional SQL query processing OLAP type. MDX stands for "Multi-Dimensional Expressions". To calculate the various movements during the observation periods, we execute some MDX queries:

- Restitution analysis results

A data warehouse should allow locate and retrieve information, to store and query, analyze and enrich, and provide visualization tools and reporting. This tool is based on a multidimensional interaction enables fast and intuitive to navigate through the information.

Figures 4, 5 and 6 illustrate the variations of the basic network in X, Y and altitude:

Spatial analysis

Spatial analysis is an essential activity for mapping and decision making.

In a geographic database (GDB) many information is not explicitly represented. Typically, this information may be reconstructed by the human eye when reading a map, as the relationship between objects "is near."

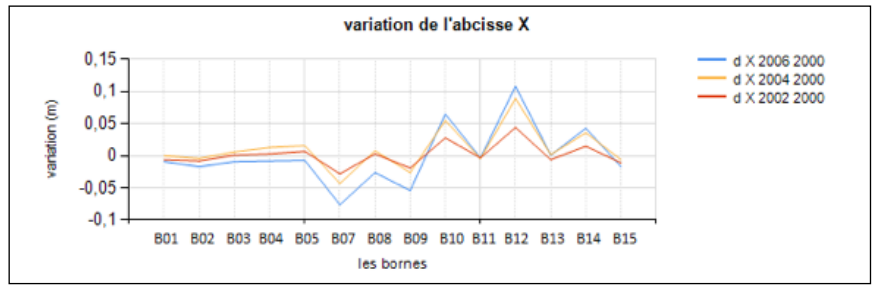

Figure 4: X abscissa Variation of the basic network.

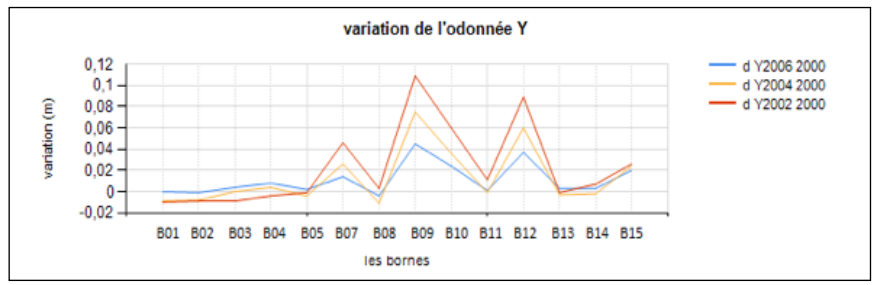

Figure 5: Latitude variation of the basic network.

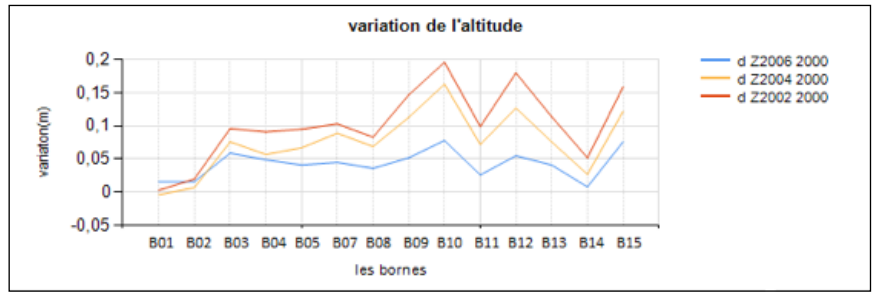

Figure 6: Altitude variation of the basic network

This work is a contribution to the monitoring work of art on possible technological responses to better control and understanding of risk exposure, this study is within the framework of systems decision support. This approach adopts dimensional modeling data organized in a manner appropriate to analysis to an analytical study of advanced data, providing an effective decision support.

The reconstruction of these relationships must meet various levels of analysis corresponding to different scales meaningful objects and phenomena that are the arguments. Spatial analysis aims to clarify these relationships.

The spatial analyses determine the spatial distribution of a variable, the relationship between the spatial distribution of the variables and the association thereof to a geographical area.

Spatial analysis refers to the analysis of a distributed phenomenon in space which also has the physical dimensions (the location, proximity, etc. ...)

To arrive at a more convenient comparison, a superposition of the contour isolines of the two periods and a surface map subtracted from the differences between the two digital surfaces were performed.

Figures represents the change in altitude and therefore the significance of the deformations of the study area

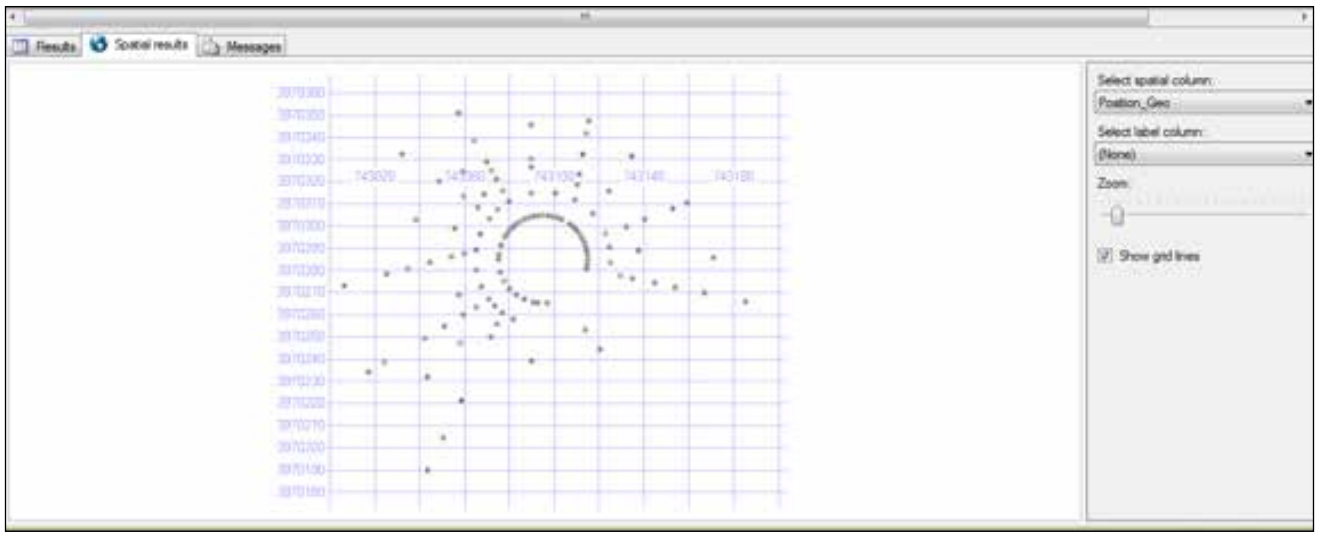

Figure 7: Network auscultation frozen ground (GL4 / Z – Arzew).

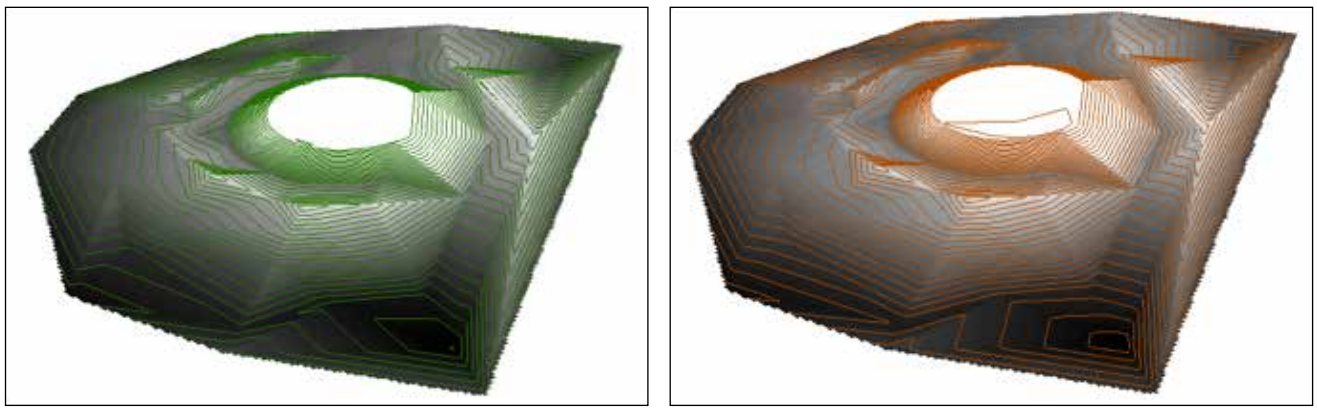

Figure 8: Representation of terrain surrounding the storage tank in 2000 (a) and 2006 (b).

in terms of compaction and swelling, it is important at the white surface, and reaches 252 mm. These numerical models constructed from our data are close to a three-dimensional reality on the ground to identify the most significant characteristics of the landforms of the area surrounding the tank.

