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Y Jade Morton

BIM, can be a solution for property disputes?

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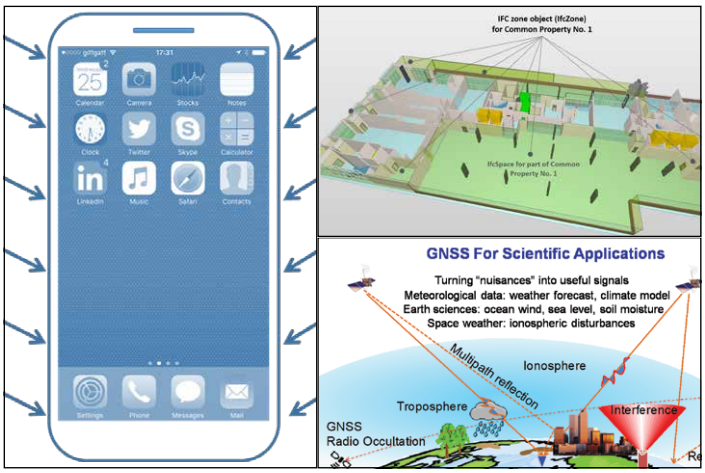

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Regarding changes to the data

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But what is comforting is the apparent course correction.

The World Bank has initiated independent Internal Audit function to perform an audit of the processes for data collection and review for Doing Business.

And why not, when at stake is the credibility itself.

Bal Krishna, Editor
bal@mycoordinates.org

BIM, can be a solution for property disputes?

With accelerated urbanization, the growing cities have been created more complex forms of multi-owned buildings. The complicated ownership rights and boundary arrangement within these properties are resulting in a significant number of disputes. As part of ongoing research, this article explores BIM as a new opportunity to prevent and resolve property disputes.

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The rise of the property disputes

Minimizing property disputes in multi-owned buildings (MOBs) become a global challenge to our society (Blandy, Dupuis, & Dixon, 2010). Most people in urban areas live in MOBs, referred to as condominium, strata properties, or apartment. With the rise of urbanization, this building is a dominant type of private property in cities. Although legal basis varies from country, MOBs, in general, form a complex arrangement of composite ownerships across the whole building (Johnston & Reid, 2013). The ownership of each flat owner involves (1) individual ownership of the flat and (2) communal ownership of shared areas. The possessor also holds memberships of owners' corporations (OC), entities in charge of owning and managing the common areas. Consequently, living in MOBs shapes the exclusive use of a dwelling with the joint use and management of common properties (CP) as a member of OCs. A high degree of shared rights, collective decision-making, and financial responsibilities among owners inevitably cause many conflicts in MOBs that escalate to property disputes (Easthope & Randolph, 2018; Hastings, Wong, & Walters, 2006). In the success of urban management, the response to disputes in using and managing MOBs plays a crucial role.

In this circumstance, the social responsibility of surveyors to harmonious urban living has stressed, especially in jurisdictions adopted the Torrence title system (i.e., Australia, Malaysia, Singapore, Russia, and some states in Canada and United States). Surveyors in those countries solely define the intertwined ownership rights, responsibilities, and restrictions (RRRs) of flats and common areas in cadastral plans, using the specification of boundaries (Kaufmann & Steudler, 1998). This plan delimits 3D spatial extent of ownership RRRs associated with using and managing MOBs. It provides a mechanism for upkeeping assets and controlling resident behaviors in MOBs by defining (1) who owns what, (2) who pays for what, and (3) who entitles to use what. We can easily observe that building subdivision failing to meet the needs of owners and residents leads to property disputes, of which the occurrence gradually increases (Easthope et al., 2014). Together with it, lack of understanding of owners and residents of ownership RRRs have caused the disputes resulting in emotional concern and huge litigation costs (Shin, Rajabifard, Kalantari, & Atazadeh, 2020). How to create and communicate the ownership RRRs in MOBs needs to be discussed for ensuring a peaceful and vibrant neighborhood in MOBs.

Ownership RRRs and disputes in multi-owned buildings

If you look at the real cases of property disputes, the linkage between ownership RRRs and the dispute occurrence becomes clear. This article focused on the context of Victoria state, Australia, to gain meaningful observation. Nearly

20% of 220 tribunal cases from 2015 to 2019 show relation to issues stemming from ownership RRRs in the *Plan of Subdivision*, the cadastral plan in Victoria. Generally, the issues are classified into 11 types, describing two streams: (1) interpretation of subdivision plan associated with using and managing flats and CPs and (2) problems in the plan regarding fair distribution of ownership power among owners. Table 1 summarizes the details of the types of issues in 41 property disputes. 32 dispute cases show relations with more than two issues.

All types of issues in disputes were triggered by the combined effects of five aspects of the subdivision plan: (1) ambiguous definition of boundaries, (2) inappropriate arrangement of ownership extent, (3) unfair allocation of co-ownership share of CP to each flat, (4) inappropriate separate blocks of CPs, and (5) improper tiered structure of OCs. In Victoria, multiple sets of CPs and their managing groups are formed within MOBs by the subdivision plan; it is to fairly cater to different interests of owners in managing MOBs, based on the real extent of usage by different owner groups. The first two aspects bring misunderstanding or confusion in their RRRs for using and managing MOBs to communities in the buildings (residents, owners, OCs). The last three aspects contribute to the failed delivery of fair approaches to accommodate the varied needs of communities over CPs and to achieve the benefit principle (the owners that benefit more from each CP block pay more); the failure frequently leads to disputes. It infers that a significant number of disputes can be avoided with better decisions of ownership RRRs by surveyors and better communication about it among the communities.

In current practice, cadastre systems are mainly based on 2D-based analog cadastral plans for building subdivision. In Victoria, all five aspects of ownership RRRs are also represented in the plan of subdivision, using 2D-based representation (figure 1). The 3D volumetric extent of RRRs is abstracted into floor and section

Table 1. Critical issues and causes of 41 property disputes in Victoria

Issues in Tribunal Case		No. of Case	Aspects of Cadastral Plan				
			Boundary Definition	Spatial Arrangement of RRRs	Co-Ownership Share	Separation of CPs	Structure of OC
CP Easement	Request for the implied easement on CPs to ensure the flat use	7	1	1	4	2	1
CP use	Exclusive use of CPs by residents	3	1	-	3	-	
CP Improvement	Validity of CP modification by residents	6	4	-	4	-	1
CP Encroachment	Encroachment to CPs caused by flat improvement	3	-	2	2	-	-
Damage in Flat	Damage in flats caused by other flats or CPs	2	1	-	1	-	-
Dysfunctional Maintenance	Inappropriate maintenance and repair of CPs by OCs	4	3	1	-	1	1
Levy for CP Repair	Controversial levy charged to flats for CP repair	6	2	3	1	5	4
Management Authority	Controversy in responsibility for managing CPs	6	3	-	3	1	-
Ownership RRRs	Problematic extent of ownership different from the intended extent	8	3	1	5	-	-
Co-ownership Share	Disproportionate share of co-ownership to CPs	5	1	4	5	3	3
Amendment of Plan	Disagreement about plan alteration regarding ownership RRR and co-ownership share	7	3	6	3	2	3

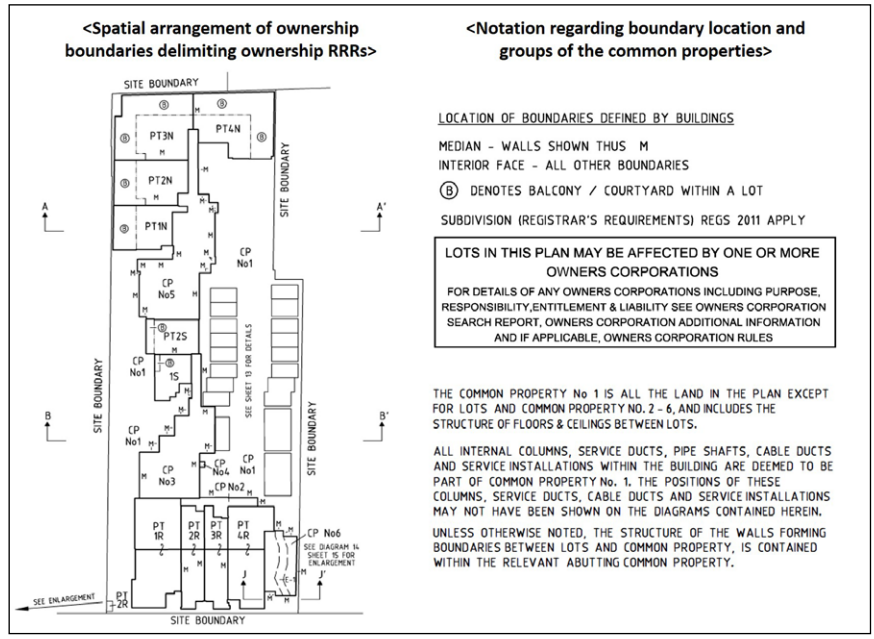

Figure 1. Sample of the plan of subdivision – spatial and semantic information of ownership RRRs in MOBs

plans, and all the other information is stated as the textual description (Libbis, 2018). This method is likely that differing views can be reached over the same diagram; the numerous pages of diagrams representing all the RRRs are also not straightforward and challenging for understanding (Rajabifard, Kalantari, & Williamson, 2012). In addition, the analog approach limits opportunities of surveyors for exploring and analyzing the various forms of ownership RRRs to deliver better MOB management outcomes. Frequent failure to create overarching and holistic governance mechanisms in MOBs has offered MOB communities to years of costly disputes. These challenges emphasized the need for the move toward a 3D digital data environment in the building subdivision.

The BIM representation of complex ownership RRRs in MOBs can be a foundation of an integrated information platform for supporting the improvement of MOB communities' perception of ownership

BIM with new opportunities

Building information model (BIM) is highly regarded as an ideal 3D data environment for representing 3D properties in the land administration business. From the object-oriented approach, BIM serves as a 3D information model of the building, which involves spatial and semantic information of all building elements (Eastman, Teicholz, Sacks, & Liston, 2011). It has the high potential to be a digitalized information repository of stratified ownership RRRs in buildings, especially for high-rise and high-density MOBs. The leveraging of BIM to building subdivision practice can facilitate better communication of ownership RRRs and better quality of the cadastral plan of MOBs.

Better communication of ownership RRRs

The BIM representation of complex ownership RRRs in MOBs can be a foundation of an integrated information platform for supporting the improvement of MOB communities' perception of ownership. The open data standard of BIM, IFC, has been designed to address information in the architecture, engineering, and construction (AEC) industry. However, high interoperability and flexible expandability of IFC allow to its application as an information source for 3D ownership of MOBs (Atazadeh, Rajabifard, Kalantari, & Shin, 2018). In IFC, the spatial aspect of ownership – vertical and horizontal arrangement of RRR extent delimited by boundaries – are represented by geometries of building and spatial elements. On the other hand, textual descriptions associated with RRRs, such as membership of OC, boundary location notation, and co-ownership share of each flat, are defined as attributes and properties of the relevant building and spatial elements.

In the IFC data structure, the ownership information of a MOB in Figure 1 is represented by IFC objects for space and building elements. In the case of a flat, its vertical and horizontal dimension is expressed as a space object overlaid on the surrounding building elements (wall, window, door, floor, and ceiling). The exact locations of boundaries of the flat are visually defined in the 3D data environment, without the help of notation (see Figure 2). In addition, the other textual information regarding the membership of multiple OCs and co-ownership share are incorporated into the space objects, as their attributes.

Same as the representation of flats, the spatial components of each CP throughout a MOB are clearly defined by objects for space and building elements. In IFC, functional spaces (i.e., corridors, lobby, lift, entry) of CPs are defined using

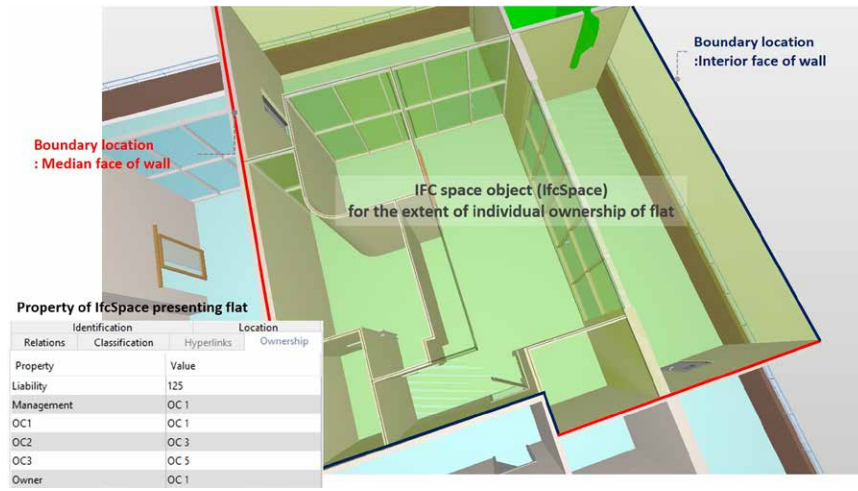

Figure 2. IFC representation of 3D extent of ownership RRRs of one flat in a MOB with textual information

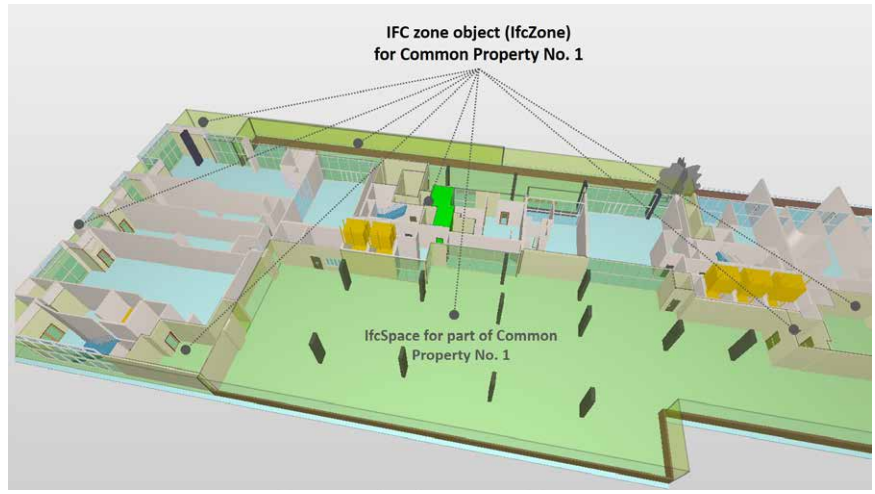

Figure 3 IFC representation of the 3D extent of ownership RRRs of common properties in a MOB

