RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 27th/28th of every month at DPSO

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

www.mycoordinates.org

Coordinates

ISSN 0973-2136

Volume XVIII, Issue 1, January 2022

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Drones reducing workplace hazards

3D mapping systems

Technology Trends

Metaverse v/s Omniverse

Augmented positioning services

FPGA implementation of a NavIC-disciplined 10MHz reference

Leica TS01
Business smart entry to Leica Geosystems' Total Stations

The Leica TS01 total station , designed specifically for India market, empowers you to carry out measurement tasks with ease and simplicity. The TS01 is an entry-level manual total station, created to help you master surveying, layout and mapping projects. Powerful built-in sensors, as well as intuitive field software, empower you to complete tasks without any delay. Leica Geosystems' highly qualified after-sales service and support network will help you manage any issue to continue work quickly.

Find out more about TS01:
https://leica-geosystems.com/en-in

Contact us: **info.india@hexagon.com**

PART OF HEXAGON

Leica Geosystems AG
leica-geosystems.com

- when it has to be **right**

Leica Geosystems

HERON®

Beyond Mobile Mapping

HERON family

INDOOR/OUTDOOR
Wearable or handheld mobile laser scanner. Versatile and suitable for any environment.
Your unmatched SLAM-based solution!

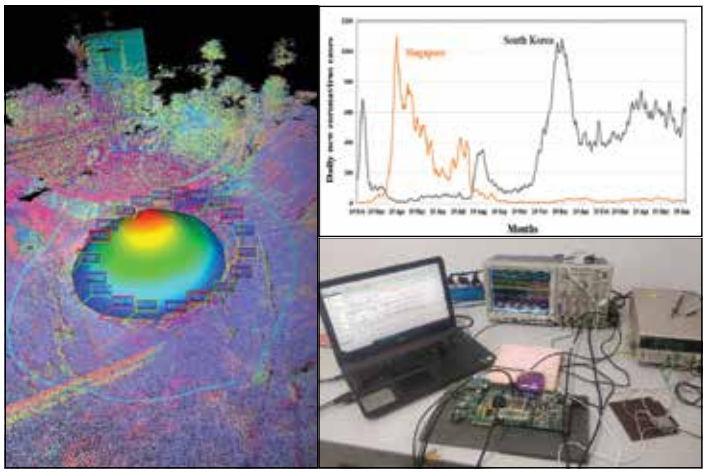
AUTOMATIC
Turn on the system and start surveying. Just walk and leave the scanner working for you.
Enjoy a professional system easy-to-use!

COMPLETE DATA
3D point clouds and 5k pano images to gather both geometry and color information at once.
The scanner you can no longer give up!

ALL-IN-ONE
Full post-processing software included. Third-party compatibility provided.
A forefront technology at your fingertips!

| www.gexcel.it | sales@gexcel.it

GEXCEL



In this issue

Coordinates Volume 18, Issue 1, January 2022

Articles

Columns

This issue has been made possible by the support and good wishes of the following individuals and companies
Aditi Verma, Aosenla Pongen, Arun Kumar Verma, Giorgio Vassena, Graeme Hooper, Guy Buesnel, James Rennie, K Shahana, Kriti Khatri, M R Sujimol, Resenmenla Longchar, Urvashi Bhat, Volker Janssen and Wapangsenla Imchen; Gexcel, Labsat, Leica, SBG System, and many others.

Mailing Address
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.
Phones +91 11 42153861, 98102 33422, 98107 24567

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

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

Printed and published by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
Published at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.
Printed at Thomson Press (India) Ltd, Mathura Road, Faridabad, India

Editor Bal Krishna
Owner Coordinates Media Pvt Ltd (CMPL)

This issue of Coordinates is of 40 pages, including cover.