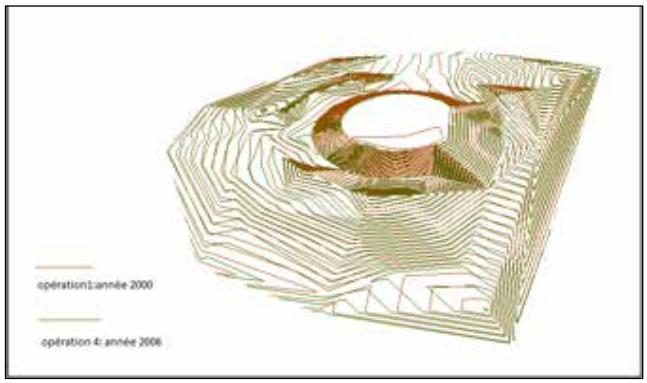

Figure 9: Contours representing the contour plot of the first and fourth operation

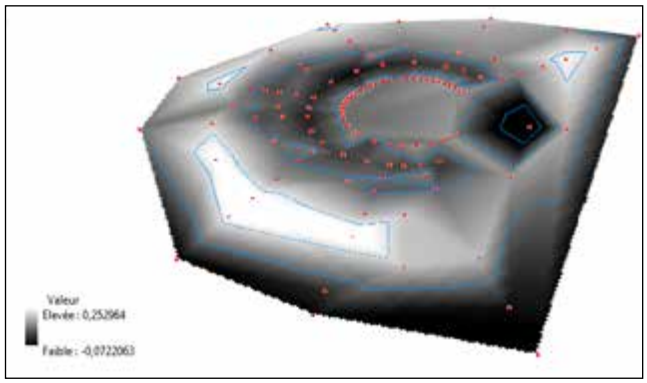

Figure 10: Surface subtracted: representing the variation in altitude between the two digital surfaces

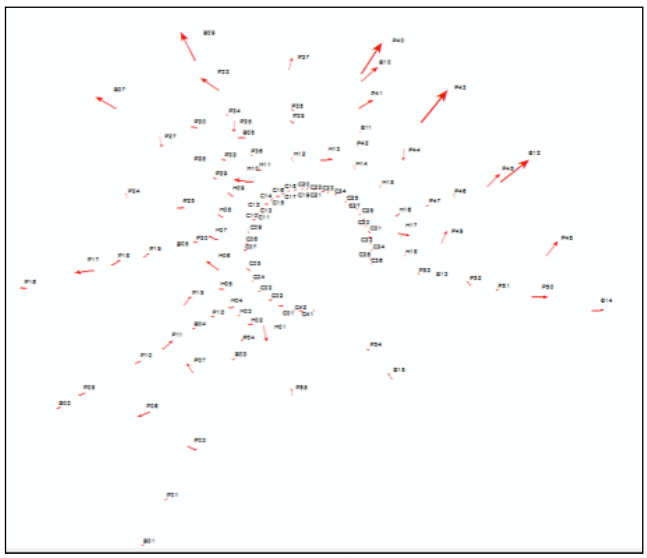

Figure 11: Planimetric displacement network points between the periods 2000 and 2006.

Figure (11) shows that the majority of the network points of auscultation of the tank in frozen soil are subject to a phenomenon of horizontal displacement in the direction north-east. The maximum value of the displacement is of the order of 163 mm.

Comparison of the results obtained during four campaigns of GPS observations helped highlight the movements of the order of 163 mm in plan and 252 mm altimetry.

Conclusion

This work is a contribution to the monitoring work of art on possible technological responses to better control and understanding of risk exposure, this study is within the framework of systems decision support. This approach adopts dimensional modeling data organized in a manner appropriate to analysis to an analytical study of advanced data, providing an effective decision support. Another category of tools derived from the first, is also booming. It is SOLAP tools that combine the analytical power of OLAP tools with visualization capabilities maps. At first it was necessary to develop a decision model dedicated to the monitoring work of art by auscultation geometry. The suggested approach to decision making is structured according to three steps of pictet. Our application focused on auscultation network storage bin GL4Z established for the surveillance of this very particular structure. Information from the 04 observation periods emerge as a decision-making element of the first order, and the ability to manage and use it wisely is a substantial contribution of new information technologies to help achieve the objectives the decision. This application allowed us good management of the time dimension, the addition of calculated measures, filtering on dimension members, exploration operations and flexible management of cartographic, tabular and graphical displays.

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COVID-19: Idled Sarasota employees contribute with fieldwork

As coronavirus disease 2019 (COVID-19) struck Florida, Sarasota began locking down its municipal buildings, and the daily workload of many city employees waned

Sarah Alban
Director of Marketing at Eos Positioning Systems.

A parking enforcement officer and city clerk are part of an innovative project in Sarasota, Florida. Municipal staff whose traditional daily work has decreased due to the pandemic are spending time on the city's streets adding crucial data to the map.

As coronavirus disease 2019 (COVID-19) struck Florida, Sarasota began locking down its municipal buildings, and the daily workload of many city employees waned. City manager Tom Barwin sent out a notice to all departments looking for creative ways to productively occupy these workers.

William Rockwell, a GIS coordinator for the city, proposed idle staff be put to work collecting much-needed accurate location and attribute data on city assets.

City workers train in a parking lot near City Hall, observing safe social distancing

Rockwell worked out a proposal with city IT director Herminio Rodriguez.

"The financial commitment was small from the city, but the return could be huge," Rodriguez said. "The city could start capturing this massive amount of data that it really needs."

Quick workforce transition

Rodriguez joined Sarasota five years ago to rebuild an IT department from scratch, complete with an enterprise geographic information system (GIS).

Last year, Rodriguez hired Rockwell to rebuild the city's GIS and update its data. In the past, Sarasota had outsourced its GIS data collection, but the data was never reliable and was now outdated.

"We want to be able to make data-driven decisions, and GIS is a big component of that," Rodriguez said.

To meet their goals of building a GIS, Rodriguez and Rockwell determined they would need to either update or re-create all the city's information assets. They had estimated the costs to be in the hundreds of thousands of dollars in outsourced labor over the course of at least five years. But the newly available city staff would be able to perform the work for no additional charge.

Because the city had an enterprise GIS, there were also no extra software costs. The city also had a box of extra iPhones left over from a service provider migration, which could be converted into

offline data collection devices. The only cost would be for professional-grade GPS receivers to enhance the iPhones' accuracy.

Taking to the streets

Rockwell met with city subject matter experts to decide which asset types to focus on. They prioritized data collection on city streetlights because of the numerous requests for information from outside organizations, such as Florida Power & Light Company and the Florida Department of Transportation. The team also determined that road signs would be easy to map concurrently.

Working from home, Rockwell set up 14 data collection kits. Each kit consisted of an iPhone loaded with Collector for ArcGIS, the city's mobile device manager software for security, a range pole, and the Eos Arrow 100 Global Navigation Satellite System (GNSS) receiver.

The next day, Rockwell met five city employees at the city hall parking lot for the first group training. The employees took care to follow social distancing guidelines while Rockwell explained the basic concepts of data collection. Employees practiced collecting sample data so Rockwell could address any initial concerns.

Rockwell handed out reflective vests, printed maps, and markers. The printed map consisted of 28 full or partial grids of the city. This allowed members of the newly improvised data collection crew, most of them not very familiar with GIS, to easily mark off where they had collected data each day.

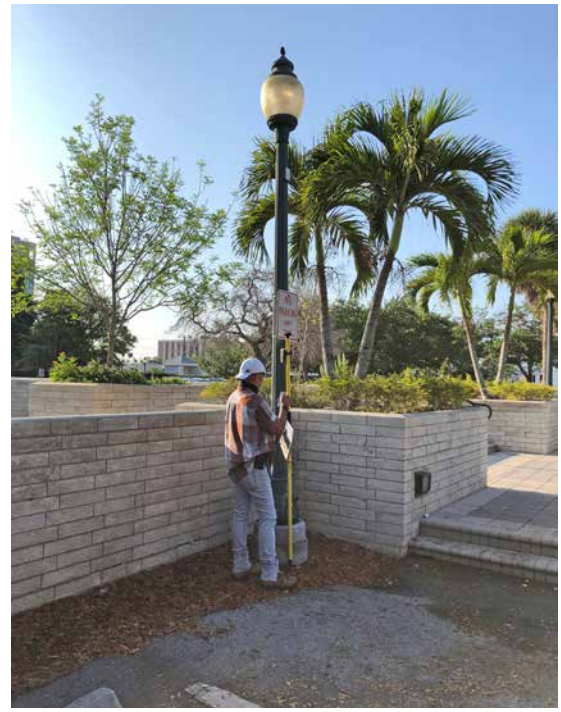
"Once they're done, they text or call me, and I can give them a new quarter section to take on," Rockwell said.