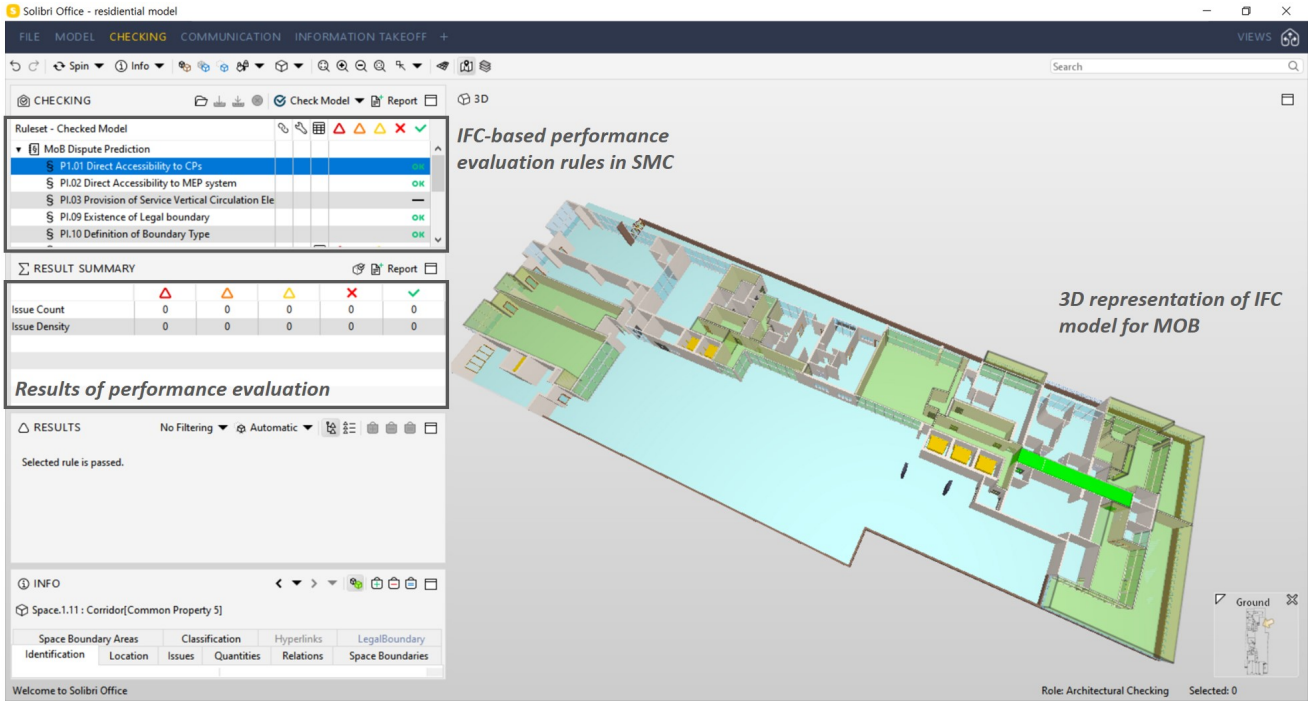

Figure 4. SMC tool for performance evaluation of cadastral plan using IFC data for MOB ownership RRRs

> The use of BIM can be a solution for improving better consistency in building subdivision for avoiding conflicts than the current practice that relies heavily on individual experience and knowledge without a systemic process.

space objects overlapping on building elements. In addition, the complicated distribution of multiple CPs spanning several floors can be clarified by grouping their space compositions into individual zone indicating each CP (see Figure 3).

The above mentioned five aspects of the subdivision plan are well demonstrated in the IFC data structure. Particularly, two aspects (spatial arrangement of RRRs and boundary definition) that frequently caused a misunderstanding of ownership and led to the inappropriate behaviors of MOB communities were well described in the 3D model. In IFC, the 3D visualization provides the explicit image of ownership boundaries and RRRs on top of the building structure. Furthermore, its digitalized representation enables the communities to interact with the various views of ownership by navigating and querying the 3D model. BIM model could remove the ambiguities in identifying RRRs associated with using and managing MOBs; it facilitates the understanding of ownership that potentially prevents the conflict in using and managing MOBs.

Better subdivision of multi-owned buildings

The dispute caused by five aspects of the subdivision plan can be interpreted as a result of the inappropriate features in the plan. It means that examining the extent to which each feature is suitable to meet OC communities' requirements can support preventing potential disputes. In this context, the extent can be defined as the performance of the feature; the performance evaluation can indicate the existence of dispute triggers in the plan. This evaluation can provide surveyors with early warnings of potential disputes in their proposed plans and an opportunity for improving the plans to minimize the potential disputes.

BIM can support this performance evaluation of the MOB cadastral plan. The BIM-based digital data environment is regarded as an ideal platform for evaluating building performance (Asl, Zarrinmehr, Bergin, & Yan, 2015). It uses a BIM model incorporating multidisciplinary information and allows users to analyze the performance of building from various views. For the performance of the cadastral plan, the evaluation requires as follows:

- a BIM model of the cadastral plan
- a set of the performance for identifying dispute triggers
- BIM-based performance evaluation rules
- BIM-based tool for evaluating performance.

The performance can be extracted from the needs of OC communities in tribunal cases or practical issues in MOBs. According to them, the evaluation rules and tools based on the BIM data structure need to be developed.

> The current 2D document-based practice shows limitations to resolve the issues by improving the plans efficiently

Using a commercial tool, the feasibility of performance evaluation for dispute prevention was examined. The Solibri Model Checker (SMC), a tool to create and check the rules on IFC data, was employed. In SMC, 28 performances were automatically checked using IFC representation of the cadastral plan in Figure 1. Figure 4 represents the SMC checking results for direct accessibility for CPs, one of the performances associated with the ownership arrangement.

According to the defined rules, SMC checked five aspects of the cadastral plan and identified the dispute triggers within them, while minimizing human involvement and interpretation. It also reduces the time and effort to recognize critical issues, compared to the manual review that overlays and analyzes numerous pages of 2D-based plans. The use of BIM can be a solution for improving better consistency in building subdivision for avoiding conflicts than the current practice that relies heavily on individual experience and knowledge without a systemic process.

Conclusion

The property disputes in MOBs become a global challenge for the seamless management of urban areas. A significant number of disputes have resulted from the issues in ownership boundaries and RRRs in the cadastral plan. However, the current 2D document-based practice shows limitations to resolve the issues by improving the plans efficiently. Accordingly, the 2D plan aroused the residents' misperception in using and managing their properties that frequently end with inappropriate behaviors and disputes.

The article addressed two new roles of BIM in response to dispute triggers in cadastral plans. As a means of better communication, BIM has the potential to deliver a full image of 3D ownership RRRs to residents in the most straightforward way. In addition, BIM also can provide the platform to examine and analyze the building subdivision in the 3D digital environment in order to facilitate the improvement of the performance of cadastral plans.

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Analyzing the cultural landscape - Preservation and development strategies

The article deals with the issue starting from a specific case, the identification and study of archaeological evidence around the Castle of Petriolo (Siena, Italy) for the protection, intervention and enhancement of this site

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The contribution that is presented aims to highlight the methodologies and tools that can lead to a full knowledge of multi-layered cultural areas or landscapes by the actions and human interventions that have changed their perception over the centuries. The use of appropriate cartographies, the archival materials and documents and the selection of the most appropriate data management and processing methodologies are crucial for the structuring of investigations in complex territories, for their protection and enhancement. This is most evident for areas characterized by the archaeological features, elements and structures. For this reason, the article deals with this issue starting from a specific case, the identification and study of archaeological evidences around the Castle of Petriolo (Siena, Italy) for the protection, intervention and enhancement of this site.

The investigation area is located in Bagni di Petriolo, along the course of the Farma stream and near the confluence with the Merse stream, in today's Municipality of Monticiano (Siena). The Farma valley delimits the current border between the provinces of Siena and Grosseto and is formed by the stream itself, which flows into the Merse stream, after collecting the waters of the Petriolo thermal springs. The Merse and Farma streams are part of the hydrographic system of the Ombrone river, one of the main connection routes between the backcountry and the Tyrrhenian coast since prehistoric times (*Torelli M. 1992; Ascheri M., Borracelli M. 1997).*

The use of appropriate cartographies, the archival materials and documents and the selection of the most appropriate data management and processing methodologies are crucial for the structuring of investigations in complex territories, for their protection and enhancement

The examination of the archaeological evidences that characterize the site started with the collection of all the published information, materials and documents relating to the Petriolo area, including the two neighbouring valleys. The documentation was thus analysed and organized according to a chronological order to allow a first hypothesis regarding the evolution of the site and the related phases of anthropic activity. Such information was subsequently linked to all the data that emerged from historical, literary and iconographic sources (*Massa S. 2017).*

In parallel with the archival analysis, the cartographic materials available from 1800 to today have been collected and examined. These were obtained mainly from the *Geoportale Nazionale* and from *Geoportale della Regione Toscana* and include aerial photos, regional technical

On a methodological level, it was therefore preferred to obtain a database from historic, literary, archival, cartographic and iconographic sources, as complete as possible and included totally in a Geographic Information System, for easier consultation and analysis

maps (CTR), maps of the *Istituto Geografico Militare* (IGM), cadastral maps and topographical/morphological maps, historic and current and at different levels of detail. The materials that emerged from the archival and cartographic research, however, required a data management and a query system to provide a solid and complete reference framework for the subsequent evolutionary study phase and for the identification of the most critical portions from the historic, archaeological and landscape point of view.

This led to the creation of a Geographic Information System thanks to which spatial information could be geo-referenced and thus identifying the different chronological phases in sequence. The materials have been structured on three distinct information levels, the first contains regional data concerning the morphology and orography of the area, urban centres, road infrastructures and regional regulations, the second reports information on the inter-provincial scale regarding mainly current and historic road infrastructure and provincial landscape plans. Finally, the third information level collects all the historic materials and current maps on a more detailed scale, so as to allow an in-depth analysis and to anchor all the data to specific points of the territory (*Favino P. 2017)*.

The overlapping and comparison of the cartographic materials have made it possible to read some evolutionary transformations of the Castle of Petriolo and its main constructions and to identify the infrastructures formerly connected to the buildings. This operation also made use of the reconstruction of the morphological trend of the soil, the geomorphological characteristics and the documentation available in such a way as to highlight the areas of greatest interest from the historic-archaeological point of view (*Bortolotto S. 2017)*.

On a methodological level, it was therefore preferred to obtain a database from historic, literary, archival, cartographic and iconographic sources, as complete as possible and included totally in a Geographic Information System, for easier consultation and analysis. From the study of these materials, the need was felt for a comparison with the current situation of the places to verify above all the first obtained results and, at the same time, to identify any signs or remains of archaeological or architectural nature, not reported in the archive documentation. In addition, the available cartographies, mostly on a scale of 1: 10,000 if not higher, represent the area and its anthropic components with a detail that did not allow immediate feedbacks and a certain positioning of the elements. Even looking at the aerial photos, past and recent, it was not possible to accurately distinguish the signs inside and outside the walls that delimited the Castle due to the definition of the aerial images and, especially, for the presence of a dense and high vegetation, the main reason that prompted us to plan a detailed on-site investigation.

The survey used a method based on Navigation Satellite Time and Ranging Global Positioning System technology, the NAVSTAR GPS, more commonly and synthetically known with the acronym GPS (Global Positioning System). However, it would be more correct to say GNSS (Global Network Satellite System) as it includes all the satellite constellations currently in orbit and therefore visible from the instruments (American GPS system with 31 satellites, Russian GLONASS system with 23 satellites, European GALILEO system with 26 satellites and the Chinese BEIDOU system with 16 satellites). The principle of operation of satellite systems is based on distance measurements between satellites in orbit around the earth with a constant distance and points on the ground of unknown coordinates and therefore to be determined. All the systems that use Global Network Satellite System procedures, regardless of their degree of accuracy and complexity, calculate the position of the receiver based on the position and time values sent by the available satellites. These are called ephemerides, that is the set of parameters necessary and sufficient to calculate the position of the satellite over time and then obtaining the position on the ground. This setting occurs only and exclusively if the instrument on the ground is able to capture the signal of some satellites, thus processing the data, through triangulations and semi-automatic corrections, to provide a planimetric and altimetric location of the points of interest *(Bertocci S., Bini M. 2012; Guzzetti 2017)*.

Coming back to the case study, the area, located in the lower part of the valley of the Farma stream, is characterized by dense vegetation, both weed and tall, and by the remains of the elevated external walls of the Castle. This specific morphological conformation of the territory and the presence of high covering elements considerably reduced the portion of the sky visible from the ground and therefore also the possibility of acquiring the signals of the satellites in orbit. Theoretically, to obtain the coordinates of a point on the ground, it is necessary to record the signal of at least 4 satellites, however it would be preferable to increase this threshold to make the determination of the data redundant thus allowing greater precision in the spatial location of the elements to be analysed.