SBG SYSTEMS

0.05° ATTITUDE | 0.02° HEADING | 1 cm POSITION

NEW ELLIPSE-D

The Smallest Dual Frequency & Dual Antenna INS/GNSS

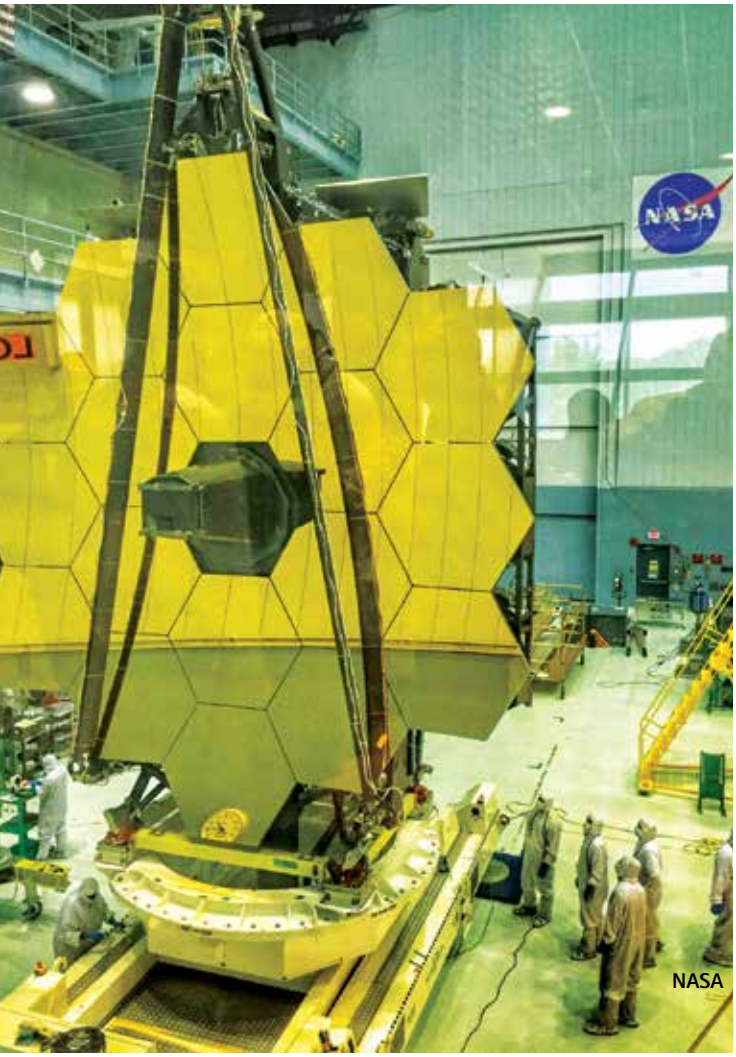
- RTK Centimetric Position
- Quad Constellations
- Post-processing Software

Ellipse-D
RTK Dual Antenna

Ellipse-N
RTK Single Antenna

OEM
RTK Best-in-class SWaP-C

Visit our website: **www.sbg-systems.com**



James Webb Space Telescope

The telescope,

A joint international collaboration led by NASA in partnership with the European and Canadian space agencies,

Developed at a cost of $8.8 billion,

Was successfully launched on 25th December 2021.

Unlike its 30-year-old predecessor, the Hubble Space Telescope, operated primarily at optical and ultraviolet wavelengths.

Webb mainly will view the cosmos in the infrared spectrum.

Equipped with primary mirror consisting of 18 hexagonal segments of gold-coated beryllium metal,

Webb is expected to provide the glimpse of cosmos just 100 million years after the Big Bang, an event estimated to have occurred around 13.8 billion years ago.

This giant leap of the technology will further unravel many mysteries of the universe like formation and the evolution of the galaxies,

It is also a testimony about us – the humankind.

Bal Krishna, Editor
bal@mycoordinates.org

Let the Metaverse v/s Omniverse race begin!

Graeme Hooper
Managing Director, GPSat Systems Australia

With the dual announcements in late 2021 by arguably the technology world's two biggest heavyweights, both declaring big future investments in 3D Virtual and Augmented Reality (VR and AR), confirms we live in interesting times. Initially, Facebook announces the company name change to META, with the promise of employing many thousands of engineers worldwide to deliver this vision. While NVIDIA, provided greater detail on their future Omniverse aspirations through new accelerated 3D AI and Quantum Computing product offerings, to support growing industrial 3D VR/AR applications.