Boost for employees and constituents in a tough time

At the end of each day, after the workers have synced their data, Rockwell assesses the team's progress. In the first few days, this allowed him to quickly spot any errors, such as photos not collected with the assets, and take corrective action.

Planning technician Billy Cooney had used GIS in the past, but he usually spent his time assisting senior planners, such as by measuring rights-of-way. Now Cooney is committed to spending two days per week doing field data collection.

"I try to help out wherever I can," Cooney said. "It's nice that I have a project that gets me out and walking around, especially now that I'm working from home and socializing less."



On the rare occasion, employees collect data for both a street light and a sign at the same time

The extra hands are helping Sarasota accelerate its planned GIS database improvements while keeping city staff productive during the pandemic.

To date, seven fieldworkers have collected data on 4,135 of the city's 6,000 streetlights and 7,950 of the city's 16,000 road signs. Then, they will collect data on the city's 35,000 trees.

Overall, response to the project has been overwhelmingly positive.

"I'm thrilled the city is supporting this initiative," Rodriguez said. "To be able to take employees doing very, very different jobs and put them in the field—this wouldn't have been possible in a normal environment."

The article was first published at Esri.com and can be accessed at https://www.esri.com/about/newsroom/blog/covid-19-idled-sarasota-employees-contribute-fieldwork/

The Components of Accurate Field Data Collection

Sarasota's GIS coordinator William Rockwell configured the asset inventory application using Collector for ArcGIS. The app comes as part of the city's GIS license and offers a variety of helpful data collection features, including the ability to work in disconnected environments.

Rockwell set a three-feet accuracy threshold in the app to ensure correct asset locations. Fieldworkers could take pictures of assets and see and update existing data rather than collect it from scratch.

For GPS receivers, Rockwell chose Arrow 100 Global Navigation Satellite System (GNSS) receivers, manufactured by Esri business partner Eos Positioning Systems. The Arrow 100 connects seamlessly with Collector for ArcGIS to provide submeter accuracy.

Bentley Systems' The Cohesive Companies

Bentley Systems, Incorporated has announced that its Acceleration Fund has launched The Cohesive Companies, a wholly owned subsidiary, anchored by the acquisition of Atlanta-based Cohesive Solutions. The new business venture will include the services team from Bentley's AssetWise business and the offerings of Bentley, Cohesive, and IBM's Maximo to support the digital transformation of infrastructure owner-operators.

The Cohesive Companies will act as a digital integrator to help infrastructure asset owners upgrade their enterprise environments to leverage digital twins-digital representations and simulations of a physical asset, synchronizing digital context (current existing conditions), digital components (engineering content), and digital chronology (lifecycle change management). Infrastructure digital twins can empower asset operators with immersive visualization and analytics visibility to predict and optimize performance. *www.bentley.com*

LG BIM Library

LG Electronics is to provide a robust BIM library for building professionals to be able to quickly integrate Revit families for LG commercial displays into BIM projects. As the leading manufacturer of innovative commercial display products, LG Commercial Displays deliver premium-viewing experiences to audiences all around the world.
LG has partnered with BIMsmith so that one can research, compare, and download LG Revit families and product documentation quickly and easily. *www.lg.com*

India will start GIS-based land buying system

India will start GIS based land buying service on a pilot basis to attract foreign companies, Commerce and Industry Minister Piyush Goyal.
Addressing USIBC's India Ideas Summit through video conferencing, he said India will identify land for setting up industries through GIS-based tool.
He said that the GIS system will have Google earth view where a person sitting in Iceland can locate land in India and can buy it. The minister also pushed for an 'early harvest' agreement with the US. *www.businessworld.in*

Google's $2.1 billion Fitbit deal faces EU antitrust probe

Google's $2.1 billion bid for fitness tracker maker Fitbit will face a full-scale EU antitrust investigation, people familiar with the matter said.

Alphabet unit Google this month offered not to use Fitbit's health data to help it target ads in an attempt to address EU antitrust concerns. The opening of a full-scale investigation suggests that this is not sufficient. The deal, announced last November, would see Google compete with market leader Apple and Samsung in the fitness-tracking and smart-watch market, alongside others including Huawei and Xiaomi.

The European Commission, which will launch the probe following the end of its preliminary review on Aug. 4, is expected to make use of the four-month long investigation to explore in depth the use of data in healthcare, one of the people said. The Commission declined to comment. Google reiterated previous comments, saying the deal is about devices and not data.

"The wearables space is crowded, and we believe the combination of Google and Fitbit's hardware efforts will increase competition in the sector, benefiting consumers and making the next generation of devices better and more affordable," a spokeswoman said.

Google's data pledge has drawn criticism from healthcare providers, wearables rivals and privacy advocates for not addressing their concerns that the deal would boost its dominance in the online search market and its trove of data. *www.cnbc.com*

Cadcorp SIS 9 service release

GIS software, Cadcorp SIS, is continuing support for Ordnance Survey (OS) data products. In its latest service release, Cadcorp SIS Desktop now connects directly to the newly released Ordnance Survey Data Hub. It has dedicated wizards for connecting to the OS Features API, the OS Maps API and the OS Vector Tile API. *www.cadcorp.com*

1Spatial announces the release of 1Integrate v2.7

It ensures compliance of data for use across the enterprise and provides automated data validation, cleaning, transformation and enhancement. It enables users to assess the quality of data to ensure it meets defined specifications and is fit for purpose.

This release adds support for Esri feature services, enhanced security features and the ability to define custom task labels. *https://1spatial.com*

AHO to undertake hydrographic survey in Beagle

Precision Hydrographic Services (PHS) has recently been contracted by the Australian Hydrographic Office (AHO) to undertake a hydrographic survey in Beagle Gulf, located in the Northern Territory of Australia, to determine the local bathymetry for navigational purposes.

The hydrographic survey is taking place between the beginning of July 2020 and the end of August 2020, with two survey vessels, the Limitless and PHS Zephyr, both displaying flags (India over Romeo – conducting survey operations) while undertaking survey.

The survey will be measuring oceanographic parameters including currents, tides and wave height in the immediate area, with oceanographic measurements recorded by utilizing surface and seabed mounted instrumentation.

SpaceX launches third GPS Block III satellite

SpaceX launched their Falcon 9 rocket with the third Block III GPS satellite, named SV03. Block III is the next generation of GPS satellites, replacing the aging Block II series. This will be SpaceX's second GPS launch, out of the five they have been awarded so far.

SpaceX previously launched the maiden GPS Block III satellite, SV01, on a Falcon 9 in December 2018. SV01 was the first launch contract that SpaceX won in the Evolved Expendable Launch Vehicle (EELV) program.

In March 2017, SpaceX beat United Launch Alliance (ULA) to secure the launch contract for the third Block III satellite, SV03. At that time, the launch of SV03 was expected in early 2019.

Although SV01 and SV03 have flown or will fly on a Falcon 9 Block 5, their mission profiles will be slightly different.

For SV01's launch, the Air Force requested that the Falcon 9 fly in an expendable configuration to dedicate more performance to the satellite. This meant that the first stage – the new core B1054 – had to be expended on its first flight.

For SV03, however, the Space Force – who now run the GPS program – gave SpaceX the go-ahead to set aside some vehicle performance to enable first stage recovery.

Because of the satellite's deployment orbit and relatively high mass – 3.9 metric tons – the first stage will perform a ballistic landing. This will take place approximately 634km downrange, on SpaceX's droneship. *www.nasaspaceflight.com*

Third Lockheed Martin-Built GPS III Satellite now climbing to orbit

After a successful launch, the third Lockheed Martin built GPS III satellite is now headed to orbit under its own propulsion. GPS III Space Vehicle 03 (GPS III SV03) is responding to commands from U.S. Space Force and Lockheed Martin engineers in the Launch & Checkout Center at the company's Denver facility. There, they declared rocket booster separation and satellite control about 90 minutes after the satellite's launch aboard a SpaceX Falcon 9 rocket from Cape Canaveral Air Force Station, Florida. After on-orbit testing, GPS III SV03 is expected to join the GPS constellation – including GPS III SV01 and SV02, which were declared operational in January and April – in providing positioning, navigation and timing signals for more than four billion military, civil and commercial users.