Considering these premises and in the impossibility of conducting a more advanced survey *(Garzulino A. 2019)*,

as too expensive in terms of time and costs, we have chosen to use a differential satellite system (DGPS), which allows to significantly increase the accuracy of the investigations compared to the traditional global consumer category tracking systems, such as road satellite navigators, smartphones, position detectors integrated with cameras, etc. This instrumentation (GNSS RTK *Topcon Hiper PRO*) consists of a base (Base Station) and a receiver (Rover Station) that operate in kinematic mode, fully integrated and connected to each other via Bluetooth technology. Specifically, considered the particular morphology and to deal with signal alteration problems due to the location and dimensional characteristics of the elements, it was decided to place the main unit (Base Station) in the only area free from vegetation and shielding elements, near the small church located close to the road that runs along the Farma stream. Here it was in fact possible to fix, with good quality, the constant signal of about 8 satellites and then proceeding with the synchronization and setting of the Rover Station to start the survey operations. Considering the environmental conditions, the period value, i.e. the time interval between two successive measurements, has been set equal to 5 seconds. Once the quantity and quality of the satellite signals picked up by the mobile receiver had been verified, it was possible to continue with the inspection of the area under investigation and with the recording of the planimetric and altimetric coordinates of each single point. By operating in continuous kinematic mode and being the receiver equipped with the OTF (On The Fly) option, it was possible to perform the entire detection campaign quickly and keeping the positioning error limited, ± 2 cm for the planimetric coordinates and ± 4 cm for the altimetries, despite the environmental difficulties encountered. Considered these critical issues, if consumer category units or less complex GPS instruments had been used a dilution of precision would have occurred mainly due to the acquisition of signals from satellites arranged in a non-profitable way for the calculation of the coordinates. Unlike these devices, the GNSS RTK has assessed the conditions for selecting the satellites fully automatically, consequently reducing positioning inaccuracies to a minimum level.

The collected data was stored thanks to the use of a mobile device connected via Bluetooth to the Rover Station and capable of showing the planimetric and altimetric coordinates directly on the screen as well as the qualitative and quantitative information of the satellite signals.

The information acquired was entered in the GIS environment and divided into categories based on the type of object detected: verification points, paths, walls, aligned structures, terracing (*Figure 1*). All the positions identified were checked once entered in the Geographic Information System and processed graphically with different colours to facilitate the identification of any connections with the archaeological and cartographic analysis previously carried out.

The reconstruction of the ground trend, the geomorphological characteristics of the area and the study of the available documentation have therefore made it possible to develop a surface investigation strategy aimed at identifying the areas of greatest interest for the future definition of an archaeological risk map. The quantity and the layout of the buildings documented by archival sources, especially in the XV century, led to a detailed survey of the area delimited by the fortified walls of the Castle and in the area outside the North-Eastern/South-Western wall. On the other hand, specific surveys were carried out in areas of interest identified following the analysis of published cartographic and bibliographic data, external to the site. The systematic survey of the spaces has led to the detection of artificially regulated areas and of numerous remains of stone structures surfacing on the terrain and in exposed sections of the slopes, while the total absence of mobile finds on the surface was noticed. The collection and analysis of cartographic and

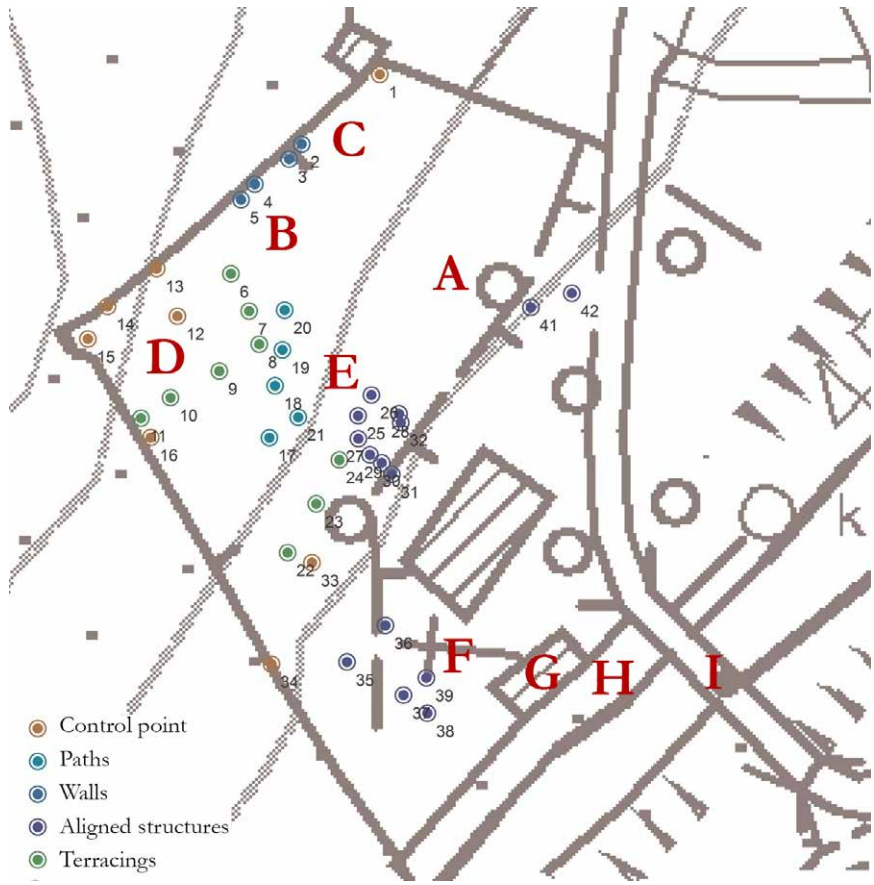

Figure 1 - Detected points and areas of investigation (in red).

The collected data was stored thanks to the use of a mobile device connected via Bluetooth to the Rover Station and capable of showing the planimetric and altimetric coordinates directly on the screen as well as the qualitative and quantitative information of the satellite signals

archaeological data have thus highlighted the presence of part of the built context of the village and of the remains of the walls pertinent to the building physically linked to the central internal section of the Northern wall of the fortification. In addition, the evidences in archival sources have provided tangible evidence regarding the organization of the settlement, the functions and often also the properties of the buildings. The acknowledgment of this information made it possible to obtain a relatively clear picture of the structure of the complex and therefore to plan subsequent investigations (*Massa S. 2017)*.

Starting from this base, further investigation phases have been planned to allow the progress of the research and to proceed with the identification of the archaeological analysis. The phases indicated and preparatory to future interventions will concern first of all the cleaning of the weed vegetation in order to investigate archaeologically the internal sector of the walls in front of the Northern and Eastern wall (*Figure 1 – A*). After cleaning with archaeological assistance, stratigraphic surveys can be carried out in the area in front of the Western corner tower above the terraces (*Figure 1 – B and D*) and between the two wall partitions linked to the Northern wall (*Figure 1 – C*). A further area to be explored from an archaeological point of view is the central sector of the fortified area, which has numerous walls, some also contiguous and coeval, to be analysed in order to better understand the planimetric configuration of the village (*Figure 1 – E*). Regarding the area of the Church, a stratigraphic survey was planned to verify the grounds and the progress of the fortification wall to the East (*Figure 1 – H*) and West (*Figure 1 – F*) of the religious building together with an elevated stratigraphic analysis. Outside the building itself, it is advisable to check the possible presence of the 'women's bathroom', of any pre-existing structures and perhaps a landing place (*Figure 1 – G*) under the current terracotta floor. It will also be interesting to investigate the stratigraphy of the tanks to verify their chronology. On the outside, a stratigraphic survey could be set on the remains of the structures of the oldest bridge, of which the ancient pillars of the ruined structure are still visible today (*Figure 1 – I*).

These analyses will give back a greater understanding of the place as a complex cultural resource and will allow a conscious enhancement of the site as an archaeological and environmental park and museum of itself.

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Satellite outage reporting: An improved approach.

The SOF offers a number of benefits for its users. The SOF XML format is well understood and defined by schema, allowing programmers to write code that can interpret the SOF without misunderstanding

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Background

In 1999, United States Space Command stood up the GPS Operations Center (GPSOC), a GPS center of expertise providing direct support to warfighters and civil agencies that served civilian GPS users. It was incorporated into operations at the GPS Master Control Station at Schriever Air Force Base, Colorado. GPSOC duties included performing mission planning and post-mission assessment, which required knowledge of GPS satellite health in order to correctly model what the user was seeing. The models took signal availability into account by implementing the information in the NANU messages.

In order to smooth the operation of their analysis, the GPSOC created a machine-readable file called the satellite outage file or SOF. The Coast Guard started posting the SOF on its public website in 2017.

The problem with NANUs

Since the early 1990's, NANUs have been a reliable means of notifying users of satellite outages. While every effort is made by the satellite operators to ensure NANUs are issued correctly, some NANUs have managed to slip through with errors. A survey of the various types of NANU errors is provided in the paper "NANU Analysis from 2007 through 2015" [1]. The paper identified a number of NANU fault types, including:

- Incorrect type
- Invalid time value -
- Incorrect reference NANU
- Duplicate NANU

Because of these faults and their corresponding effect on user mission operations, GPSOC personnel explored ways to identify satellite outages dependably and with accuracy. The result was the SOF, a machine-readable file that containing pertinent information (Date, start/stop times, NANU type & number) for NANUs reporting satellite outages.

Description of the SOF

The SOF is formatted using extensible markup language (xml), which is both machine readable and readable by humans. For a detailed description of the SOF, refer to latest edition of ICD-GPS-240, Section 30 [2].

The body of the SOF contains a list of all outage NANUs issued since January 1998. By "outage NANUs" is meant, reports of satellites not broadcasting or planned to broadcast healthy signals. These include scheduled outages, unscheduled outages, new satellites in the constellation, and decommissioned satellites. It does not include GENERAL or LEAPSEC NANUs.

There are three types of entries in the SOF: PREDICTED, CURRENT, and HISTORICAL.

PREDICTED. The PREDICTED entry is used to identify future outages which are not yet underway. Figure 1 below presents a FORECAST OUTAGE NANU for SVN52 (PRN31) from Day of Year/ Time 004/0905 to 004/2105 in the year 2019. Figure 2 shows the NANU translated into a PREDICTED entry

in the SOF identifying the outage as FCSTDV with the corresponding start and stop days/times. The types of NANUs identified in the SOF as PREDICTED are FCSTDV, FCSTMX, FCSTEXTD, FCSTRESCD, and FCSTUUFN.

Figure 1. FCSTDV NANU 2018074

```
NOTICE ADVISORY TO NAVSTAR USERS (NANU) 2018074
SUBJ: SVN52 (PRN31) FORECAST OUTAGE JDAY 004/0905 - JDAY 004/2105
    NANU TYPE: FCSTDV
    NANU NUMBER: 2018074
    NANU DTG: 281645Z DEC 2018
    REFERENCE NANU: N/A
    REF NANU DTG: N/A
    SVN: 52
    PRN: 31
    START JDAY: 004
    START TIME ZULU: 0905
    START CALENDAR DATE: 04 JAN 2019
    STOP JDAY: 004
    STOP TIME ZULU: 2105
    STOP CALENDAR DATE: 04 JAN 2019
```

Figure 2. SOF Entry for NANU 2018074

```
<PREDICTED SVID="31" SVN="52" NAME="NANU" TYPE="FCSTDV" REFERENCE="2018074" START_YEAR="2019" START_DOY="004" START_HR="09" START_MIN="05" START_SEC="00" END_YEAR="2019" END_DOY="004" END_HR="21" END_MIN="05" END_SEC="00" />
```

CURRENT. The CURRENT entry is used to identify satellite outages that are ongoing at the time the SOF is produced. The types of NANUs identified in the SOF as CURRENT are UNUSUFN and LAUNCH.

HISTORICAL. The HISTORICAL entry is used to identify outages that have occurred in the past and are completed. The types of NANUs identified in the SOF as HISTORICAL are FCSTSUMM, UNUSABLE, UNUNOREF, USABINIT, and DECOM.

Accessing the SOF

The SOF is updated and posted after the 2 SOPS issues a NANU, although since additional checks are required prior to issuing the SOF, this update is not immediate. The U.S. Coast Guard Navigation Center (NAVCEN) posts it to their site within a few minutes, which is available here: www.navcen.uscg.gov.

In addition to the NAVCEN, several companies post copies of the SOF as a convenience to their users. Analytical Graphics, Inc. (AGI), posts to this site:

http://navigationservices.agi.com/SatelliteOutageCalendar/SOFCalendar.aspx.

CelesTrak posts one on https://celestrak.com/GPS/sof/current_sof.txt

SOFs are actively used on a regular basis by many users. T.S. Kelso of CelesTrak reports that on his site alone the SOF file is being downloaded between 10 and 18 times a day. [3]

SOF behaviors

The author shares several observations on the behavior of the satellite outage file since its inception in 2004.

By and large the SOF matches the NANUs that are issued, yet there have been times when this is not so. For example, in 2011, the SOF omitted NANU data from February through July [4]. This was subsequently corrected by the satellite operators. As another example, a SOF downloaded in August 2020 included entries for predicted outages for satellites that had been decommissioned and were no longer in the almanac (SVN34/PRN18, SVN60/PRN23, SVN41/PRN14).

Several users have observed significant delays in the SOF being issued following NANUs. This issue of latency is an important one for users, since they rely on the timeliness of outage notifications for their services. The author conducted a survey of SOF timeliness for NANUs issued between January and mid-August 2020. Of the 36 SOFs analyzed 50% of them were issued within one hour of the NANU, 95% were issued within three hours. The other 5% were a combination of various times, including more than 3 hours and SOFs being issued prior to their associated NANUs.

Benefits of the SOF

The SOF offers a number of benefits for its users. The SOF XML format is well understood and defined by schema, allowing programmers to write code that can interpret the SOF without misunderstanding. Utilizing the GPS outage data from a SOF file removes ambiguities in processing NANUs. While NANUs provide the same information as the SOF, their implementation is complex and occasionally inconsistent, making it not well-suited for machine interpretation. Users can suffer from misinterpreting the NANU-based data resulting in invalid results, such as inaccurate flight plans and post mission assessments. [5]

Following are examples of commercial and government uses in mission planning and assessment:

- The SOF has been an integral part of Analytical Graphics Inc's (AGI) navigation software since 2008. Their Systems Took Kit (STK) has a Navigation Files Plugin that allows users to implement SOF files to model past, present and future GPS satellite outages for mission planning and post-mission assessments.
- OneSky, a Supplemental Data Service Provider (SDSP) for unmanned aerial systems (UAS) and UAS Traffic Management (UTM), incorporates the SOF to provide accurate navigation accuracy for the routes users are flying. It fulfills one of the FAA's requirements for UAV flight planning.
- Air Transportation Planning. The SOF can help accelerate notification times, minimize errors in operation, and reduce customer service interactions. As an example, the FAA can use the SOF as a data feed in their Service Availability Prediction Tool, eliminating the need to manually resolve discrepancies in NANUs.