While Facebook is a well-known name, however, unless familiar with electronics, NVIDIA is less known. But that doesn't mean they are not significant, as most computers employed in the geospatial sciences industries heavily rely on the amazing parallel processing Graphics Processing Units (GPUs) ICs, that power the modern "GeForce" graphics cards and many consumer 3D gaming consoles.

Metaverse/ Omniverse (MO) – The difference.

It seems the Metaverse will be a place where people can interact, work and create a cyberspace future that exists in parallel with life in the physical world. META expects it to reach a billion people within the next decades. While Omniverse focuses on the industrial world, moving towards cyberspace digital transformations for lower transaction costs and higher efficiencies. A new world populated by industrial Digital Twins (DT) autonomous robots, governed by high fidelity virtual 3D environments with all the constraints and details of the real world physical space, which is a sort of Metaverse in itself.

So, emanating from these two significant announcements several questions quickly arise;

What does this mean for the Geospatial Sciences & Navigation (GS&N) industry futures and which new technologies, innovations or capabilities will be required to deliver MO's new extreme frontiers? The answer, current solid growth will definitely continue, however, growth may quickly transition to explosive, fuelled by new extreme levels of financial investments by companies like META and NVIDIA delivering into future AR/ VR ecosystems. Visualisation display technologies, along with navigation and 3D perception sensors (LIDAR/ RADAR), artificial intelligence and Digital Twins, are all essential ingredients to these new virtual worlds yet to be created.

As modern internet races towards a MO future, GS&N industry's challenge will to be adequately satisfy the anticipated huge demand for high fidelity 3D digital twins. Both for static cities environments and landscapes, while also, for 3D scaled model avatars of movable objects such as people, machinery, etc.

The required technologies, such as, phased array radar, advanced weak signal processing and Time Difference of Arrive, etc, have existed for many decades in other RF disciplines. However, other than GRIFFIN projects none of these have ever been migrated across to GNSS spectrum protection missions. This "do-nothing" GNSS spectrum policing mindset needs to change.

As modern internet races towards a MO future, GS&N industry's challenge will to be adequately satisfy the anticipated huge demand for high fidelity 3D digital twins. Both for static cities environments and landscapes, while also, for 3D scaled model avatars of movable objects such as people, machinery, etc. Then, very quickly fuse/ blend both the underlying 3D navigation and perception sensor real time data, with the digital twin spatial avatars, all in interactive AR/VR immersive 3D-MO environments. The futuristic 3D immersive technologies imagined by the Avatar movie, are now not that far off.

What will future Omniverse industrial customers be looking for in 2022?

The rollout/ push for improved automation in safe and sustainable ways for delivering increases in productivity, while producing better outcomes for the environment is expected to their highest priorities. GNSS as the most versatile outdoor navigation and absolute positioning sensor has a very significant contribution/ role to play in this area. However, with automation comes with very substantial legal responsibilities that all systems be developed and tested to the highest industrial safety integrity standards. For Australian industry AS61508 or similar, are the standards that govern the formal certification of GNSS sensors in machine automation safety critical applications. These are complex and very arduous standards to meet, and so, to move certified GNSS enabled automation solutions forwards, our customers expect all potential GNSS issues comprehensively addressed, including spectrum protection.

Developing new MO solutions – Challenges/ Opportunities for the GS&N industries

The early immersive navigation MO facilitators will certainly be those mission critical GNSS users in aviation, mining, marine and agriculture where the adoption advantages are hugely beneficial. Consequently, for these same users any GNSS navigation signal failures or interruptions produce potential outcomes that are usually quite dire. These clients are looking for practical solutions to both quickly detect GNSS signal issues and very accurately geolocate the RF interference source. With solutions like GNSS Rf InterFerence FINder (GRIFFIN), effective regional GNSS spectrum protection is now a reality. The challenge for the different GNSS industries is to both plan and regionally deploy effective solutions that ruggedises regional GNSS environments. For example, huge nationwide mobile phone tower infrastructure could be progressive made dual purpose with the addition of GNSS spectrum monitoring/ protection type technologies.