Lockheed Martin designed GPS III to help the Space Force modernize the GPS constellation with new technology and capabilities. The new GPS IIIs provide three times better accuracy and up to eight times improved anti-jamming capabilities over any previous GPS satellite. They also offer a new L1C civil signal, which is compatible with other international global navigation satellite systems, like Europe's Galileo, to improve civilian user connectivity.

GPS III also continues the Space Force's plan to field M-Code, a more-secure, harder-to-jam and spoof GPS signal for our military forces. GPS III SV03 brings the number of M-Code enabled satellites to 22 in the 31-satellite GPS constellation. *www.lockheedmartin.com*

European Commission cuts space budget

The European Commission (EU) proposed to allocate €16 billion to enhance EU's leadership in space. However, the budget gas been slashed for science and technology, including space. The budget for the European Space Programme has now been set at €13.2 billion, of which €8 billion will be invested in the satellite navigation system Galileo and €.4.81 billion for Copernicus, Europe's earth observation programme. In the earlier budget, €9.7 billion was allocated for Galileo and €5.8 billion for Copernicus.

The remaining 392 million euros is going to be split between European space situational awareness (SSA) investments and GovSatCom, an initiative aimed at providing secure satellite communications for EC members. Horizon Europe, the EU's next research and innovation program will receive a budget of €80.9 billion. The figure is quite less as compared to the proposed €94.4 billion put forward by the European Commission in May. The budget for R&D have also got significantly cut.

European GNSS Agency launches MyGalileoDrone contest

The European GNSS Agency (GSA) has launched its MyGalileoDrone competition on July 17. Design and development of drone-based applications or services, using a Galileo-enabled receiver, are the main targets of this competition. They should address the EU's key priorities

such as the Green Deal, and support the EU Recovery Plan for Europe.The deadline for submission is August 31.

The competition aims to tap into the EU's innovative spirit. They seek to deliver services and applications which can contribute and boost Europe's competitiveness, resilience and sustainability. The solution based on drone operations should also seek to add value by increasing accuracy, availability and robustness of position as well as integrity.

The contestants should focus on not only design and development, but also prepare their drone based application or service for a commercial launch. The solution should leverage Galileo to provide a position fix. The use of EGNSS should be understood in the broad sense, and kept in mind that Galileo can be integrated in the flying platform, the ground control station, or in other devices supporting the operation, such as a smartphone or even in the frame of U-Space services.

EUR 100,000 will be rewarded as the first prize in the MyGalileoDrone competition, with EUR 60,000 for second, EUR 40,000 for third, and a fourth prize of EUR 30,000. *www.gsa.europa.eu*

Advanced GNSS Anti-jam by Raytheon

The UK Ministry of Defence Equipment and Support office tasked Raytheon to develop a prototype system to exploit assured and resilient position navigation and timing information derived from GNSS, according to a statement. Under the contract, Raytheon UK's Assured Positioning Navigation and Timing business will deliver a Technology Demonstrator Programme, with advanced multi-element anti-jam technology, to prove the integration of the A-J with a next-generation multi-GNSS receiver to both accelerate and de-risk the availability of such systems to end users.

The Programme will take advantage of Raytheon UK's extensive A-J heritage and established capability in the development of reduced size weight and power technologies, including Landshield and Landshield Plus, to enable the fitment of GNSS A-J to a wider range of platforms. It will help mitigate the increasing threat of satellite signal interference and provide a future solution that will protect our Front-Line Commands and Critical National Infrastructure.

Landshield houses a multi-element antenna and the anti-jam processing in a single small, affordable, 'one-box' solution that interfaces at RF level to the GPS receiver, with minimal system modification required. The device is intended to replace existing unprotected GPS antennas, as well as enhance original installations where protection against jamming and interference is required. It interfaces with standalone GPS receivers or those integrated within communication, inertial navigation, sighting, and vehicle or weapon-aiming systems.

KVH receives $10 million order

KVH Industries has received a new order with a net value of more than $10 million for its TACNAV® tactical navigation systems for use by an international military customer. KVH's fiber optic gyro (FOG)-based TACNAV systems are designed to provide unjammable inertial navigation data that fills in the gaps when GNSS is lost or unavailable, helping to keep soldiers and missions on track. *kvh.com*

Russia to place 6th ground station of Glonass satellite navigation system in Brazil

The Precision Instrument-Making Systems research and production corporation (part of the State Space Corporation Roscosmos) will place a non-request measuring station of the SM-Glonass satellite navigation system in the city of Belem (the state of Para in Brazil), Roscosmos reported. The Russian company signed the corresponding contract with the Federal University of Para and the Research Development and Support Foundation (FADESP).

The measuring station of the SM-Glonass system is designed to continuously monitor the signals of the Glonass, GPS, Galileo, Compass and QZSS navigation systems. The station is also required for controlling the reliability parameters of navigation signals of global navigation satellite systems. *https://tass.com*

Delivery of innovative z-axis capabilities for public safety

NextNav, the leader in z-axis and 3D geolocation services, and Sonim Technologies a leading U.S. provider of ultra-rugged mobility solutions, have announced a new partnership to make NextNav groundbreaking z-axis technology available to first responders and 911 emergency services.

Drawing on NextNav's carrier-grade network and innovative software, Sonim will be the first to offer NextNav-enabled devices capable of delivering z-axis (altitude) measurements for Public Safety and 911 emergency services. Using NextNav's software, first responder applications on Sonim devices will provide more accurate altitude data – capable of floor level (± 3m) accuracy mandated by the FCC – 95% of the time for locating 911 callers and minimizing response times. *NextNav.com*

Ramjack Technology Solutions and Syntony GNSS partnership

Ramjack Technology Solutions has announced a partnership with Syntony GNSS. Syntony innovations extend GPS coverage into previously inaccessible spaces, giving mining operations relentlessly reliable connectivity. Built on software-based navigation, mining operations can fully customise and upgrade their system to continue maximising their investment through the life of the product. The productivity gains and increased safety capabilities will be a game-changer in the mining industry, and this partnership will allow Ramjack to further introduce enhanced connectivity into even the most rugged of global mining operations. *www.ramjacktech.com*

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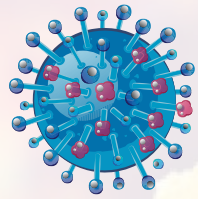
Tracking C  VID

ESA's COVID-19 space hunting platform

The European Space Agency (ESA) has recently launched an internal initiative to cull ideas for supporting its member states in the study and analysis of the COVID-19 pandemic. Under this initiative ESAC's Galileo Navigation Science Office has managed to get one of its ideas taken up under the name of the "COVID-19 Space Hunting Platform".

The platform's remit is to facilitate access to and processing of some of the existing COVID-19 databases for epidemiological studies, topping them up with data from ESA's earth observation satellites. The aim is then to tap into artificial intelligence procedures to look for any correlations between COVID-19 spread and environmental parameters, such as humidity, temperature, etc. The hope is thereby to help researchers generate products and stats that might be useful for decision-making purposes in terms of protection measures and lockdown, while also vetting the efficiency of the measures taken.

Development of the COVID-19 Space Hunting Platform is to be primed by the technology multinational GMV. The Universidad Politécnica de Valencia will also be weighing in with support for processing, data analysis and interaction with diverse epidemiological research groups. This university has defined a mathematical COVID-19 transmission model and has been publishing periodical updates and forecasts of its trend in Spain. *www.gmv.com*

COVID-19 population vulnerability dashboard created

Esri has collaborated with the United Nations Population Fund (UNFPA) to create the UNFPA COVID-19 Population Vulnerability Dashboard. This new interactive tool will provide public health workers, policy makers, and the general public with access to useful information on populations vulnerable to coronavirus disease 2019 (COVID-19) in order to target preparedness and response and to help save lives.

The dashboard highlights population vulnerabilities at the national and subnational levels, using data from the latest Integrated Public Use Microdata Series (IPUMS) census samples for 94 countries. It identifies populations at older ages, including those living alone, and includes risk factors for COVID-19 transmission such as residential density (household size and persons per room) and access to piped water and other amenities. Daily updates on COVID-19 cases and deaths are embedded in the dashboard, as is global data on health sector readiness. This includes the density of available health care workers, hospital beds, and intensive care units (ICUs). *esri.com*

Jacobs develops new model to help clients

Jacobs has developed a new COVID-19 modeling software program that is based on accepted probabilistic modeling techniques, and fuses publicly available datasets for COVID-19 infection statistics, sources such as the Centers for Disease Control and Prevention isolation guidelines, other publicly available data, and client or organizational-level data, and explores the differences between virus propagation based on various non-pharmaceutical interventions.