Implementation of the SOF has advanced the use of satellite outage information for satellite prediction and assessment tools. Its usefulness has been hampered by issues with accuracy and timeliness. As one user said "It is the perfect solution to many issues. But it has to be trusted."

Summary and recommendations

Implementation of the SOF has advanced the use of satellite outage information for satellite prediction and assessment tools. Its usefulness has been hampered by issues with accuracy and timeliness. As one user said "It is the perfect solution to many issues. But it has to be trusted." [6]

In order to get to this point of trustworthiness and usability, several actions are proposed.

- Timeliness. Satellite operators should consider changes in processing SOFs to advance their timely release. As an objective, endeavor to achieve the timeliness values provided in ICD-GPS-240 for the NANUs, namely, within one hour after outage start (ICD-GPS-240, Table 10-IV) [2].
- Correctness. Satellite operators update procedures to correctly process satellite decommission NANUs (DECOM).
- Monitoring. Organizations responsible for validating the performance of GPS data should include a check of the SOF and make their intermediate results available to the satellite operators as a closed loop to ensure timely and quality products.

As more attention is paid to the quality and timeliness of the SOF, its use by mission planners and mission assessment organizations, both civil and military, will increase, allowing them to take advantage of the benefits the SOF is able to offer.

Disclaimer and acknowledgements

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Doing Business – Data Irregularities Statement

The World Bank Group has issued the following statement on August 27, 2020 on the Doing Business Report:

Over the 17 years of its existence, the Doing Business report has been a valued tool for countries seeking to measure costs of doing business. Doing Business indicators and methodology are designed with no single country in mind, but rather to help to improve the overall business climate.

A number of irregularities have been reported regarding changes to the data in the Doing Business 2018 and Doing Business 2020 reports, published in October 2017 and 2019. The changes in the data were inconsistent with the Doing Business methodology.

The integrity and impartiality of our data and analysis is paramount and so we are immediately taking the following actions:

- We are conducting a systematic review and assessment of data changes that occurred subsequent to the institutional data review process for the last five Doing Business reports.
- We have asked the World Bank Group's independent Internal Audit function to perform an audit of the processes for data collection and review for Doing Business and the controls to safeguard data integrity.

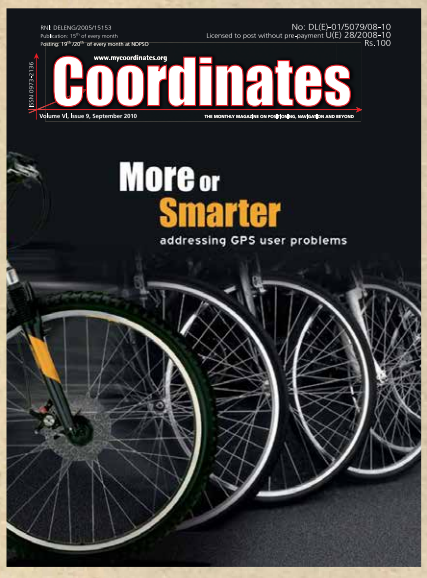
We will act based on the findings and will retrospectively correct the data of countries that were most affected by the irregularities.

The Board of Executive Directors of the World Bank has been briefed on the situation as have the authorities of the countries that were most affected by the data irregularities.

The publication of the Doing Business report will be paused as we conduct our assessment. *www.worldbank.org*

In Coordinates

10 years before...



mycoordinates.org/vol-6-issue-9-September-2010

More GPS or Smarter GPS?

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High satellite availability over the past several years has led the navigation community to depend on full fixes and overdetermined solutions, deemphasizing the use of dynamics. Familiarity and preoccupation with instantaneous position have allowed robustness to become a casualty of convenience. The authors believe that marked improvements are entirely within reach, without a need for straining budgets or scientific breakthroughs, by exploiting a combination of well-known methods with other techniques which, due to relatively recent appearance, are largely unknown.

User authentication schemes for GNSS selective broadcasting

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In this paper three different solutions are proposed for the problem of location- based selective broadcasting of traffic messages. The first proposed functional architecture is quite secure against an eventual attack for the presence of an anti-tamper receiver. Besides, it is not very heavy from the computational burden point of view. In fact the Local Element ciphers information with a number of keys equal to the number of Hot Spots.The second proposed architecture does not contemplate the use of an anti- tamper receiver and the eventual attacks are prevented by the use of the ground velocity and the ship type inside the second key. This solution is less secure then the first while the computational effort remains similar. Moreover, a communication link between the Local Element and Mobile Elements is contemplated in order to make the vehicle type known.

Assessing the Security of Navigation System

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The article examines navigation security by using eLoran as a case study. It discusses the possible attacks that could affect the signal and user. It determines the vulnerability level and looks at available mitigations. In analyzing on-air attacks, the article quantifies the amount of power needed to jam or spoof Loran signals and determines the feasibility of an attacker to achieve these levels. While the required power is orders of magnitude larger than that need to jam GNSS, it is still not very large.

"An ideal GNSS system is one that is impossible to spoof and difficult to jam"

says Professor Y Jade Morton, President, Institute of Navigation (ION) and Director of the Colorado Center for Astrodynamics Research at the University of Colorado Boulder in an interview with Coordinates magazine

Professor Y Jade Morton is currently the Director of the Colorado Center for Astrodynamics Research at the University of Colorado Boulder where she mentors students, faculty, staff and an international network of collaborators throughout the world. Dr. Morton has made pioneering contributions to the advancement of GNSS receiver technology and its applications. She was awarded her Ph.D. in Electrical Engineering at Pennsylvania State University. She is a recipient of the IEEE Kershner Award, the Institute of Navigation's (ION) Burka and Thurlow Awards, and is a Fellow of the ION, RIN and the IEEE. She is the current ION president.

In 2020, the Institute of Navigation (ION) celebrates the 75th year since its founding. On this occasion, it would be good to review the ideas and objectives that lay behind the creation of ION.

For the past 75 years, ION has been the world's premier professional organization in advancing the art and science of position, navigation, and timing (PNT) and in providing a viable networking and educational platform for members coming from industry, academia, and government agencies. Today, the field of PNT is experiencing exponential growth, and PNT professionals are in high demand from the ever-expanding sectors requiring PNT expertise. Along with this exciting progress are challenges and new opportunities as our demographics are changing and the modern means of communicating, networking, and learning are constantly evolving. More than ever, ION must dynamically adapt and anticipate the changing trends in the field. With the support of a strong international member community, and the dedication of an excellent staff, ION is well-poised to play a crucial role of bringing together application engineers and product vendors, educators and

ION INSTITUTE OF NAVIGATION CELEBRATING 75 YEARS

students, scientists, researchers, and policy makers to maximize the positive impact of PNT technologies on society in the 21st century.

Would you like to elaborate on some of the achievements of the ION and also the challenges before?

ION has a wide range of achievements which include its unmatched conference and workshop organizations, numerous educational and outreach programs and initiatives, the government fellowship program, technical sponsorship and collaborations with other international professional organizations, journal and conference publications, and facilitation of standard development. I would like to highlight a few outstanding achievements which I personally witnessed since my affiliation with ION nearly two decades ago. The first and fundamental achievement is the success of ION's conferences. Each ION conference offers a unique "flavor" and technical contents to an appropriate mix of audience in the PNT community. ION constantly adapts its conferences to the need of the community. For example, in 2013, ION launched the Pacific PNT meeting to address the growing interest in the development of PNT systems and applications in the Pacific Rim countries. This bi-annual meeting has attracted a large proportion of first-time attendees from Asian Pacific countries. I am looking forward to the 5th Pacific PNT meeting, now planning to be held in Hawaii in April 2021. Since 2004, ION has been the lead sponsor for international student competitions, such as the autonomous lawn mower and autonomous snowplow competitions. These competitions have inspired many undergraduate students to pursue a career in the field of PNT and automation. Another major achievement is the African GNSS Outreach program sponsored by the ION Satellite Division. For the past decade, led by past ION president Pat Doherty, this outreach program has educated over 500 graduate students and faculty from African countries and other developing nations on the fundamentals of satellite navigation and applications. Some of the students are now recognized experts in the field. ION has sponsored (and committed to sponsor) 10 government fellows during the past two decades. The government fellowship program, sponsored in cooperation with the American Association for the Advancement of Science, offers ION members a unique educational experience while providing the US government a resource of technical experience and private sector perspectives, which ultimately helps to foster public policy on the issues that affect our society and our profession. Finally, the ION community has been the driving force and the liable resource that has led to the establishment of a number of much needed technical standards, including the recently adopted GNSS Software Defined Receiver Metadata Standard.

As a professional organization in a rapidly evolving field, ION has faced (and continues to face) many challenges. For example, PNT is a traditional engineering field dominated by men. Such dominance was reflected in the composition of the ION community. In recent years, however, under the leadership of past president Dr. Dorota Grejner-Brzezinska, ION and its sponsors have taken a number of initiatives to promote, encourage, and support women in PNT and successfully improved the diversity in ION events and leadership teams.

Another challenge is the evolving demographics of the field of PNT. New generations of PNT professionals adopt new means of communicating and networking. ION must dynamically develop strategies to keep engaged with the changing field. Finally, ION's journal NAVIGATION has long faced challenges from competitors and ranking and impact factor issues. In recent years, however, thanks to the relentless effort of our editors, Drs. Boris Pervan and Richard Langley, the team of associate editors, the ION staff, and countless reviewers, NAVIGATION is gaining greater recognition, attracting quality submissions, and ramping up its ratings.

Can you briefly touch upon your research interest in 'intersection of satellite navigation technologies and remote sensing' and other research priorities?

Satellite navigation, as implied by its name, is designed for navigation applications. However, it is well-known that some of the largest and toughest errors associated with satellite navigation solutions are the so-called propagation effects, including multipath, ionosphere, and troposphere errors. The satellite navigation community treats these errors as nuisances and has devoted much effort to mitigate them. However, these errors contain signatures of the signal propagation environments and can be used to extract information on the environment. The remote sensing community has been working on retrieving atmospheric profiles, ionospheric states, urban propagation channel conditions, ocean surface wind and roughness, and land cover soil and vegetation moisture, etc. by using ground, airborne, and LEO satellite-based GNSS receiver measurements. Because of the large number of navigation satellites, their well-defined signal structures, and their distributed global coverage, navigation satellite signals are ideal signals-of-opportunity for remote sensing applications. However, the measurements tend to be very challenging as they are often associated with highly disturbed, weak signals. By working in the "intersection of the satellite navigation technologies and remote sensing", our goal is to integrate our expertise accumulated in the navigation community and knowledge of scientific interactions of the signals with the environment to advance our understanding of the space and Earth surface environment.

By working in the "intersection of the satellite navigation technologies and remote sensing", our goal is to integrate our expertise accumulated in the navigation community and knowledge of scientific interactions of the signals with the environment to advance our understanding of the space and Earth surface environment

What is your idea about a Perfect GNSS System?

An ideal GNSS system is one that is impossible to spoof and difficult to jam. Its signals should be relatively simple and elegant so that receiver signal processing can be done in a power-efficient manner and allow fast acquisition and accurate tracking. It should be inter-operable with other GNSS and backward compatible with its predecessors. It should have limited multipath errors even when operating in urban environments. It should be built on a reference frame and time standard that can be easily adopted by a wide variety of applications and systems across geographical and political borders. Finally, it should support multiple carriers and both data and pilot channels on all carriers to enable receivers operating in challenging environments. The carriers should have sufficient spectral separations to ensure accurate estimations of ionosphere errors, or be at frequencies where ionospheric and atmospheric effects are insignificant.

Would you like to comment on GPS III and also on other existing and upcoming systems including NavIC?

Since December 2018, three GPS III satellites have been launched. An additional seven GPS III satellites are under construction by Lockheed Martin and are expected to be launched by 2023. In addition to the legacy L1 C/A, L1 and L2 P(Y), and modernized L2C, L5, and M code signals, GPS III satellites also broadcast a new civil signal, the L1C. The L1C signal

consists of a pilot and a data component with an asymmetrical power split (75% for pilot and 25% for data) and is transmitted in phase with orthogonality achieved by the code division multiplexing. The data component uses BOC (1,1) modulation to achieve backward spectral compatibility with the legacy L1 C/A signal. The pilot component features a Multiplexed BOC (MBOC) modulation, which enables GNSS interoperability with BDS, Galileo, and QZSS. GPS III satellites transmit an updated civil navigation message, CNAV-2, which employees sophisticated error detection and correction scheme. CNAV-2 also includes additional parameters such as the GPS/GNSS time offset (GGTO) parameters for multi-GNSS applications and Earth orientation parameters for space borne applications. In addition to the advances in signal modulation and navigation data message transmission, GPS III satellites carry laser retro-reflectors to allow tracking of satellite orbits independent of radio signals, thereby allowing satellite clock errors to be disentangled from ephemeris errors. At the time of this interview, Lockheed Martin is selected to build up to 22 GPS III Follow On (GPS IIIF) satellites by 2034. The GPS IIIF satellites are planned to incorporate additional capabilities such as Distress Alerting Satellite System for search and rescue, Regional Military Protection (RMP) capability, satellite crosslinks for rapid command and reduced age of data, spot beam antennas, and a fully digital navigation payload, while maintaining compatibility with next generation Operational Control System (OCX) and the existing GPS constellation. Compared to its predecessors, GPS III is inching closer to the ideal GNSS system discussed earlier.