Risks to effectively facilitating new MO avatar future

Fortunately, the modern internet has for decades been a wonderful tool to globally share information. However unfortunately, there has been huge growth in shared mis/dis information deliberately spread to cause confusion and undermine trust in governments or institutions. This cyber cancer is expected to mutate into future MO avatar applications also. For the navigation technologies, the GNSS industry needs to adopt a different philosophical mindset with regards to GNSS technology resiliency. Rather than solely focusing on enhanced receiver senor technologies attempting to avoid RF interference, which is some regards is a pointless exercise, extra R&D technologies should be applied to actively monitor and interdict in regional GNSS spectrum issues. The required technologies, such as, phased array radar, advanced weak signal processing and Time Difference of Arrive, etc, have existed for many decades in other RF disciplines. However, other than GRIFFIN projects none of these have ever been migrated across to GNSS spectrum protection missions. This "do-nothing" GNSS spectrum policing mindset needs to change.

Priorities for 2022

At a global level, humanity's two current massive challenges are to concurrently deal with both COVID19 and Global Climate Change. Going forwards, both have the potential to adversely affect future populations in many profound undesirable ways. However strangely both these catastrophes are closely related, and whereas, future MO technologies offer significant panacea solutions to both. A future world where MO is globally prevalent and available to all. Delivering a better "connected world" whereby, populations are less dense, the need/ desire for travel is less and industry is operating far more efficiently, with substantially less waste.

The dominant 2022 priority for the GS&N industries must be to embrace MO technologies and to facilitate the Avatar movie's visionary MO world as quickly as possible.

5 ways drones are improving workplace safety standards

James Rennie
Director & CEO, AUAV

A site safety inspection often entails proximity to dangerous sites, working at great heights, and operating in confined spaces. This may cause worker health and safety risks across industries such as manufacturing, construction, mining, and roof inspections due to slips, trips, falls, electrocutions, and other injuries.

In such circumstances, drones or unmanned aerial vehicles (UAVs) have emerged as workplace safety heroes as they can capture and provide visual insights on a site's physical condition before an operator decides to send their team up a roof or close to a perilous site.

Want to know how exactly these small flying machines can reduce workplace hazards and save hundreds of lives every year? Read on to find out.

Secure inspection and monitoring at construction sites

Drones in construction have come a long way. For example, before the actual construction starts, drone inspection for the entire site, using near- and far-infrared cameras, 3D mapping software, and laser range finders to ensure that the next project phase can proceed smoothly.

As opposed to a human-led site survey, drones can complete the pre-construction site inspection in a short period.

Drones for construction sites can make all the tasks easier and safer such as monitoring workers laying the foundation or atop scaffoldings, site security surveillance, and generating progress reports. Field workers can get real-time video footage using UAVs without venturing into dangerous areas on the site. Thus, commercial drones can eliminate the risk of falling from heights while performing structural maintenance inspections.

Reduction in workplace fatality rate

According to the Bureau of Labour Statistics (BLS), there were 4,764 fatal work injuries recorded in the U.S alone in 2020. Almost half of them were in construction and transportation operations.

Why waste precious lives when you can get drones to do all the treacherous work? Not only do drones capture images of job sites and access areas with hazardous materials, but they also ensure that projects stay on track in terms of budget and deadlines.

Improved safety at mining sites

It is unsafe for a human inspector to enter every part of the mine given how small, dark, and dangerous it could be. Therefore, drones are an excellent solution as they can produce digital terrain models that give operators a better perspective of the site.

Today, UAVs come with advanced technologies like AI and VR which allows operators to take a virtual tour of the site remotely. GPS may not be available underground, in which case, the SLAM (simultaneous localization and mapping) system in drones comes in handy.

Protection from hazardous substances and radiation

Drones can alleviate workplace injury and illnesses by reducing exposure to toxins and radiation. A great example of this is when drones were used to explore the disaster site at Japan's Fukushima Daiichi Nuclear Power Plant in 2011. The task of collecting vital information for managing the disaster would have been too dangerous for humans due to high radiation levels. Enter UAVs that helped the first responders in creating disaster maps from a safe distance and also delivering essential supplies to people in need of assistance.