This model can be manipulated to create and assess various scenarios which clients may access – in combination with guidance from governments and health organizations, expert advice from medical professionals, and internal mitigation strategies and protocols. This may help inform the decision-making process with respect to restarting public transportation operations, like rail, road and aviation, or in planning and executing major capital programs. *www.jacobs.com*

VSR700 prototype performs first autonomous free flight

The prototype of Airbus Helicopters' VSR700 unmanned aerial system (UAS) has performed its first free flight. It performed a ten-minute flight at a drone test centre near Aix-en-Provence in the south of France. It derived from Hélicoptères Guimbal's Cabri G2, is an unmanned aerial system in the 500-1000 kg maximum take-off weight range.

This is a significant step in the programme following the first flight in November 2019 when the prototype was tethered to comply with regulatory requirements. To enable this free flight, Airbus Helicopters implemented geofencing, a virtual perimeter, which enabled and justified a flight clearance from airworthiness authorities for free flight. The flight test programme will now evolve to progressively open the flight envelope. *www.airbus.com*

Drone technology transforms ABP's asset management

Associated British Ports (ABP), the UK's leading and best-connected port owner and operator, announced it has successfully embedded drone technology into its asset management practices and policies, following an 18 month program. It utilised PwC's specialist drone digital transformation team to support drone adoption and transformation in asset management, while Aerodyne Group, a DT3 (Drone Tech, Data Tech and Digital Transformation) solutions provider, was selected as ABP's drone service provider, bringing its extensive experience and world-class technology to bear. *www.abports.co.uk*

Industrial drone-in-a-box

Percepto has announced that it's on-site autonomous drone has passed level 5 hurricane testing at the Florida International University Wall of Wind. The box can withstand winds of up to 150mph making it one of the most rugged AI drone-in-a-box on the market for all weather conditions. The drone platform is already able to land in high winds and in snow.

The innovation allows customers like Florida Power and Light (FPL) to react immediately in the aftermath of a hurricane, assessing and fixing any damage without endangering their staff, when the weather is still very challenging in the state where the most residents per year experiencing outages.

FPL's goal is to eventually put a drone-in-a-box at every substation, transmission yard, plant and solar facility, according to Eric Schwartz, manager of FPL's aerial intelligence response.

Percepto's system is approved by the FAA for flights two miles Beyond Visual Line of Sight (BVLoS) and FPL's waiver from the FAA enables the solution to cover the entire facility with regular, pre-programmed autonomous flights over the plant's 11,000 acres. *https://percepto.co*

Safe integration of drones from ground to sky

EVA and Unifly have announced that they are joining forces. Together, the two partners provide an end-to-end solution for the drone services market by combining EVA's drone infrastructure (portable Vertical Stations) and Unifly's cutting-edge UTM technology.

Through this partnership, EVA and Unifly help streamline the safe integration of drones into the airspace and offer operators – private organizations and government agencies alike – an easy-to-deploy solution to support their operational needs. *www.unifly.aero*

NUAIR validates AVSS drone parachute recovery system

Following vigorous testing, completed in collaboration with NUAIR, the drone parachute recovery system by Aerial Vehicle Safety Solutions (AVSS) for the DJI M200 series has been validated as compliant with industry standards.

The parachute recovery system (PRS-M200) is a safety product for unmanned aircraft systems (UAS), commonly referred to has drones, which automatically deploys a parachute if the drone malfunctions in the air.

This is the third parachute standard validation performed by NUAIR and the first for the DJI M200 series, advancing the potential for commercial drone package delivery and routine flights over people. *www.nuair.org*

VECTOR-400 – a new compact autopilot

UAV Navigation has launched a new product known as the VECTOR-400, a compact autopilot which has been designed specifically for Aerial Targets (Unmanned Aerial Targets, UAT).

It features a robust enclosure and a military-grade connector designed to withstand the harshest environments, in accordance with MIL-STD 810 and MIL-STD 461. It is able to continue a mission in case of individual sensor failure and even when subject to jamming, maintaining accurate estimations of attitude and position. It features advanced algorithms for stall prevention and the ability to carry out an efficient gliding maneuver in case of engine failure.

The VECTOR-400 uses an Air Data Attitude and Heading Reference System (ADAHRS) and Inertial Navigation System (INS) developed by UAV Navigation, which provides high precision attitude information and which allows reliable navigation even under the most demanding circumstances. The AHRS gives the VECTOR-400 the capability to

operate in GNSS-denied environments (less than 30 m/min drift) and also to execute highly dynamic maneuvers. *www.uavnavigation.com*

US Air Force awards DroneShield contract for base defense

DroneShield Ltd has announced that the United States Air Force (the "USAF") has awarded DroneShield a contract to deploy multiple units of DroneShield's DroneSentry™, an integrated detect-and-defeat counterdrone (C-UAS) system, at the Grand Forks Air Force Base, protected by the 319th Security Forces Squadron of the USAF (the "319th SFS"). As part of the contract, the USAF acquired an option to acquire additional systems following the initial deployment.

DroneSentry™ utilizes DroneShieldComplete™, an intuitive and feature-rich user interface for alerting, tracking and reporting drone activity within the coverage area. The system will receive regular firmware updates, including the Company's upcoming cutting edge Artificial Intelligence-based firmware rollout, planned for late 2020. *www.droneshield.com*

First commercial BVLOS permit by Terra Drone Indonesia

Terra Drone Indonesia has obtained a license to operate a long-distance mission or better known as Beyond Visual Line of Sight (BVLOS), issued by the Directorate of Airworthiness & Aircraft Operations (DAAO), Director General of Civil Aviation, Ministry of Transportation of the Republic of Indonesia. By obtaining this permit, Terra Drone Indonesia will be able to fully utilize the maximum potential use of drones, especially for missions such as surveys, surveillance, and patrols. *www.terra-drone.co*

Hyundai Robotics and Hyundai E&C to develop construction robots

Hyundai Robotics, Korea's No. 1 industrial robot producer, has joined hands with Hyundai E&C to develop construction robots.
Through this MoU, both companies will jointly carry out

- The development of robots working at construction sites
- Mobile service robot business
- Development of core technologies for autonomous driving in construction sites and buildings
- Promotion of mid-to-long-term business. Additionally, both companies will establish an R&D cooperation system that is available at all times to continuously demonstrate and commercialize the developed technology.

www.hyundai-robotics.com

Self-Driving Mobility Solutions for Japan, Southeast Asia by Mobileye and WILLER

Mobileye, an Intel Company, and WILLER, one of the largest transportation operators in Japan, Taiwan and the Southeast Asian region, have announced a strategic collaboration to launch an autonomous robotaxi service in Japan and markets across Southeast Asia, including Taiwan. Beginning in Japan, the companies will collaborate on the testing and deployment of autonomous transportation solutions based on Mobileye's automated vehicle (AV) technology.

The two companies aim to begin testing robotaxis on public roads in Japan in 2021, with plans to launch fully self-driving ride-hailing and ride-sharing mobility services in 2023, while exploring opportunities for similar services in Taiwan and other Southeast Asian markets. *intel.com*

Tracking Cattle and buffalo

FERAL buffalo and unmanaged cattle in northern Australia will be tagged and monitored from space as part of the world's largest satellite herd-tracking program.

More than 1000 animals will be tracked over the next 3.5 years in a bid to turn the destructive pests into economic, environmental and cultural opportunities.

The $4 million project uses technology developed at James Cook University and aims to create a new best practice for managing large herds using space technology.

JCU eResearch Centre director Professor Ian Atkinson said satellite GPS tracking tags will be attached to the animals' ears and deliver real-time, geographically-accurate insights into herd behaviour, density and movements across the landscape.

The animals will be tracked across a combined area of 22,314 square kilometres, taking in the Arafura swamp catchment in Arnhem Land in the Northern Territory, and Upper Normanby and Archer rivers on Cape York Peninsula in Queensland.