The other GNSS also had an exciting year. GLONASS is undergoing a transition stage with the launch of the last GLONASS-M satellite (second generation GLONASS satellites) in March 2020. Already, two of the third generation GLONASS satellites, GLONASS-K1, are launched and the remaining batch of nice are planned for launch by 2023. This

> The biggest winner in this multi-GNSS age is the remote sensing and scientific applications. With each satellite ray-path serving as an observable of the signal propagation environment, a larger ensemble of transmitters will provide improved spatial resolution and coverage of the physical world of interest

will be followed by GLONASS-K2 satellites, which are redesigned systems hosting a passive hydrogen maser AFS with expected one-day stability of $5x10^{-15}$ (0.3 m SISRE) and transmitting a full suite of modernized CDMA signals in the existing L1 and L2 bands as well as the L3OC signal. This year also marks a special milestone for Galileo and BDS. Galileo is expected to be fully operational by the end of 2020 when two new Galileo satellites are scheduled to be launched to bring the total number of the operational satellites in the constellation to 24. Already, Galileo has achieved an impressive SISRE of 25cm (95%), despite the 6-day service outage that occurred in July 2019. This year also sees Galileo's transition to its second generation satellites with the first order of four satellites expected to be under contract by the end of 2020. BDS achieved fully operational status in June 2020 with the launch of the final satellite that completes the BDS-3 network. The 30 operational BDS satellites offer the most orbital diversity among all GNSS, including 24 MEO, three IGSO, and three GEO satellites, to provide both global services and enhanced regional services, as well as other featured services such as BDSPPP, BDSBAS, regional message communication, and global SAR functions. BDS reached this impressive status with an unprecedent 21 successful launches from

For both GNSS-RO and GNSS-R applications, the receiver antenna is pointed towards Earth's surface. Terrestrial transmissions of broadband radio signals will directly enter the antenna's main lobe to interfere with the processing of the already weak and disturbed signals. The FCC's decision is indeed a very "disturbing" news for the GNSS remote sensing community

November 2017 to June 2020. All BDS-3 satellites are equipped with inter-satellite links (ISL) to drastically improve satellite orbit accuracy by nearly 100% to 30 cm.

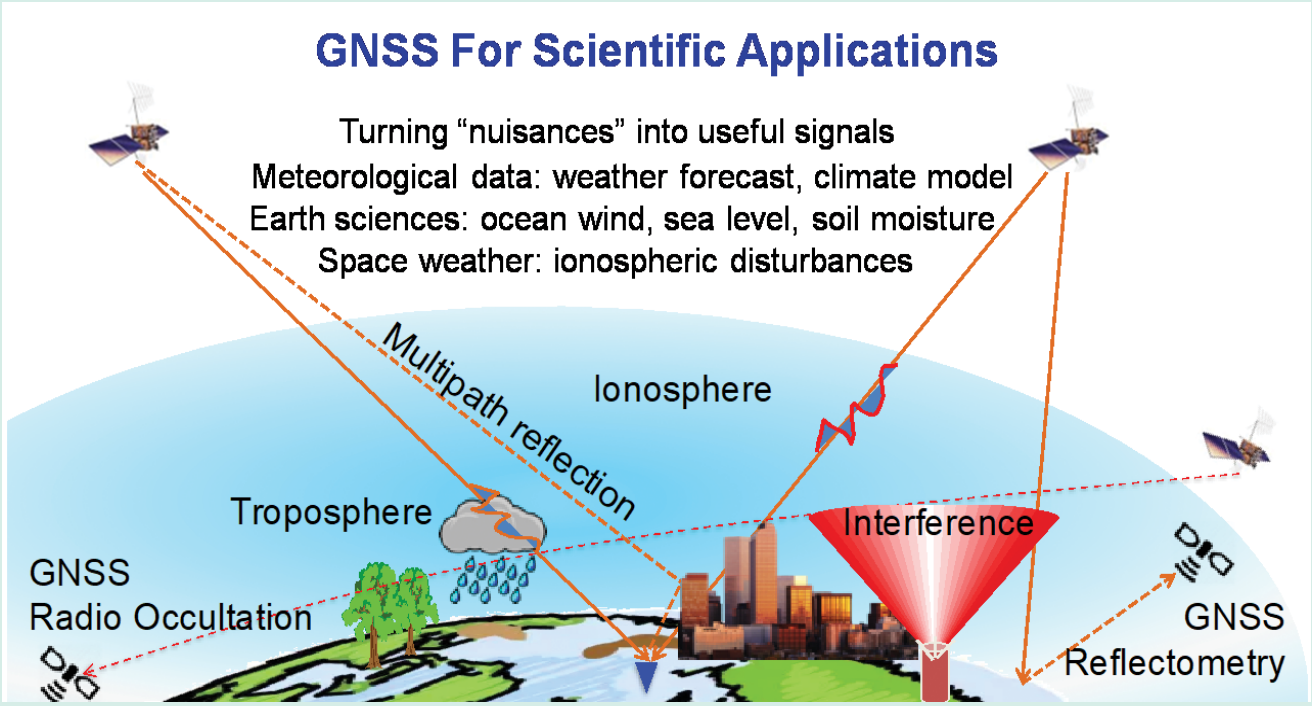
There are now three potential regional navigation satellite systems (RNSS), serving the Asian Pacific and Indian Ocean areas. Two of the RNSS, QZSS and NavIC, have been fully operational in recent years. QZSS currently has four satellites in IGSO orbit. A QZSS-1R satellite is expected to be launched later in 2020. QZSS is also expected to take over the transmission of MTSAT, Japan's SBAS in 2020. Three additional satellites are planned to be launched after 2023. QZSS satellites transmit signals compatible with GPS L1 C/A, L1C, L2C, and L5. NavIC currently has seven active satellites, three GEO and four IGSO satellites, and has plans to extend to 11 satellites in the future. NavIC satellites transmit signals at L5 and S band. A messaging interface is embedded in the NavIC system to allow command center to send warnings to specific geographic areas. The Regional South Korea Positioning System (KPS) is a new RNSS currently under planning. KPS is expected to launch three GEOS and four IGSOs to cover South Korea and about 1000km of Pacific Ocean and Australia.

This is a world of multi-GNSS systems. What advantages do you see about this scenario?

Multi-GNSS offers several advantages. The larger number of combined satellites in space improves the geometric diversity and hence the PVT solution accuracy. This is especially true in urban environments where a large number of satellites may be blocked by buildings. The redundancy introduced by these extra satellites also improves the signal availability and reduces the probability of blackout (or complete loss of navigation solutions). Multi-GNSS also provides more rich spectral diversity and improves the jamming resistance. Finally, I believe the biggest winner in this multi-GNSS age is the remote sensing and scientific applications. With each satellite ray-path serving as an observable of the signal propagation environment, a larger ensemble of transmitters will provide improved spatial resolution and coverage of the physical world of interest.

What is your take on FCC's Ligado spectrum decision?

Like many others in the PNT community, I think the decision will have a profound negative impact on satellite navigation and many important applications. There have been many discussions on the impact of the broadband system on navigation applications. I would like to highlight its potential impact on remote sensing applications. Two notable remote sensing applications are the GNSS radio occultation (GNSS-RO) and GNSS reflectometry (GNSS-R). GNSS-RO has been recognized as a major data source of atmospheric profiles needed for weather models, climate studies, and ionosphere monitoring. It retrieves these measurements by receiving and processing the Earth limb scan of GNSS satellite signals. GNSS-R utilizes reflected GNSS signals from the Earth's surface to infer the surface properties such as hurricane wind development, evolution of wetland, snow-water storage, ice and vegetation coverage, and sea



level changes. For both GNSS-RO and GNSS-R applications, the receiver antenna is pointed towards Earth's surface. Terrestrial transmissions of broadband radio signals will directly enter the antenna's main lobe to interfere with the processing of the already weak and disturbed signals. The FCC's decision is indeed a piece of very "disturbing" news for the GNSS remote sensing community.

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

Interference, jamming, and spoofing will always be there and may get smarter over time. As we move into a world that becomes more reliant on autonomous systems, the threats will have an increasingly higher impact. We must be creative in developing techniques to detect and mitigate both intentional and un-intentional adversary factors. These techniques are, and should, continue to be addressed at multiple levels, including antennas, signal design, receiver signal processing, and the integration with other complementary sensors.

Given this, what's your opinion on GNSS backups?

GNSS backups serve society's interest. While there are many alternative navigation resources

> Today's GNSS receivers are customized for a vast number of specialized applications with wide ranging complexities, capabilities, and resource requirements. On the high-end of the spectrum are reference monitoring stations which are capable of direct sampling the entire L-band spectrum and perform signal monitoring, oscillator anomaly detection, interference analysis, and ionosphere characterization in real time

being explored to offer solutions when GNSS is compromised, none of these sources offer the type of coverage provided by GNSS that we (and our applications) are accustomed to. This is particularly true for safety-of-life applications. Dedicated GNSS backups will be very helpful for these applications.

What technology trends do you envision in GNSS receivers in the near future?

Today's GNSS receivers are customized for a vast number of specialized applications with wide ranging complexities, capabilities, and resource requirements. On the high-end of the spectrum are reference monitoring stations which are capable of direct sampling the entire L-band spectrum and perform signal monitoring, oscillator anomaly detection, interference analysis, and ionosphere characterization in real time. In the middle sector are high accuracy consumer and scientific applications. For the consumer sector, RTK receivers are now capable of providing mm-level carrier phase-based relative positioning; and PPP technologies can yield sub-cm level standalone absolute positioning. For scientific applications, airborne, spaceborne, and ground-based systems are designed to track nuisance features such as reflected signals, signal bending angles, and carrier phase disturbances that are routinely removed and filtered by navigation receivers to retrieve information on our space environments and Earth surface conditions. On the low-cost, high-volume mass market end, current generation cellphones have integrated the entire PNT functionality utilizing all GNSS constellation signals and carriers into a single CMOS chip that consumes a few mW, costs a few dollars or less, and with performances that outshine aviation-grade GPS sets from merely a decade ago. On the further extreme low-cost end are asset tracking devices that periodically take a "snapshot" of GPS signals for post-processing to achieve localization at a few meters of accuracy.

> Interference, jamming, and spoofing will always be there and may get smarter over time. As we move into a world that becomes more reliant on automation, the threats will have an increasingly higher impact. We must be creative in developing techniques to detect and mitigate both intentional and un-intentional adversary factors

The future trend of GNSS will be driven by continued diverging needs of specialized applications and to ensure efficient sensor integration. Such needs will favor more open architectures and standardization. While ASICs have demonstrated to be the best in terms of performance and low power requirement, software-programmable ASICs will most likely be the dominant platform for future GNSS receivers due to their flexibility and the maturing technologies.

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

Using alternative positioning technologies including other radio signals-of-opportunity to augment GNSS has been an active research area for a while. These alternative technologies are especially helpful in densely populated urban areas where GNSS signals may be blocked. For defense-related applications in GNSS-denied areas, they are also important. There is definitely synergy between the alternative navigation technologies and GNSS-based systems. The synergy should be thoroughly exploited to ensure seamless transitions between GNSS-based navigation solutions in benign environments and multi-sensor augmented alternative products under challenging conditions.

There are only a limited number of universities in the US and in other countries that have dedicated curriculum for PNT/GNSS. Such limited educational resources cannot meet the high demand for PNT/GNSS experts in industry and government laboratories

Would you like to comment on autonomous navigation?

There is no doubt that autonomous navigation will improve productivity, safety, and resource utilization efficiency. Autonomous navigation is an unstoppable trend and leading industries are hopping on the wagon. But there will be challenges along the way. A critical piece in enabling autonomous navigation is the integrity of navigation solutions. Sensor integration holds the key to improving integrity measures. Some of the factors we mentioned earlier (such as alternative navigation technologies, backup systems, and multi-GNSS) are all important pieces that will make it happen.

You have a long association with academia. Given the pace of technology evolution, what challenges do you see before the academic community and PNT/GNSS education?

PNT/GNSS are interdisciplinary fields. We often see PNT/GNSS educators spreading across multiple departments, such as aerospace engineering, civil engineering, computer science, electrical engineering, geomatics engineering, mechanical engineering, physics, survey, etc. Unlike other traditional, well-defined disciplines, PNT/GNSS curriculum requires a wide mix of subjects. As a result, there are only a limited number of universities in the US and in other countries that have dedicated curriculum for PNT/GNSS. Such limited educational resources cannot meet the high demand for PNT/GNSS experts in industry and government laboratories. This is a major challenge in the near future before the academic community. A side effect of the imbalanced educational resources and industry demand is the challenge for universities to retain high caliber students in PhD programs. Students get irresistible offers from industry as soon as they have had experience with PNT projects.

How do you see the employment prospects of the students pursuing a career in PNT and GNSS?

As I stated above, there is a high demand for students with masters and PhD degrees in GNSS and PNT from private industry and government laboratories. We cannot graduate them fast enough! And they get incredible offers. As a result, our GNSS classes are getting very large. For example, there are 85 students enrolled in Professor Penina Axelrad's graduate level class "Introduction to GNSS" this fall at the University of Colorado, Boulder. Out of ~200 seniors that are working on senior capstone projects this year at our Aerospace Engineering Department, nearly 50 of them are on projects with a focus on or having elements related to PNT.

What likely impacts do you anticipate due to the ongoing Covid-19 crisis on the PNT and GNSS community?

COVID-19 is impacting everyone. For the PNT/GNSS community, there are both short-term and long-term impacts. In the short-term, COVID-19 is preventing in-person meetings, limiting laboratory work, and delaying project completion. In the long-term, like many other disasters and crises that occurred in the past, COVID-19 may stimulate, accelerate, or change the course of some technology development such as contact tracing, autonomous systems, and transportation, all of which are reliant on PNT.

"GNSS industry and the associated applications will be relatively less impacted by Covid-19"

says John Pottle, Director, Royal Institute of Navigation in an interview with Coordinates magazine

John Pottle
Director, Royal Institute of Navigation

With the world turning upside down, do you think this is time for the organisations to redefine their vision and missions in line with the changing paradigm?