Low-risk surveillance of power lines

Maintenance of the lines that transmit electricity to our homes and businesses requires a crew to check for possible damage, branching, or vegetation that could knock the lines down. Using drones to perform this task eliminates the risk of working with high voltages and heights. Drones can also reduce the time and cost required to do the job.

Prioritizing work health and safety involves protecting the employees from workplace accidents, injuries, and illnesses. Using drones not only creates a safe workplace, but also reduces costs, downtimes, and absenteeism which in turn boosts productivity and employee morale.

With these advantages, drones are sure to become as common as cranes and backhoe loaders in the future!

Technology trend in 3D mapping systems for mining

Prof. Giorgio Vassena
CEO, Gexcel Srl.

Three-dimensional surveying technologies adopted in the mining and quarrying industry offer great benefit to the management of these production sites.

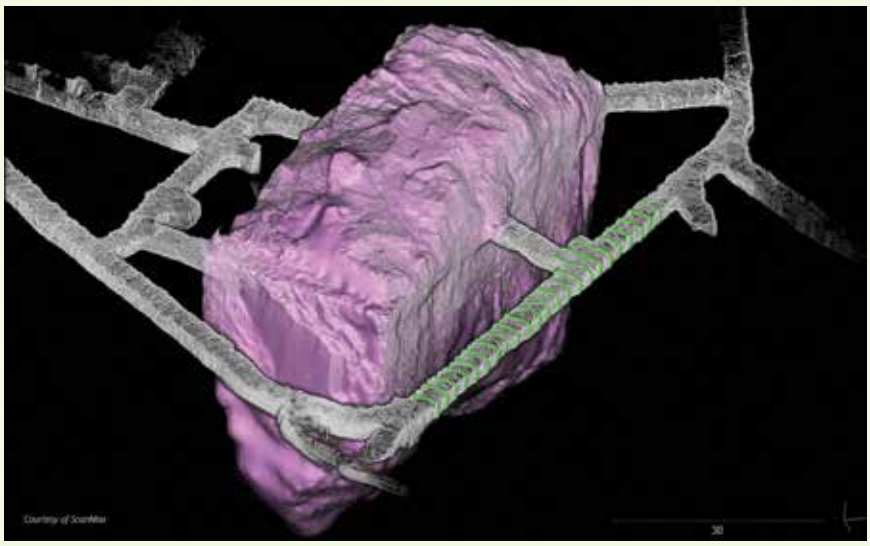
To date, the most popular instruments for 3D data acquisition have been mainly terrestrial laser scanners (TLS), based on LiDAR technology, with very high accuracy (2-3 mm). Unfortunately, the time required for data acquisition and post-processing, as well as the need to often use targets for scans relative alignment, have limited their uptake in the mining field. Besides, performing static scans into operating mines can be critical for accessibility, interference with normal excavation and transport activities, as well as for surveyors' safety during the acquisition.

The introduction of SLAM-based indoor mobile mapping (iMM) systems is revolutionizing this scenario, promoting greater adoption of 3D surveying technology in this area as well.

As everyone probably knows, the iMM concept involves surveying indoor areas with an instrument equipped with a multi-beam LiDAR sensor coupled with an inertial system, all managed by a simultaneous localization and mapping (SLAM) algorithm that calculates the surveyor's trajectory and generates the accumulated registered 3D point cloud of the surveyed area. A critical aspect of this technology is the accuracy, considering that multi-beam sensors typically provide around 2-3 cm and, for several purposes, this still represents a sort of limit. But not for mining applications where such level of accuracy is more than sufficient, as they do not need the precision and resolution provided by TLS systems. On the contrary, iMM systems allow for greater survey efficiency, with a drastic reduction in data acquisition and processing time, resulting in lower overall survey costs.

These 3D mapping systems are profitably used in various applications, both in traditional and new industries. These undoubtedly include surveying activities in deep mines to estimate the volumes of material extracted, i.e., for what is known as production progress mapping.