The CSIRO and Charles Darwin University will develop data management tools, satellite company Kineis will provide access to their satellite fleet and technical expertise and the North Australian Indigenous Land and Sea Management Alliance (NAILSMA) are also involved. *www.northqueenslandregister.com*

NavVis IndoorViewer 2.7

NavVis has announced the release of NavVis IndoorViewer 2.7. It is an innovative web-based deliverable that, in just a few clicks, turns laser scan data into basic building models displayed as 360° realistic digital buildings, point clouds and customizable floorplans. It is also available as a cloud-based SaaS solution – NavVis Cloud – can be set up on-demand without the need for added IT infrastructure and maintenance. Additionally, the intuitive user-friendly interface means that users without the technical expertise to work with point clouds and modeling software can move through and interact with the building remotely, as if they were on site. *www.navvis.com*

Economy vector signal generator by Rohde & Schwarz

The R&S SMCV100B is the first economy signal generator that covers the 5G NR extended FR1 frequency range up to 7.125 GHz, making it ideal for mobile communications applications. It also uses the R&S WinIQSIM2 simulation software. This software supports all common cellular and wireless connectivity standards, including standards for IoT and Wi-Fi (802.11xx) and many more. In total, more than 30 standards are available, along with an arbitrary waveform generator to output user-defined signals.

In the automotive industry, the R&S SMCV100B can be used for end-of-line testing of car radios or GNSS navigation equipment. Broadcast standards can be combined with mobile communications, wireless and navigation standards.
For Go/NoGo tests, the generator can output GPS, GLONASS, Galileo and BeiDou signals of a single navigation satellite. Predefined, time-limited I/Q sequences can be output for functional tests with fixed satellite positions.

FPGA based real-time coders for broadcast standards used worldwide are available. The R&S SMCV100B supports analog and digital radio standards as well as second and third generation digital terrestrial and satellite based television standards. This is the first economy platform that supports ATSC 3.0 in addition to the DVB-T2 and DVB-S2X standards.

The R&S SMCV100B uses an advanced direct RF concept to generate output signals for frequencies up to 2.5 GHz. This allows I/Q modulation and RF signal generation to be performed in the digital domain, virtually eliminating the I/Q imbalance errors and LO leakage commonly seen with conventional analog I/Q modulators. *rohde-schwarz.com*

China launches high-resolution remote-sensing satellite

China has successfully sent a high-resolution multi-mode imaging satellite into the planned orbit from the Taiyuan Satellite Launch Center in north China's Shanxi Province recently. The satellite is a civil-use optical remote-sensing satellite with a resolution up to the sub-meter level. It will operate in Sun-synchronous orbit.

It can provide high-precision remote-sensing image data for several industries including surveying and mapping, natural resources, emergency management, etc. *www.xinhuanet.com*

Global radio signal monitoring service by HawkEye 360

HawkEye 360 Inc., the first commercial company to use satellites to create a new class of radio frequency (RF) data and data analytics, has announced that it is offering a daily Regional Awareness Subscription (RAS) service. It delivers mission-critical insights by allowing organizations to identify, monitor, and analyze signal behavior over time. Large-scale RF signal mapping provides deeper situational awareness in these regions, with the data sets.

HawkEye 360 will work with customers to define a Regional Awareness Subscription that can span millions of square kilometers. Current RAS collection areas include the Mediterranean, South China Sea, and the Korean Peninsula. HawkEye 360 curates a collection plan that routinely gathers a combination of high-demand signals. The company delivers the data in an open standard GeoJSON format that seamlessly integrates with most applications. *www.he360.com*

Planet and SpaceNet partnership for Multi-Temporal Urban Development Challenge

Planet partners with SpaceNet LLC, a nonprofit focused on machine learning techniques for geospatial applications, to support the SpaceNet7 Multi-Temporal Urban Development Challenge, which was just recently announced. The challenge focuses on developing better methods to track building construction over time using Planet imagery mosaics. Rapid and accurate remote-sensing of infrastructure change can aid in a variety of efforts, from infrastructure development to disaster preparedness to epidemic prevention.

Established in 2016 by In-Q-Tel's CosmiQ Works, and DigitalGlobe (now part of Maxar Technologies), SpaceNet is dedicated to accelerating the research and application of open source AI technology for geospatial applications. It offers free, precision-labeled, electro-optical and synthetic aperture radar satellite imagery data sets and runs challenges with prizes to foster emerging analytical frameworks.

Planet images the entire landmass of the Earth on a daily basis at 3-5 meter resolution. The high temporal cadence and planetary coverage of their Dove constellation enables an entirely new class of remote-sensing applications, including detecting rapid urbanization, updating maps in a diverse set of geographical areas (not just dense urban areas), detecting unplanned infrastructure development, finding illegal activities in protected areas and uncovering precursors to deforestation. *www.planet.com*

DAVILUS – the first 3d map of Germany

The DaViLuS project was funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI) and is part of the German "Action Plan for UAVs and Flight Taxis".

FlyNex and HERE Technologies, together with the Northern Business School, visualized Germany's airspace for drones in 3D for DaViLuS. The result: a complete 3D map, including air areas, topography and important buildings, is now available to every user free of charge and in full.

DaViLuS stands for data visualization of airspace structure and is a map that visualizes the lower airspace in 3D. This means that hills and mountains, as well as individual buildings, are represented in 3D. As in Map2Fly, the regulations and zones are drawn in, so that the requirements for unmanned flights can be viewed. In total, over 21 million objects have been classified and displayed.

The visualization of the lower airspace structure allows autonomous movements. Due to current applications and legal requirements, drone flights are directly dependent on the earth's surface conditions. To automate flights, not only hills, mountains, and heights but also buildings and risk areas have to be considered in the planning.

This is because the surface conditions on the ground, in conjunction with legal requirements, create new airspaces, which are explicitly associated with requirements for the use of drones. In the future, the drone itself must be able to orient itself in space and recognize spaces, constraints, and obstacles. This can be done either actively or passively. *www.flynex.io*

UP42 partnership with Vultus

UP42 has announced a new partnership with Vultus, a leader in precision farming technologies. UP42 customers can now use Vultus Fertilization Zoning Maps algorithms to fine-tune crop management—with more agricultural technologies coming soon.

Fertilization Zoning Maps—the first in a series of proprietary algorithms Vultus brings to UP42 as a partner—shows farmers which parts of their fields need more or less fertilizer. Conventional methods of fertilizer application treat all areas of a field uniformly, despite specific areas requiring a tailored approach. Integrating AI, historical data, and three years of extensive research, Fertilization Zoning Maps divide fields into five zones that are classified according to the variable fertilization rate the soil requires. *up42.com*

Eos Positioning Systems high-accuracy GNSS receivers

Eos Positioning Systems (Eos), the manufacturer of the popular high-accuracy Arrow Series GNSS receivers for the GIS market, has announced several new releases.

These announcements include the expansion of the availability of the popular Eos Locate™ underground mapping solution, compatibility with the new ArcGIS Field Maps, the inaugural release of Eos Tools Pro for Windows. It allows organizations to accurately map already-buried assets straight to ArcGIS Online via either ArcGIS Collector or ArcGIS Field Maps. *www.eos-gnss.com*

BAE Systems Completes Acquisition of Military GPS Business

BAE Systems has completed its acquisition of the Collins Aerospace Military GPS business from Raytheon Technologies Corporation, bringing decades of experience, innovative technology, and an extensive installed base of products to the company.

As announced in January, this asset purchase is a unique opportunity to acquire a high-quality, technology-based business that augments the existing BAE Systems Electronic Systems portfolio through the addition of world-class GPS anti-jamming and anti-spoofing technology that enables reliable navigation and guidance for a range of defense missions. *www.baesystems.com*

Q-CTRL and Advanced Navigation Partnership

Q-CTRL, a startup that applies the principles of control engineering to accelerate the development of quantum technology, announced a global research and technology development partnership with Advanced Navigation, a provider of AI-based navigational hardware.

The two organizations will now be conducting joint technical development in support of both the civilian and defense markets focused on quantum-enhanced precision navigation and timing (PNT). *https://q-ctrl.com*

F100 GNSS receiver by Geneq Inc.

Geneq Inc. has announced its new F100, a multi-constellation GNSS receiver with very high level of technology integration. It is an evolution of the well-known F90 with new features that will fulfill the surveyor's demands in terms of field performance, flexibility and cost-effectiveness. It tracks multi-constellations (GPS, GLONASS, Galileo, Beidou…) and can maximize the acquisition and tracking process with all-in-view GNSS frequencies.

Honeywell expands navigation offerings

Honeywell has introduced the HGuide n380, a new inertial navigation system that communicates position, orientation and velocity of an object — such as an autonomous vehicle or unmanned aerial vehicle (UAV) — even when global navigation satellite signals are unavailable. It is built using Honeywell's rigorous design standards to withstand harsh environments in the air, on land or at sea. This new inertial navigation system is composed of Honeywell's HGuide i300 inertial measurement unit (IMU), a GNSS receiver and Honeywell's proprietary sensor fusion software, which is based on the algorithms used for navigation on millions of aircraft every day. *www.honeywell.com*

Time and Frequency instrument by Microchip

Microchip Technology Inc. has announced that its SyncServer S650 M-Code time server has received approval from the U.S. Air Force GPS Directorate of the Los Angeles Air Force Base for use in support of military communication systems, radars and networks.