Covid-19 has impacted practically every organisation and citizen across the globe. First I would like to say that my thoughts are with those who have been most heavily impacted, whether it be from a health or economic perspective.

In an organisation, when a risk is realised, as has been the case with the pandemic, it's always an opportunity to reflect and learn from what has happened and how the organisation responded. For some it will be a review, for others a major change, whether as an individual or an organisation.

How has Covid-19 impacted RIN activities? How you plan to deal with it?

The Royal Institute of Navigation's aim is to promote knowledge understanding to advance positioning, navigation and timing in all its forms. To an extent this can still happen virtually – one really unexpected thing for us has been that far more people have joined presentations and training we have offered online than we would ever have seen at a physical meeting. The challenge is that during a talk or presentation gets everyone only starts to think through the topic; the really great discussions, insights and ideas normally flow when you meet afterwards. As soon as it is safe to do so we will plan to start meeting together in person again. However, it seems certain that most meetings in future will also include a hybrid element, with an opportunity to join online too.

What likely impacts you anticipate due the ongoing Covid-19 crisis on GNSS industry, especially in the context of economic impact in UK and in EU?

The only certainty at present is uncertainty, probably for some time to come. The tragedy of the present pandemic seems to be that the highest impact is on the weakest. While this is painful to witness, I believe it's true to say that the GNSS industry and the associated applications are, generally, relatively strong and hence will be relatively less impacted. Those skilled in positioning, navigation and timing will still be in demand in a high-tech world that will continue to value science and data literacy.

I believe that job creation and employment related to positioning, navigation and timing will continue to grow, as the fundamentals needs and opportunities are strong

What challenges you see before the academic community and GNSS education? How do see the fallout of this crisis in job creation and employment?

The short-term challenge is that mobility is restricted. The UK attracts many international students and these will be lower next year, resulting in a projected 25% average reduction in income for universities. This, in turn, is leading to structural and operational reviews.

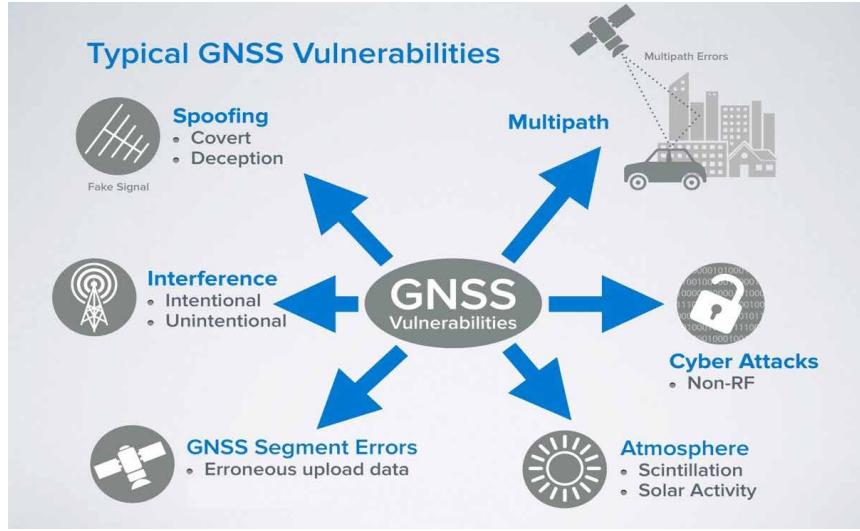
However, I am a great believer in what I call the "fundamentals". It is a fact that science, technology, engineering and maths are needed to enable global sustainable development. Also that resilient position and time are essential everywhere in the modern world. As such, I believe that job creation and employment related to positioning, navigation and timing will continue to grow, as the fundamentals needs and opportunities are strong.

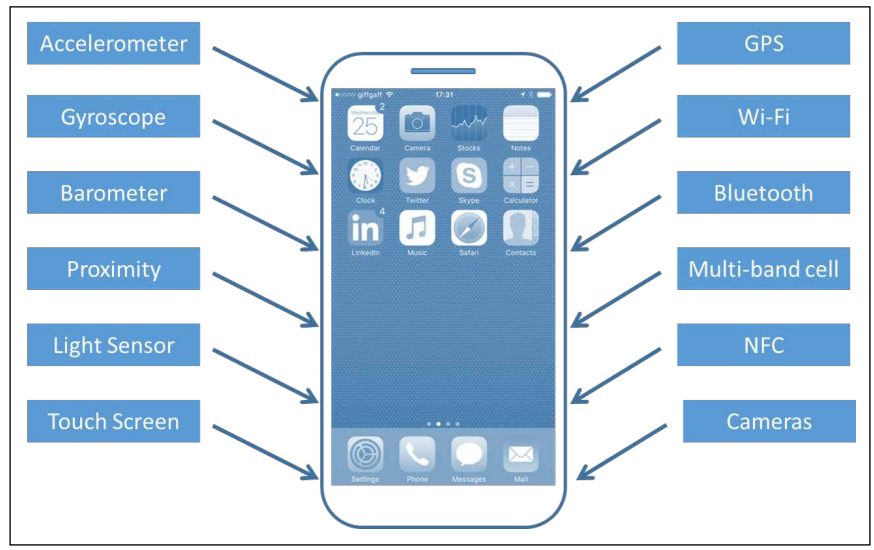
Do you see some new opportunities emerging out of this?

We have seen in many places that technology presents opportunities but is not always intelligently or optimally applied to solving problems. Contact tracing apps based on smartphone proximity sensors is a great example. So, generically, I see a real need and opportunity for more "systems thinking" to solve big problems. Applying the rigour and discipline of systems integration is a real opportunity to increase both impact and productivity.

In August 2010 in an interview with Coordinates you predicted that "Eventually all receivers will be multi-GNSS." How do you see now that observation?

Well, it's usually a really bad idea to predict the future, but that one has been proven right! My next prediction? Eventually all positioning, navigation or timing systems will integrate multiple





sensors and not rely on GNSS alone. This is necessary to achieve resilience in the face of growing cyber threats as the world becomes more connected.

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

Each is increasing and becoming more sophisticated, but generally in a predictable way. To combat this, we will see more layered systems approaches to deliver trusted position or time. There will be no one solution, but by assessing requirements and risks methodically it is possible to build resilient and robust positioning systems, even with increased interference, jamming and spoofing.

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

Sensor fusion in mobile devices already combines these technologies to offer almost continuous positioning – there is always a "blue dot". However, the issues at present are that accuracy for Wi-Fi and cellular positioning are relatively lower than GNSS. Current

I see great potential for fully autonomous systems to be much safer and more efficient than current so-called driver assistance or semi-autonomous modes

developments to measure round-trip-time rather than received signal power will bring us a real improvement in accuracy for Wi-Fi and cellular positioning. Another really interesting development for positioning is the increased use of cameras in phones, and possibly also other sensors such as ultrasound as a type or radar.

Would you like to comment on autonomous navigation?

This is a big topic. My top level observation is that I see great potential for fully autonomous systems to be much safer and more efficient than current so-called driver assistance or semi-autonomous modes.

After Brexit, would you like to comment on its implication on Galileo? What about an UK GNSS?

For most applications the open services are all that is needed and there are already plenty of ranging sources available from the existing GNSS's. My understanding is that the UK's current use of encrypted GPS for military purposes is not impacted by Brexit. So in many ways there is not a "problem to solve" in relation to provision of services. The question of whether the UK needs control over its own space-based positioning, navigation or timing assets is very much a strategic and political question that I am happy to leave to the politicians to decide!

AerialSphere launches next-gen mapping technology

AerialSphere have launched XP360 web application and API, which creates an online home search experience that is transforming the residential real estate market - enabling agents to better attract and engage clients with the latest in mapping technology. XP360 features a simple, user-friendly interface that empowers brokers and agents to add a new level of interactivity in home searches that goes way beyond traditional aerial views of homes. It gives prospective home buyers the ability to see homes, neighborhoods, schools and other points of interest. *https://aerialsphere.com.*

R&D agreement with the UK Rail Research and Innovation Network

HS2 Ltd has has signed an agreement with leading railway research centres in UK universities that will enable it to access world-leading research capabilities, knowledge and facilities. The agreement with the UK Rail Research and Innovation Network (UKRRIN) will enable HS2 Ltd to be at the forefront of innovation in the rail sector. The first project under the new agreement will be led by the University of Birmingham and will use simulation models to improve understanding of the performance of expansion joints used on high-speed rails. *www.hs2.org.uk/*

3D maps now with Velodyne Lidar

Velodyne Lidar, Inc. has announced Kaarta Cloud® which exclusively supports Velodyne's lidar sensors. The new cloud-based application is a platform to process, store, and share 3D spaces. Paired with high quality lidar to capture the environment in 3D, the data is uploaded into cloud to quickly and easily process it into a point cloud for use.

Mobile scanning systems are continually advancing and the possibilities for use are expansive. There is growing interest in lidar imaging for post-earthquake assessment, surveys of damaged buildings, aiding first responders in emergency situations and more. *https://velodynelidar.com.*

Bushfire Inquiry Report by NSW Government

The NSW Government, Australia has released the independent NSW Bushfire Inquiry, which examined the causes, preparation and response to the devastating 2019-20 bushfires.

All 76 recommendations will be accepted in principle, with further work to be done on specific timelines to give communities assurance that changes will be made to keep them safe.

Resilience NSW, led by Commissioner Shane Fitzsimmons, has been tasked with coordinating and overseeing the implementation of the Inquiry's recommendations as the government finalises its approach. *www.nsw.gov.au*

China launches new optical remote-sensing satellite

China successfully launched a new optical remote-sensing satellite from the Jiuquan Satellite Launch Center in northwest China. The satellite, Gaofen-9 05, was sent into orbit by a Long March-2D carrier rocket. Gaofen-9 05 has a resolution up to the sub-meter level. It will be mainly used for land surveys, city planning, land right confirmation, road network design, crop yield estimation and disaster prevention and mitigation. *www.xinhuanet.com*

Satellite data to power credit assessment of farmers

ICICI Bank, India announced the usage of satellite data—imagery from Earth observation satellites—to assess credit worthiness of its customers belonging to the farm sector. The Bank is the first in India and among few globally to use satellite data to measure an array of parameters related to the land, irrigation and crop patterns and use it in combination with demographic and financial parameters to make expeditious lending decisions for farmers.

The Bank has been using satellite data for the past few months in over 500 villages in Maharashtra, Madhya Pradesh and Gujarat and plans to scale up the initiative to over 63,000 villages shortly across the country.

This initiative gains significance at a time when people are advised to stay indoors and avoid travel in the wake of the Coronavirus pandemic. This use of satellite data provides quick and technically sound analysis of the land, crop and irrigation patterns from remote locations, without the need of the customer or a bank official having to visit the land. It offers farmers the significant advantage of reliable data being provided to the Bank without any hassles of travel, operational or logistical expenditure to them.

The Bank has partnered with agri–fintech companies specialising in harnessing space technology and weather information for commercial usage. It has worked closely with them to build reports with over 40 parameters for assessing credit-worthiness of a farmer with deep study of the land, irrigation and crop patterns. The analysis is put together using algorithms to analyse images available from satellites around the planet. Additionally, the Bank has worked on further scoring models to create indices at district level, village level as well as for individual land to provide an estimate of the past and future agriculture income, the timing of harvest and sources of income, and thus, provide key inputs to credit assessments. *www.icicibank.com*

Japan–US comprehensive dialogue on space – Excerpts of Joint statement

Pursuant to the shared goal of continuing to advance bilateral space cooperation and to further strengthen the Japan-U.S. alliance as declared by the leaders of both nations, the Government of Japan and the Government of the United States of America held the Seventh Meeting of the Japan-U.S. Comprehensive Dialogue on Space in Tokyo, on August 26, 2020.

This meeting was co-chaired by representatives from the Ministry of Foreign Affairs and National Space Policy Secretariat, Cabinet Office for Japan, and by representatives from the Executive Office of the President's National Space Council and National Security Council for the United States. Principal participants included the Ministry of Foreign Affairs; National Space Policy Secretariat; National Security Secretariat; Ministry of Internal Affairs and Communications; Ministry of Education, Culture, Sports, Science and Technology (MEXT); Ministry of Economy, Trade and Industry; Ministry of Environment; Ministry of Defense; Japan Aerospace Exploration Agency (JAXA); and National Institute of Information and Communications Technology (NICT) from the Japanese side, and the Departments of State, Defense, and Commerce; and National Aeronautics and Space Administration (NASA) from the U.S. side.

Through this Dialogue, Japan and the United States continue the work to enhance and strengthen cooperation between the two countries from a broad, inclusive, and strategic perspective. With the participation of experts from across the two governments, the Dialogue series emphasizes a whole-of-government approach to civil, commercial, and national security space interests and cooperation.

At this meeting, both sides provided updates on their respective space policies, including the recent revision of the Basic Plan on Space Policy on the Japanese side and the release of the Defense Space Strategy on the U.S. side. Both sides renewed their strong determination to expand bilateral cooperation in a variety of areas including space security, international rule-making, space situational awareness (SSA), space exploration, commercial space activities, and global navigation satellite systems and to seek opportunities for cooperation with third countries and in international fora. Both sides engage in robust bilateral cooperation in Earth observation, including weather forecasting, Earth science, land and ocean observation, and environmental and space weather monitoring. Together both sides also take lead roles in multilateral coordination of the global observing system. Japanese and U.S. weather and Earth observation satellite systems are essential components of the global observing system on which other nations rely. Both sides

also discussed other important issues regarding space utilization, such as space resources and the use of space for Maritime Domain Awareness. The United States welcomed Japan's effort to establish a new framework for satellite development and demonstration.