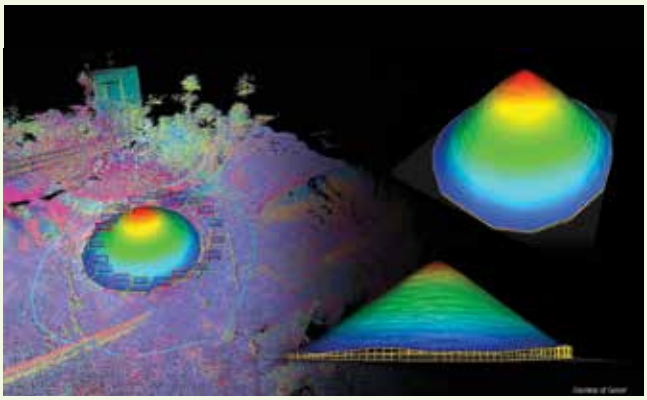
When the survey must also produce the 3D geometry of the underground mine, with expected accuracy of 10-20 cm, it is necessary to constraint the survey to topographic control points surveyed with a total station and by means of benchmarks generally placed on the vault of the mine tunnel. But even in this case, the overall productivity advantages of the SLAM approach are not lost.



Another relevant feature of SLAM technology especially in this area is the ability of some of these systems to be vehicle mounted. This allows surveys to be carried out at speeds of 15-20 km/h in excavation tunnels, further increasing productivity compared to standard procedure, which usually requires the operator to wear the instrument like a backpack or hold it in his hand.

The versatility of iMM systems allows us to take advantage of them in different mining needs, for example, to survey vertical shafts that often require a 3D mapping to verify the erosion of walls, to update dimensions, to perform clash detection analysis

and more. Compared to the existing technologies, the SLAM systems are dramatically faster and almost every site can be mapped ensuring surveyors with a high level of safety.



The iMM approach is also particularly flexible: the instrument can be used both in extreme situations, such as inside deep mine tunnels, but also to calculate volumes of material stored outdoors in open storage areas. In open-pit quarries and for stockpiles estimation, the use of drones for surveying based on the photogrammetric approach is becoming increasingly popular. The iMM approach integrates well with this technology and is primarily used when the stockpiles are inside sheds or when there are only a few piles to map and therefore the drone approach is not productive enough due to the limited mapping area to be investigated.

In conclusion, all the features described – the ease of use, the speed of data acquisition and processing, the versatility and productivity of the system – are undoubtedly the characteristics that justify the successful use of iMM technology for 3D mapping in the mining industry.

High-accuracy augmented positioning services will become the new normal

Guy Buesnel
PNT Security Technologist, Spirent

The need for better positioning authentication and proof of location.

There is a growing focus on the integrity of GNSS data. New message authentication schemes like the Galileo Open Service Navigation Message Authentication (OSNMA) and the CHIMERA authentication scheme being developed for GPS will allow user equipment to differentiate between authentic and fake Galileo and GPS signals.

In their efforts to reduce carbon footprint and verify the provenance of goods (identifying illegal fishing, for instance), the supply chain sector will be looking to authentication technologies like these to provide reliable proof of position - as well as to enable more efficient trajectories.

High-accuracy augmented positioning services will become the new normal

In 2022, we will see new efforts from chipset providers and OEMs to offer high-accuracy augmented positioning services to enable centimetric accuracy. This will also help to improve the reliability of PNT signals for a variety of applications, including surveying, mapping, precision agriculture, asset management, UAV, construction, robotics, and more—applications that traditional GNSS is just not accurate enough to support.

Week number rollover fallout will continue

We will continue to come across Week Number Rollover incidents and reports in 2022. Whilst the event was known about and oh-so predictable - on 6th April 2019 the GPS satellite system reached the end of its second epoch, with the 10-bit week number encoded in its data stream resetting from 1,024 to zero, and a number of systems encountered problems on the date of the rollover. And there are more to come.

This is because some manufacturers have squeezed more lifespan into their receivers by using pivot dates to start counting the 1,024 weeks from the date the firmware was compiled, rather than from the first day of the second GPS epoch – meaning that more Week Number Rollover issues will come to light during this coming year. It's very simple to test for Week Number Rollover issues using a GNSS simulator, helping to prevent any undesired behaviour in time-dependent systems.