M-Code, an encrypted military signal broadcasted in GPS frequency bands, is required by congressional mandate for mission critical Department of Defense (DoD) applications in hostile environments. Microchip's SyncServer S650 M-Code equipped time and frequency server provides a secure, accurate, flexible platform for synchronizing mission-critical electronic systems and instrumentation. For DoD programs requiring jam-resistant, encrypted time and frequency signals from the GPS military M-Code Precise Positioning Service (PPS), the SyncServer S650 M-Code is a secure time and frequency instrument with a fully integrated M-code GPS receiver. *www.microchip.com*

Mosaic-T GNSS timing module by Septentrio

Septentrio has announced an addition to its GNSS timing portfolio: mosaic-TTM is a high-end GPS/GNSS* receiver module built specifically for resilient and precise time and frequency synchronization under challenging conditions. Its multi-frequency multi-constellation GNSS technology together with AIM+ Advanced Interference Mitigation algorithms allows mosaic-TTM to achieve maximal availability even in the presence of GNSS jamming or spoofing**. This compact surface-mount module is designed for automated assembly and high-volume production. *septentrio.com*

CHC Navigation introduces CGI-610 GNSS/INS Sensor

CHC Navigation (CHCNAV) has announced the release of the new CGI-610 GNSS/INS sensor, a high-precision dual-antenna receiver offering reliable and accurate navigation and positioning solutions for demanding land, marine, and aerial applications. The tight fusion of the latest GNSS technology with an industrial-grade MEMS IMU is powered by CHCNAV's algorithms to deliver accurate hybrid position, attitude and velocity data, even in complex and obstructed environments where GNSS outages can occur.

The CGI-610 is a powerful GNSS/INS system supporting data output up to 100 Hz to meet the requirements of highly

dynamic applications (airplane, train, car etc.). The optional external odometer sensor for ground vehicles can provide an additional independent measurement of displacement and speed, which is fused with the GNSS/INS navigation solution.

Trimble 4D Control software version 6.0

Trimble Monitoring has introduced the latest version of its software platform for real-time displacement monitoring—Trimble® 4D Control™ software (T4D). It introduces three and 12-month subscriptions, and three-tiered edition options. These new subscription options give providers of monitoring services the flexibility to choose the appropriate subscription model based on the project duration.

T4D 6.0 introduces three installation options, tailored to the various project requirements of specialized monitoring consultants, land surveyors, construction companies, dam and mining operators: *www.trimble.com*

Trimble Inpho version 10.1 now available

Trimble announces version 10.1 for all Inpho software products including UASMaster. The software suite is a comprehensive workflow solution enabling photogrammetrists to rapidly produce highly accurate and quality deliverables for their clients. The modular offering provides the ultimate flexibility depending on whether large frame aerial imagery, LiDAR or Satellite data is being used. *www.trimble.com*

ProStar joins Trimble's GIS Business Partner Program

Trimble has announced that ProStar has joined Trimble's GIS Business Partner Program. As part of the program, ProStar has implemented the Trimble® Precision SDK (Software Developer Kit) to integrate high-accuracy positioning capability in its PointMan® mobile application running on smartphones and tablets using Trimble GNSS receivers. *geospatial.trimble.com*

IFEN's NCS NOVA GNSS Simulator is now available

IFEN GmbH has announced that its NCS NOVA GNSS Simulator now supports dual-RF outputs. The NCS NOVA GNSS Simulator is a high-end, powerful and easy to use satellite navigation testing and R&D device. It is fully capable of multi- constellation and multi-frequency simulations for a wide range of GNSS applications. The simulator is one of the leading solutions on the market providing multiple GNSS frequencies in one box. *www.ifen.com*

Carlson Announces Next-Generation BRx7 GNSS Receiver

Carlson Software has announced its next-generation multi-frequency, multi-GNSS BRx7 smart antenna. It is a full redesign of Carlson's flagship GNSS receiver, delivering class-leading specifications, performance, and value for surveyors, contractors, engineers, GIS professionals etc. The smart antenna comes with a dual-band radio module that is capable of both 400 MHz and 900 MHz operation. This allows for the long range capability of the UHF 400 MHz signal plus the ability to switch to the 900 MHz frequency-hopping spread spectrum (FHSS) signal for better performance in noisy radio environments. *www.carlsonsw.com*

Dual-band sub-meter level GNSS positioning module for eMobility

Quectel Wireless Solutions have released its LC29D module. It is a sub-meter level GNSS module that integrates dead reckoning (DR) and multi-band (L1/L5) real-time kinematic (RTK) algorithm technologies with fast convergence times and reliable performance. The module supports dual-band GNSS raw data output and integrates 6-axis IMU sensor to deliver high-accuracy positioning performance in seconds.

Based on the Broadcom BCM47758 GNSS chip, the LC29D can concurrently receive signals from up to six constellations (GPS, GLONASS, Galileo, IRNSS, BeiDou and QZSS) at any given time, which maximizes the availability of sub-meter level accuracy. *www.quectel.com*

Tersus introduces BX40C RTK Board

Tersus GNSS Inc. has announced the release of the BX40C RTK Board to support its series of GNSS boards and provide high accuracy, fast positioning services. Powered by new Tersus ExtremeRTK™ GNSS Technology, the BX40C Board can support multi-constellation and multi-frequency all-in-view satellite tracking. It can be integrated with autopilots and inertial navigation units to meet various developing requirements. It is ideal for high-precision positioning, navigation, and mapping. *www.tersus-gnss.com*

Hemisphere Phantom™ OEM module in Bad Elf Flex™ GNSS Receiver

Bad Elf, LLC has announced the complete transition of all Bad Elf Flex receivers to the Hemisphere GNSS Phantom OEM module. As one of the first partners to incorporate the Phantom, Bad Elf Flex offers significantly enhanced capabilities and further exemplifies their commitment to future-ready GNSS designs.

Bad Elf Flex offers the first scalable-accuracy GNSS receiver with a daily option to choose between L-Band and RTK. In standard configuration, it achieves 30-60 cm accuracy in real-time for GIS use. *www.bad-elf.com*

NovAtel releases ROS driver

NovAtel has released its first purpose-built driver, powered by Robot Operating System (ROS), to support its OEM7 family of GNSS receivers. The driver provides an optimized interface enabling users to accelerate autonomous development projects by quickly incorporating NovAtel OEM7 receivers into custom applications. The driver is available for immediate download through the new NovAtel GitHub repository or as a ROS Binary Package for direct installation. *novatel.com*

GNSS RTK rover with Visual Positioning

Leica GS18 I GNSS RTK rover with Visual Positioning allows users to capture points of interest from a distance and measure points from the images in the field or the office.

Visual Positioning technology (sensor fusion combining GNSS, IMU and a camera) allows users to reach previously inaccessible or obstructed points safely and efficiently. Visual Positioning is based on photogrammetric technology with near real-time data processing, allowing surveyors to check the quality of their data while on site.

The GS18 I continues the success from the tilt-compensated Leica GS18 T rover. In addition to visual point positioning, it inherits all the functionalities of a GS18 T, including the ability to map and stake out points with either tilted or levelled pole. *hexagon.com*

Spectra Geospatial and Aplitop Collaboration

Spectra Geospatial has announced a collaboration with Aplitop, a supplier of specialized surveying and civil engineering software, to provide a comprehensive tunnel survey solution to increase productivity for survey service providers. This collaboration provides surveyors and geospatial professionals with a complete hardware and software solution for performing efficient tunnel construction surveys. *www.spectrageospatial.com*

BVLOS trials supported by the DGCA in India

Unifly shares its expertise during the future BVLOS trials supported by the Directorate General of Civil Aviation (DGCA) in India. The goal is to help define India's regulatory framework for UAVs. Led by AutoMicroUAS, a leading Indian drone manufacturer, a number of BVLOS test flights will be performed over the course of the following months to collect as much data as possible to make routine UAV deployment on a large scale possible in the future.

The Indian government provides multiple locations for 100 hours' worth of BVLOS scenarios to several consortia. This consortium will focus on conducting drone-spraying operations for agricultural purposes, windmill surveillance operations, and medicine delivery, the last in a semi-urban environment . These trials are to exploring the vast agricultural and healthcare purposes of drones, identified by the Indian government as some of the biggest priorities concerning BVLOS flights.