Both sides shared the view that it was important for leading spacefaring nations to promote bilateral and multilateral space cooperation with transparency and discussed possible ways for the two countries, with partners, to cooperate in expanding space activities and utilization to address the needs of other nations, especially in the Indo-Pacific region. Both sides recognized the role of space applications such as satellite-based Earth observation and navigation in the context of solving global issues including achieving the Sustainable Development Goals (SDGs). *www.state.gov*

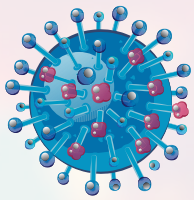
SkySat Constellation Complete by Planet

The world's largest fleet of high-resolution imaging satellites just welcomed three new satellites to the family. On August 18, 2020, SpaceX's Falcon 9 rocket launched SkySats 19, 20 and 21.

Over the next several weeks the SkySat satellites will use their onboard propulsion to boost themselves up to their operational altitude of 400 km, and also begin phasing their orbital plane with respect to SkySats 16-18 in order to maximize coverage and revisit. These three new SkySats join the 18 others already in orbit and significantly expand the capacity to provide world class, high-resolution images to a variety of commercial, governmental, academic and non-profit organizations.

SkySats 19-21 are also the final SkySats to be built and launched, completing the campaign of 21 satellites originally planned by the SkyBox team in 2009. Eleven years later, the innovation of the SkySat design and mission remains world-class and continues to move the high-resolution satellite industry forward. *www.planet.com*

Tracking COVID



Atkins predict digitally driven COVID recovery

Atkins – a member of the SNC-Lavalin Group – has shared the findings of its independent research, which assesses the impact of COVID-19 on the UK infrastructure sector, measures confidence, and explores the roles of government and the private sector during recovery.

The work – which was carried out by the independent market research organisation Savanta ComRes on behalf of the Atkins – represents the first comprehensive survey of senior public and private sector decision makers across different subsectors within infrastructure, particularly transport, property and utilities.

In total, 398 responses were completed via an online survey during June and July 2020 and 8 in-depth interviews were conducted.

The report, entitled "Infrastructure Insights: COVID Impact and Recovery", found that while the industry has been impacted by the pandemic – with organisations reporting that 16% of the work they had on immediately before Covid-19 had been postponed or cancelled completely – 52% of senior decision makers were confident that they would see outlooks for the sector return to pre-crisis levels by Q4 of 2021. In the private sector, almost 7 in 10 respondents predicted a return to their organisation's pre-crisis outlook before the end of next year.

There is general agreement that the sector will not emerge from the crisis in the same form, with the vast majority of respondents agreeing that digital innovation will be increasingly important. *www.atkinsglobal.com*

Telespazio and e-GEOS's platform for coronavirus

Using AI to integrate satellite data and knowledge from the online so as to isolate new outbreaks of Covid-19, while monitoring areas where people congregate. This is often ECO4CO – Earth Cognitive System for CoViD-19 – a platform created by Telespazio and e-GEOS (a company owned by ASI, 20%, and Telespazio, 80%), and winner within the Health Emergency category of the worldwide involve "Innovative Ideas and Technologies vs. COVID-19 and beyond", launched by the United Nations Industrial Development Organisation (UNIDO) in response to the coronavirus emergency. Telespazio and e-GEOS tied for the award with the Chinese company Shanghai Zhizhong Environmental Protection Technology.

ECO4CO systematically organises the skills and know-how of the entire Telespazio Group, and can correlate data from global observation and positioning satellites with non-satellite information from web searches and social network messages using artificial intelligence systems. In this way, using predictive analysis systems and autonomous acquisition of satellite data, as well as tracking and data learning ability, the platform supports systematic surveillance of areas of aggregation such as parks, public markets and sports stadiums, supplying data on human activity and on any possible gatherings. The information obtained can help isolate new outbreaks of the epidemic while monitoring places where people tend to concentrate. *www.telespazio.com*

GPS III successfully introduced into EGNOS services

Introduction of the first GPS III satellites into EGNOS services was successfully achieved on 27 July 2020, following the initiation by GPS of a transition from its "GPS Block II" satellites to its new generation "GPS Block III" satellites.

The GPS operational constellation started in 2020 to migrate from GPS II satellites to the new generation GPS III satellites. Through cooperation exchanges with the US, the European Commission and the European GNSS Agency (GSA) obtained assurance on the "backward compatibility" of the GPS III satellites with regard to GPS II, and in particular concerning their failure characteristics.

Based on this, the GSA developed a step-wise approach to accelerate the introduction of GPS-III into the EGNOS system, overwriting the initial plan for GPS III system qualification within EGNOS 242B System release development.

As a first step, the GSA implemented a fast-track process to be as quick as possible while staying safe and respectful of the roles and obligations of the Service Provider and of the Product manufacturer.

For this purpose, the GSA has organized and performed, with the support of the European Satellite Services Provider (ESSP), Thales Alenia Space France (TAS-F) and the European Space Agency (ESA), a careful safety assessment, based on design analyses and a dedicated ad-hoc measurement campaign. This has allowed the GSA to substantiate and approve the introduction of the first two GPS-III (PRN-4 and PRN-18) into the EGNOS Design Safety Case.

Based on this, ESSP submitted the proposed change, along with its safety assessment, to the EASA change oversight process, resulting in an authorisation from EASA delivered on 23 July 2020. Following this, ESSP upgraded the EGNOS operational baseline and the first two GPS III satellites were successfully introduced into the EGNOS Signal in Space on 27 July 2020.

The improvements brought to the EGNOS SoL service performance were already noticeable by the EGNOS users since that day.

The GSA is currently planning to extend its fast-track process in order to introduce these additional GPS III satellites into operations, until the delivery and entry into service of the next major System release (ESR 242A) in 2021 which will be also updated to GPS III. *www.gsa.europa.eu*

GPS M-Code Installs Complete at Operational Sites

The United States Space Force's Space and Missile Systems Center took a major step towards Operational Acceptance of the long awaited GPS Military-Code (M-Code) with the completion of the major M-Code Early Use (MCEU) hardware and software upgrade to the GPS Operational Control System (OCS) on July 27.

The encrypted M-Code signal enhances anti-jamming and anti-spoofing capabilities for the warfighter. M-Code signals are currently available on all 22 GPS Block IIR-M, IIF and III space vehicles currently on orbit. The installs were completed at the Master Control Station at Schriever Air Force Base, Colorado and Alternate Master Control Stations at Vandenberg Air Force Base, California. *us.af.mil*

New WAAS satellite launched

5 Flight VA253 was launched from the Guiana Space Centre, Kourou, at 2204 UTC on 15 August. The heaviest ever Ariane launcher carried 3 satellites, which included WAAS, to cover North America.

The WAAS satellite-based augmentation system (SBAS) is compatible with the European Geostationary Navigation Overlay Service (EGNOS), Indian GPS Aided Geo Augmented Navigation (GAGAN) and the Japanese Multi-functional Satellite Augmentation System (MSAS). All use a network of ground-based reference stations to determine real-time GPS errors, which are sent to master stations which relay correction messages via the SBAS satellites. The corrections are transmitted to receivers via GPS frequency and format. The FAA WAAS accuracy requirements (95%) for an aircraft instrument runway approach down to 200 ft - Localizer Performance with Vertical guidance (LPV-200) - is 16m horizontal and 4 m vertical; actual performance has been 0.7m horizontal and 1.2m vertical. *www.faa.gov*

GPS III SV03 receives operational acceptance

The United States Space Force (USSF) and the Space and the Missile Systems Center achieved another major GPS milestone on July 27 when the GPS III Space Vehicle (SV) 03 received USSF's Operational Acceptance approval.

The GPS III satellites are the newest generation built by Lockheed Martin that provide precise positioning, navigation and timing information with three times better accuracy, and up to eight times improved anti-jamming capability than previous generations of GPS satellites. This marks the third GPS III satellite to receive operational acceptance in less than a year.

SV03 was launched on June 30 and was the second National Security Space Launch (NSSL) mission launched on a SpaceX Falcon 9 rocket. This was the first NSSL mission where a Launch Service Provider recovered a booster, with SpaceX successfully recovering the first stage and fairings as part of the launch. The GPS III SV03 mission was dedicated to Colonel Thomas G. Falzarano, 21st Space Wing commander, who passed away in May. *us.af.mil*

Worldwide navigation declared for BeiDou

Chinese President, Xi Jinping, officially commissioned the system

on 31 July at a ceremony at the Great Hall of the People in Beijing.

The 55th and final satellite in the BeiDou constellation, launched on 23 June into geosynchronous equatorial orbit (GEO) at ~22,000 miles (~36,000 km), had completed all tests and been declared operational.

Hence the 3rd-generation BeiDou system (BDS-3), which began providing navigation services in 2018, has become operational worldwide. The final constellation comprises 27 medium earth orbit (MEO), 5 GEO and 3 inclined geosynchronous orbit (IGSO) satellites.

This should provide global navigation services similar to GPS, GLONASS and Galileo. It will use, amongst other transmissions, a frequency of 1575.42 MHz - the same as GPS L1 and Galileo E1 civil signals - and multiplexed binary offset carrier (MBOC) modulation, similar to the future GPS L1C and Galileo's E1. Satellite-based augmentation (SBAS) and SAR facilities are included. *https://apnews.com*

Galileo next-gen satellites on the horizon

Following the European Commission's decision to accelerate development of Galileo Next Generation, ESA has asked European satellite manufacturers to submit bids for the first batch of the Galileo Second Generation (G2) satellites. The new spacecraft are expected to be launched in about four years. The next-generation satellites will provide all the services and capabilities of the current first generation, together with a substantial number of improvements as well as new services and capabilities.

ESA is implementing a dual-sourcing approach, and two parallel contracts are expected to be signed around the end of 2020 amongst the current three bidders. Under the plan, each of the two selectees will build two satellites for development purposes, with options for up to 12 satellites in total.

The first satellites of the new constellation are foreseen for launch before the end of 2024, together with updated ground systems to support the new satellites.

These second generation satellites will gradually take over from the current first generation satellites in the provision of Galileo services, and will therefore at a future date constitute a complete constellation plus the necessary in-orbit spares.

ESA serves as the design, development and procurement agent for Galileo satellites on behalf of the European Commission, which funds the system overall. *www.esa.int*

New plan to enable GPS access in Sydney tunnels

Plans to boost GPS signals in Sydney's road tunnels are taking shape, which could help motorists, freight and emergency services navigate tunnels more accurately, quickly and safely.

Transport for NSW Deputy Secretary for Greater Sydney, Elizabeth Mildwater, said 'repeaters' are banned in tunnels but the Australian Communications and Media Authority (ACMA) is considering changing the law to let the technology be used.

"The freight industry – one of the primary users of tunnels – also uses GPS to actively provide information on tracking and on-board communication. With the delivery of major tunnel projects across Sydney like WestConnex, NorthConnex, M6 Stage 1, Western Harbour Tunnel and Beaches Link, it's important we act as soon as possible."

Transport for NSW has made a submission to the Federal regulator to install and trial re-transmission points inside tunnels to simulate satellite signals.

"Standard modern vehicles are equipped with more than 50 sensors, generating data referenced in time and space to a specific location," Ms Mildwater said.

GPS signals are a type of radionavigation-satellite service (RNSS). Re-transmission of RNSS signals are banned in Australia under the Radiocommunications Act 1992, due to the risk of interfering with other GPS signals. *www.transport.nsw.gov.au*

Navigation satellite next year by the UAE

The UAE has announced plans to develop and launch a navigation satellite in 2021, followed by the launch of a more advanced version the year after.

Funded by the UAE Space Agency, the project will be the first one to be carried out at the new Satellite Assembly, Integration and Testing Centre in Al Ain (AIT Satellite Centre).

The facility, which was launched in partnership with Airbus and Tawazun Economic Council, is located at the UAE University's National Space and Science Technology Centre (NSSTC) and aims to increase the nation's satellite development capabilities. The satellites are not meant to replace the existing Global Navigation Satellite Systems, which offers global coverage through four different versions operated by Europe, the United States, Russia and China, as well two regional ones owned by Japan and India. *www.thenational.ae*

FCC grants E9-1-1 Galileo request to AT&T

The U.S. Federal Communications Commission (FCC) granted a request on August 19, 2020 for authorization from AT&T Services to use Galileo for emergency location purposes. It plans to use Galileo in conjunction with GPS to improve the accuracy of its E9-1-1 location services on mobile devices, and facilitate faster response from emergency services when wireless callers dial 9-1-1. The request was approved by the FCC's Public Safety and Homeland Security Bureau. *https://docs.fcc.gov*

SUAVE clinches Smart City award

The Singapore Land Authority (SLA) is proud to announce that the Smart Unmanned Aerial Vehicle Enhanced (SUAVE) project has been chosen by IDC (International Data Corporation) Government Insights as the best Asia Pacific Smart City project under the "Urban Planning and Land Use" category of IDC's 2020 Smart City Asia Pacific Awards (SCAPA).

SUAVE is a machine learning algorithm that analyses images captured by drones to automatically identify building defects requiring maintenance. Together with the "SmartLAMD" app that was developed by SLA, SUAVE helps to maintain and improve building conditions through the early identification of potential maintenance issues, from cracks and debris to water ponding and even plant growth, thus enabling the speedy handling of these minor issues.

At the same time, SUAVE provides tremendous time and cost savings. Officers now use only 12.5% of the original conventional inspection time to review and address potential maintenance issues. Aside from saving time, SUAVE has also significantly reduced inspection and repair costs. Deploying drones for building inspection only uses 60% of the cost required for a conventional physical inspection that uses boom lifts. *www.sla.gov.sg*

Phase One Industrial and Acecore partnership

Phase One Industrial has signed an agreement with Acecore Technologies.

Phase One Industrial developed the iXM series cameras for UAV-based aerial imagery. The iXM 100MP and iXM 50MP are high-productivity metric cameras with a range of specially designed RSM lenses. The iXM cameras are ready for easy integration with a wide range of UAV platforms.