Geo-spatial big data analysis of Covid-19 spectrum envelope of first and second wave of the outbreak in the SE Asian region

This spreading of the spectrum caused marked variations in population mortality between different countries depending upon Covid-19 spectrum envelope characteristics with its spectrum peak height and width, existing healthcare infrastructure

Wapangsenla Imchen
ICFAI University Nagaland (IUN), Dimapur, India

Aditi Verma
Qualcomm India Pvt. Ltd, Raheja Mindspace IT Park, Madhapur, Hyderabad, India

Dr Resenmenla Longchar
ICFAI University Nagaland (IUN), Dimapur, India

Aosenla Pongen
ICFAI University Nagaland (IUN), Dimapur, India

Dr Arun Kumar Verma
Vice Chancellor, ICFAI University Nagaland (IUN),Dimapur, India (Former Senior Scientist, Defence Research Development Organisation)

Abstract

The outbreak of Covid-19 emerged from Wuhan, China during December 2019 and spread geo-spatially in more than 200 countries causing more than 182.969 million people of the global population infected and 3.963 million deaths (as on 30 June 2021), which is still spreading in geo-spatiotemporal way with multiple peaks of Covid-19 spectrum. This has seriously threatened the human health and life of the people posing the challenges to control the severity due to multiple peaks of Covid-19 spectrum observed during the pandemic period.

The spatial spreading of covid-19 spectrum due to large-scale migration from Hubei province of China caused the outbreak in the Southeast Asian region covering the latitude between 38°N to 6°S. The Southeast Asian countries observed first and second wave of covid-19 spectrum with different spectrum envelope, which caused severe population mortality depending upon the spectrum pattern of the outbreak. This spreading of the spectrum caused marked variations in population mortality between different countries depending upon Covid-19 spectrum envelope characteristics with its spectrum peak height and width, existing healthcare infrastructure and its supply chain management of healthcare delivery systems of the country, which stressed the need for Covid-19 spectrum analysis of the first and second wave, and population mortality to develop predictive spectrum models of the third wave to determine the severity and population mortality.

In this paper, big-data predictive spectrum models of mortality have been developed based on the analysis of Covid-19 spectrum of the Southeast Asian region using spectrum envelope characteristics and population mortality data from 15 April 2020 to 30 June 2021, for predicting severity of third wave of Covid-19 outbreak, for countries that lie at the latitude beyond 38°N, which can be used by decision makers to design the lockdown measures and geo-spatial supply chain management of healthcare delivery system.

Introduction

The outbreak of the 2019 novel Corona virus disease (Covid-19) spread geo-spatially in more than 200 countries of the globe causing more than 182.969 million people of the global population infected and 3.963 million deaths (as on 30 June 2021) from 26.016 million people infected and 0.931 million deaths (as on 30 August 2020).

The exponential increase in spreading of corona virus spectrum in spatiotemporal way to the new geographical locations has seriously threatened the human health and life of the people as well as posed the challenges for countries to control the severity of the outbreak (Corona virus, 2020). The spatial spreading of corona virus spectrum due to large-scale migration from Hubei province of China caused the outbreak in the Southeast Asian region covering the latitude between 38°N to 6°S. The first case of corona virus was reported in Thailand on 13 January 2020, which was followed by South Korea on 20 January 2020, and Vietnam and Taiwan on 22 January 2020 prior to reach Hong Kong and Singapore on 23 January 2020. Malaysia reported the first corona virus case on 25 January 2020, which further geo-spatially spread to Philippines on 30 January 2020 prior to reach Indian Sub-continent on 31 January 2020. National lockdowns were imposed by the respective governments of the Southeast Asian countries as measures to control the severity of the spectrum of the outbreak (BBC, 2020).

The Hong Kong, Vietnamese and South Korean governments imposed national lockdowns as measures to control the exponential rise of the spectrum of corona virus from 8, 13 and 20 February 2020 respectively, after 16, 22 and 31 days of the first reported corona virus case. The governments of Singapore, Malaysia, Philippines, Thailand, Taiwan and India imposed these measures from 6, 13, 15, 20, 24 and 25 March 2020 respectively, whereas, the Indonesian government imposed a national lockdown from 15 March 2020. The Myanmar government executed a national lockdown on 13 March 2020, prior to the arrival of first corona virus case on 27 March 2020 (BBC, 2020).