The tests will be performed in remote areas, beyond the normal ground control coverage. Unifly's BLIP will enable safe BVLOS drone flights thanks to its real-time tracking and in combination with the Unifly Data Collector.

The BLIP is an autonomous weather-proof tracker that functions independently from the drone itself as a stand-alone digital blackbox. *unifly.aero*

Integration of camera and drone technologies

Phase One Industrial has signed an agreement with Acecore Technologies. Together, these companies' high-end products are opening new opportunities in drone-based high-accuracy mapping and inspection markets.

Under the new agreement, Acecore will support Phase One Industrial's iXM range of cameras in the UAV market for high-accuracy mapping and inspection. Acecore will be using the iXM camera in three drone models: ZOE, NEO and NOA. The Acecore NOA flagship model can fly up to 45 minutes with any PhaseOne iXM / iXM-RS camera and lens option. *www.acecoretechnologies.com*

MARK YOUR CALENDAR

September 2020

GNSS Advancements for AEC Virtual Conference Experience (VCX) Event
September 9-10, 2020
www.assetmapping.events/gnss

Commercial UAV Expo Americas – Virtual Event
15 -17 September, 2020
https://www.expouav.com

Amsterdam Drone Week & UAM Hybrid Summits
17 September 2020.
www.amsterdamdroneweek.com

ION GNSS+ VIRTUAL
21-25, September 2020
https://www.ion.org/gnss/

October 2020

Intergeo Digital 2020
13-15 October
https://www.intergeo.de

10th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing (IGRSM 2020) – Virtual
20-21 October 2020
http://igrsm.org/igrsm2020/index.html

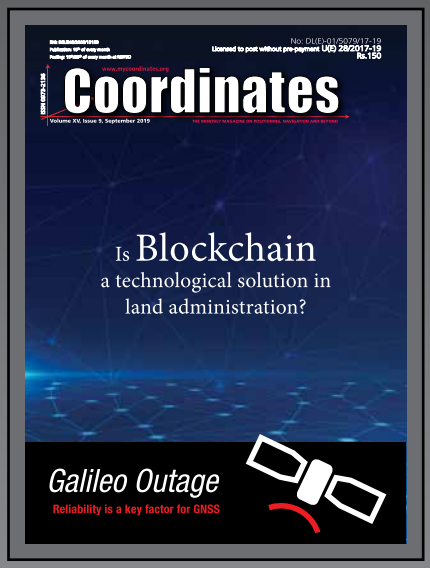
International Symposium on Satellite Navigation (ISSN 2020)
21-24 October Nanjing University of Information Science and Technology, Nanjing, China
http://issn2020.csp.escience.cn/dct/page/1

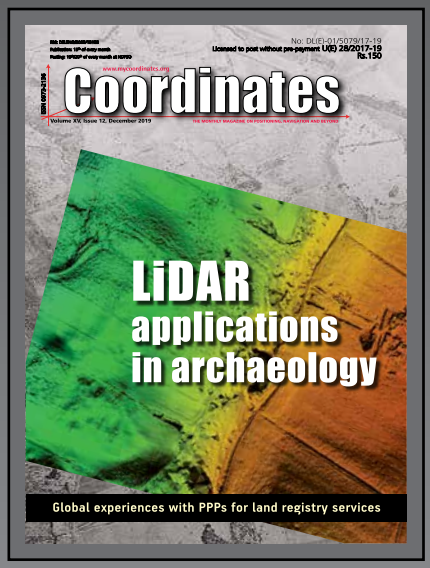
November 2020

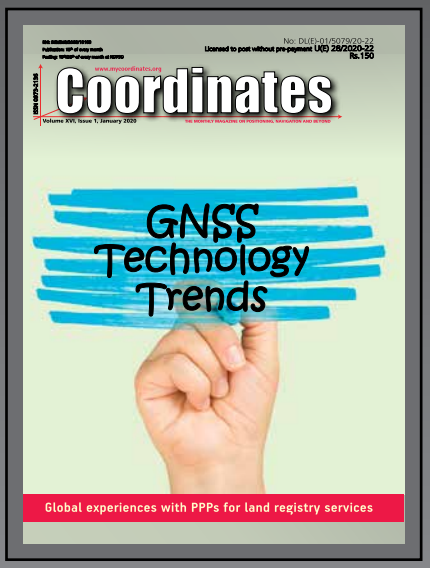
Autodesk University (Digital)
North and South America
November 17-20
Europe, Middle East, Africa, and Asia Pacific
November 18-20
https://www.autodesk.com/autodesk-university/

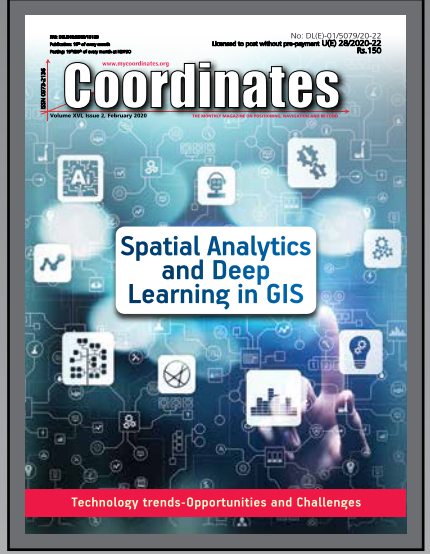
December 2020

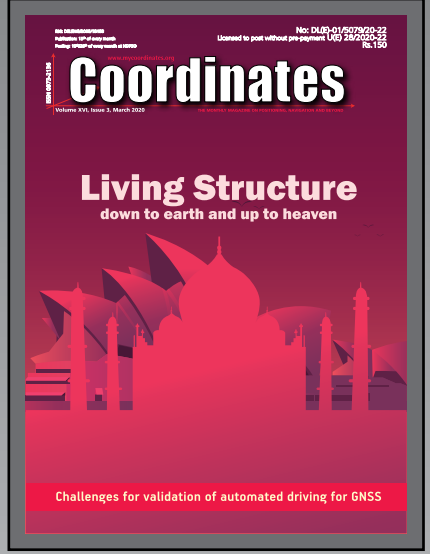
Amsterdam Drone Week & UAM Hybrid Summits
1 - 3 December 2020.
www.amsterdamdroneweek.com

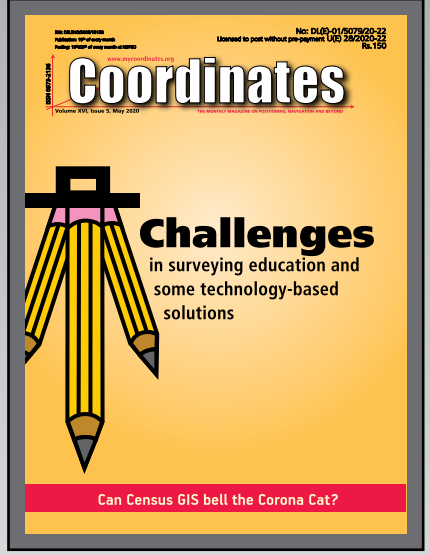


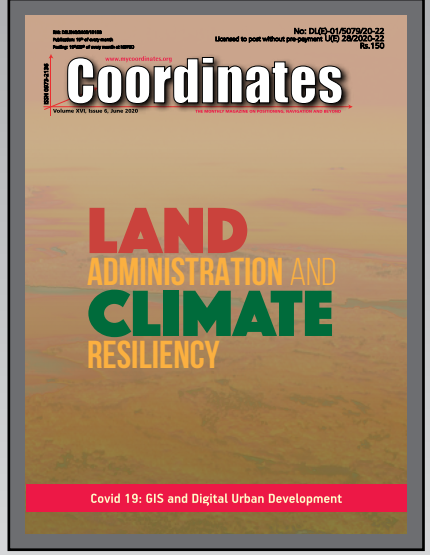


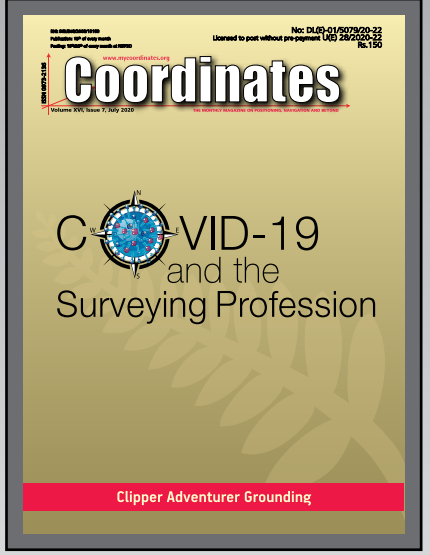












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