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, offering fast and efficient, simple, and reliable UAV solutions. *www.acecoretechnologies.com*

Department 13 successfully deploys MESMER C-sUAS platform

In July of 2020, Department 13 successfully completed onsite field testing and training to officially deliver the latest deployment of its counter drone technology MESMER to the Indian government. Its Indian based distributor, Shastra Corporation, successfully tendered to supply the Indian government with Department 13's C-sUAS platform MESMER and provided rigorous infield testing and compliance to exceed approval requirements from industry and government regulators. *https://department13.com*

L3Harris Technologies awarded contract from US Navy

L3Harris Technologies has received a contract from the U.S. Navy for the Medium Unmanned Surface Vehicle (MUSV) program. This is the Navy's first program for an unmanned surface vehicle to support the Navy's Distributed Maritime Operations strategy.

L3Harris will integrate the company's ASView™ autonomy technology into a purpose-built 195-foot commercially derived vehicle from a facility along the Gulf Coast of Louisiana. The MUSV will provide intelligence, surveillance and reconnaissance to the fleet while maneuvering autonomously and complying with international Collision Regulations, even in operational environments. *www.l3harris.com*

Valqari introduces the Drone Delivery Station

Valqari, the Chicago start-up that solved the last inch logistics problem with its patented universal drone delivery infrastructure, has launched its largest solution to date with the Drone Delivery Station. This new technology offers a safe and convenient landing station with six separate storage units to accommodate multiple drone and traditional deliveries or pickups. The drone delivery station also maintains a digital chain of custody throughout the entire delivery process to give users peace of mind knowing their packages are secure until retrieved. *www.valqari.com*

Europe's largest drone hub in Rotterdam

Terra Drone invests in Dutch Drone Solution provider Skytools to offer corporate and government clients with advanced drone solutions. The companies will together establish a strong drone hub in Rotterdam consisting of Training facilities and Research & Development centers.

Terra Drone Corporation is announcing the completion of its investment in Skytools, a leading Dutch company that provides advanced drone solutions to corporate and governmental clients. *www.terra-drone.net*

FLIR Systems introduces Vue TZ20 dual thermal camera drone payload

The FLIR® Vue® TZ20 is the first high resolution, dual thermal sensor gimbal built for the DJI® Matrice V2 200 Series and Matrice 300 airframes. It gives drone pilots the situational awareness they need to complete their missions.

Featuring both a wide-angle Boson sensor with a 95-degree field of view and a narrow-angle Boson with a 19-degree field of view, the Vue TZ20 enables pilots to put more pixels on target with ease. With 640x512 resolution and a 20-times digital thermal zoom capability, pilots can safely capture thermal data from a distance. The payload is IP44 rated to provide operability in poor weather conditions and weighs just 640 grams (1.4 lbs.). *flir.com*

Gaode introduces AR driving navigation feature

AutoNavi has developed a navigation app called Gaode, which is one of the first apps to provide drivers with AR navigation. Using the camera phone, Gaode looks at the road ahead and displays the relevant information, including navigation instructions, highlights signs and issues warnings all in real time.

The new AR feature recognizes objects in the surrounding environment, including passing vehicles, pedestrians, lane lines, traffic signs and traffic lights, according to the company. The feature also has driving safety assistance, which offers vehicle distance monitoring and warnings for things ahead like potential collisions, traffic lights and pedestrians.

GeoSpace Labs releases new fleet command cloud platform

GeoSpace Labs has announced the general availability of its new Fleet Commander cloud back office platform. It provides j1939 and j1708 data updates every 15 seconds to back-end office users, completely visualized and geospatially encoded. This will mean a fleet manager can make decisions in PERFECT REAL TIME using knowledge of every aspect of a nationally distributed fleet of vehicles and driver hours of service legal requirements including over 100 onboard computer parameters (this is more real-time decision making data provided faster than most air traffic controllers have available). Further, the historical data streams are stored in cloud data array for deep analytics going back 6 months.

The new Fleet Commander platform also provides real-time weather data fully integrated into the fleet geospatial views, so multiple data points are available when dispatching. This includes the exact operating status of power units and associated trailers and chassis, any reported suspect codes from the power unit engines onboard computer, the drivers exact working status like how many hours driven and how many hours legally remaining to drive, the fuel status of the vehicle, weather conditions for the entire trip, and customer geospatial coordinates. *https://geospacelabs.com*

DPL Telematics launches AssetView Max Tracking System

DPL Telematics has announced the release of the AssetView Max Tracking System. It is an advanced solution for wireless monitoring and remote tracking of any powered or unpowered asset to improve logistics, manage inventory and curb theft. The long lasting, portable GPS unit is completely self-contained and may be hidden on any asset, installing in seconds. Its proprietary TruTrace Adaptive Tracking technology increases its reporting frequency when movement is detected and automatically reduces it when stationary. *http://www.dpltel.com*

Semtech collaborates with AWS and TensorIoT

Semtech Corporation has collaborated with Amazon Web Services (AWS) and TensorIoT to simplify Internet of Things (IoT) solution development by offering Asset Tracking and Smart Building Kits that integrate Semtech's LoRa® devices and the LoRaWAN® protocol with AWS IoT services. Systems Integrators and Enterprises are now able to use AWS IoT services to accelerate the pilot-to-production lifecycle for their digital transformation applications, while leveraging key AWS native services, such as AWS IoT Core, Amazon API Gateway, AWS Lambda, Amazon CloudFront, Amazon Simple Storage Service (Amazon S3), and Amazon DynamoDB. The new Asset Tracking and Smart Building Kits are the first vertical product offerings based on the LoRaWAN protocol built using AWS IoT Core and a serverless architecture. In combination, these offerings pave the way for other industry verticals such as utilities, smart home, smart community, and smart healthcare to provide similar solutions that benefit from long range, low power IoT capabilities that LoRaWAN provides. *www.tensoriot.com, www.semtech.com*

GNSS RTK rover with Visual Positioning

Leica Geosystems, part of Hexagon, unveils the Leica GS18 I a versatile, GNSS RTK rover with Visual Positioning. It 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. It 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 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.

Combining the accuracy and speed of the Spectra® Focus® 35 robotic total station with the simple workflows of Aplitop TcpTUNNEL, running on the ST10 or Ranger 7 data collector, enables tunnel surveyors to perform excavation control, automated survey and stakeout of tunnel cross-sections. *www.spectrageospatial.com*

Sony to release high-precision GNSS receiver

Sony Corporation has announced the upcoming release of high-precision GNSS receiver LSIs for use in IoT and wearable devices. The new receiver

LSIs boast the industry's lowest power consumption*1 for dual-band positioning operation—only 9 mW.

Increasing use of IoT and wearable devices that utilize location information has resulted in growing demand for GNSS receiver LSIs. Precise positioning and reliable communications must be ensured to maintain proper operation of IoT and wearable devices, which are being used even in difficult communication environments and unstable conditions, such as multipath propagation situations caused by reflection off the ground or nearby buildings or the effects of the swinging of the arms when attached to a person's wrist.

The new LSIs support not only the conventional L1 band reception, but also L5 band reception, which is currently being expanded across GNSS constellations, thereby making them capable of dual-band positioning. *https://presscentre.sony.eu/*

Spirent introduces SimIQ to Accelerate GNSS Product Evolution

Spirent Communications plc has announced the release of SimIQ, a new software that will allow for earlier and more efficient GNSS testing during product development. From software-in-the-loop through to final form testing, it enables developers to collaborate across the full design lifecycle through the creation, sharing and replay of I/Q data files.

SimIQ has been developed to meet the growing need to test GNSS capabilities earlier to accelerate product development, while simultaneously reducing costs by identifying issues prior to the purchase of hardware components. It extends multi-frequency, multi-constellation simulation capabilities to cover software-only testing needs through the capture and replay of high fidelity I/Q data files.

SimIQ will be available to new and existing customers beginning in Q4 2020. *www.spirent.com*

VectorNav introduces New Miniature IMU and GNSS/INS product line

VectorNav Technologies have introduced a groundbreaking new line of inertial products: the VectorNav Tactical Embedded. Featuring a tactical-grade IMU and a multi-band GNSS receivers, it delivers milliradian attitude accuracy and centimeter-level positioning capability in a miniature 15 gram package.

VectorNav's Tactical Embedded line delivers unprecedented size to performance and enables cost reductions for a wide range of autonomous pointing and geo-referencing applications, such as gimballed ISR, SATCOM systems, LiDAR mapping and photogrammetry, among many others. *www.vectornav.com*

Cyient to Acquire IG Partners

Cyient, a global engineering and digital technology solutions company, has agreed to acquire specialist Australian consulting firm, IG Partners, to expand its end-to-end offerings for the local and regional resources sector.

The partnership will enable the development of a unique customer proposition that allows its customers to take full advantage of the growing convergence between operational and information technologies. *www.cyient.com*

HUBER+SUHNER launches new SENCITY® PTC antenna

HUBER+SUHNER has launched its new SENCITY® PTC Antenna which boasts the highest number of heavy-rail certifications in the industry. Deployed throughout the USA, PTC (Positive Train Control) systems are designed to monitor and, if necessary, take control of railway vehicles to provide railway operators with increased safety.

The new Antenna offers advanced features such as high voltage and high current protection, added protection for the antenna and RF path from catenary line strikes which can destroy electronic devices. The antenna meets the highest requirements for mechanical robustness and fire safety according to the EN 50155 and NFPA-130 standards. *hubersuhner.com*

New evolution of its flagship GNSS solution by Trimble

Trimble has introduced the Trimble® R12i GNSS receiver, the latest addition to its GNSS portfolio. It incorporates Inertial Measurement Unit (IMU)-based tilt compensation using Trimble TIP™ technology, which enables points to be measured or staked out while the survey rod is tilted, empowering land surveyors to focus on the job at hand and complete work faster and more accurately.

Designed with flexible signal management that enables the use of all available GNSS constellations and signals, the Trimble ProPoint GNSS engine provides new levels of reliability and productivity. In addition, the ProPoint engine is a key enabler of the new TIP technology. Surveyors can continue to use the R12i's tilt compensation functionality even in challenging environments when other solutions struggle to maintain GNSS and inertial positioning. *https://R12i.trimble.com*

Elevate your performance with UltraMap 5.0

Vexcel Imaging has released UltraMap version 5.0, the latest update of its all-in-one aerial photogrammetry software featuring comprehensive DTM generation and full integration of Ortho Production in UltraMap Studio.

With the introduction of a completely new Digital Terrain Model (DTM) algorithm based on automatic semantic image segmentation and intelligent filtering, UltraMap 5.0 now generates comprehensive DSMs and DTMs for export at unprecedented quality. Additionally, several new features have been implemented to facilitate and speed up the data production process. From simultaneous DSM and DTM editing in

one interface and simple re-processing for ortho products, to the full integration of Ortho Production in UltraMap Studio and new quality control tools like visualization of non-ground objects: Customers gain the best possible insight and control over their data throughout the entire value chain to create 3D spatial data products that meet the highest photogrammetric standards. *www.vexcel-imaging.com*

Applanix introduces next generation OEM solution

Applanix has introduced the Trimble® AP+ Air OEM solution for Direct Georeferencing of airborne sensor data. The solution enables users to accurately and efficiently produce maps and 3D models without the use of ground control points. It is a powerful solution for manned platforms yet small enough for use on Unmanned Aerial Vehicles (UAVs). It is also compatible with virtually any type of airborne remote sensor, including photogrammetric cameras, LiDAR, hyper and multi-spectral cameras, and synthetic aperture radar. *www.applanix.com*

New version of Quadri by Trimble

Trimble is introducing a new version of its Quadri cloud-based BIM server and collaboration platform. This solution will offer an innovative common data environment platform for infrastructure projects specifically to the European market.

Quadri now promotes both open formats and third-party software in a bi-directional workflow. Planners, designers and contractors can use their preferred engineering software and add a shared, live project model. The open formats software also allows project owners to see abreast of their project through an equivalent model. All changes in a project are tracked including change history. Quadri will be now offered as a software-as-a-service solution for model and issue management, bundled with Trimble's file data management system, Trimble Connect. *www.trimble.com*

Atmospheric monitoring and earth observation microsatellites

Space Flight Laboratory (SFL), a developer of 52 distinct microspace missions, has announced the successful launch and deployment of the GHGSat-C1 greenhouse gas monitoring microsatellite and the Slovenian NEMO-HD Earth observation microsatellite. SFL developed the small satellites at its facility in Toronto.

Established at the University of Toronto Institute for Aerospace Studies (UTIAS) in 1998, SFL has developed CubeSats, nanosatellites, and microsatellites that have achieved more than 126 cumulative years of operation in orbit. These microspace missions have included SFL's trusted attitude control and, in some cases, formation-flying capabilities. Other core SFL-developed components include modular (scalable) power systems, onboard radios, flight computers, and control software.

GHGSat Inc. awarded SFL the development contract for GHGSat-C1 ("Iris") after building the pathfindingGHGSat-D ("Claire") microsatellite launched in 2016. Using high-precision target tracking capabilities developed by SFL, Claire successfully demonstrated that sources of methane and other gas emissions could be detected and measured from space. SFL is currently developing another microsatellite, GHGSat-C2, for the company. *www.utias-sfl.net*

MyGalileoSolution competition

The European GNSS Agency (GSA) launches the #MyGalileoSolution competition. The contest is targeting European innovators and entrepreneurs ready to develop location-based solutions, such as mobile applications, wearable-based solutions, asset management and tracking solutions, or robotics, leveraging Galileo as a source of positioning, navigation and/or timing. A wide participation from all Member States is expected.

GSA has a successful track record in supporting and boosting GNSS-based innovative applications. For years the Agency has been leading several research and innovation initiatives such as the Galileo Masters, Horizon 2020 projects, and more recently European competitions like the 2019 MyGalileoApp and Hackathons across Europe and beyond.

With a prize pool of almost € 1.5 million, MyGalileoSolution is the largest competition ever organized by the GSA. It consists of two independent and parallel tracks, each one with a list of goals and deliverables. Track 1 - From Idea to Prototype – aims to develop a beta version of an application or a prototype of a solution implementing an idea, reaching minimum 50 % of its functionality. Track 2 -From Prototype to Product – aims to develop a fully functional solution ready to be commercialised starting from a beta version of an application or a prototype. *www.gsa.europa.eu*

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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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