There are marked variations in the spectrum of daily new cases of corona virus between different countries situated at different latitudes below 64°N of the hemisphere (Corona virus, 2020). Spatial big data predictive analysis of daily new corona virus cases carried out for 28 countries that lie below the latitudes of 60°N including the Southeast Asian region, resulted into the development of predictive spectrum models for six different stages of the spectrum of the outbreak such as complete recoverable stage, recoverable stage, safe stage, stabilizing stage, critical stage and beyond the critical stage as knowledge classifier (Verma et al., 2020).

Higher population mortality from corona virus observed in northern latitude exhibiting the population mortality with decreasing north south gradient based on mortality data of 02 April 2020 (Panarese and Shahini, 2020). In Rhodes et al. (2020), population mortality from corona virus between different countries situated at latitudes below 64°N showed marked variations with relatively low population mortality at latitudes below 35°N based on mortality data of 15 April 2020. Spatial big data analysis on population mortality carried out for 28 countries based on mortality data from 15 April to 08 June 2020 supports lower population mortality for countries situated at latitudes between 35°N and 35°S (Verma et al.,2020).

The Southeast Asian countries observed first and second wave of Covid-19 spectrum with different spectrum envelope, which caused severe population mortality depending upon the spectrum pattern of the outbreak. This spreading of the spectrum caused marked variations in population mortality between different countries depending upon Covid-19 spectrum envelope characteristics with its spectrum peak height and width, existing healthcare infrastructure and its supply chain management of healthcare delivery systems of the country, which stressed the need for Covid-19 spectrum analysis of the first and second wave, and population mortality to develop predictive spectrum models of the third wave to determine the severity and population mortality. In this paper, big-data predictive spectrum models of mortality have been developed based on the analysis of Covid-19 spectrum of the Southeast Asian region using spectrum envelope characteristics and population mortality data from 15 April 2020 to 30 June 2021, for predicting severity of third wave of Covid-19 outbreak, for countries that lie at the latitude beyond 38°N, which can be used by decision makers to design the lockdown measures and geo-spatial supply chain management of healthcare delivery system.

Spectrum models of different stages of the outbreak

The empirical spectrum models for predicting the trends of different stages of the outbreak have been for developed based on coefficients of predictive spectrum models of different countries based on 5 days moving average of daily new corona virus spectrum as knowledge classifier, such as Beyond the Critical Stage (Phase 5), Critical Stage (Phase 4), Stabilizing Stage (Phase 3), Safe Stage (Phase 2), Recoverable Stage (Phase 1), and Complete Recovery Stage (Phase 0). The polynomial spectrum models developed for predicting the trend of the spectrum for different stages of the outbreak is expressed as (Verma A K et al, 2020):

$$y(x) = A_0 + A_1 x + A_2 x^2 + A_3 x^3 + A_4 x^4 \quad (1)$$

where x is the number of days, $y(x)$ is daily new corona virus cases, and A_0, A_1, A_2 , A_3 and A_4 are the coefficients for different stages of the outbreak and given in Table 1.

These coefficients vary with maximum expected peak of spectrum of the outbreak and follow polynomials such as

$$y\,(x{:}max) = \text{Constant} + X_1 x + X_2 x^2 \quad (2)$$

Figure 1(a) to 1(e) depicts the variation of the coefficients of spectrum models for different stages of the outbreak. It shows the different variations of the coefficients for different stages of the outbreak and helps in predicting the trends of the spectrum.

Spectrum of daily new corona virus for South East Asian countries

Figure 2 depicts the spectrum of the daily new corona viruses

Table 1: Coefficients of different stages of the outbreak

Complete Recovery	Equations	x2	x1	constant
A0	$y = 2.0336x^2 + 52.841x - 52.766$	2.0336	52.841	-52.766
A1	$y = -0.8587x^2 - 18.92x + 18.994$	-0.8587	-18.92	18.994
A2	$y = -0.0437x^2 + 2.7256x - 2.6091$	-0.0437	2.7256	-2.6091
A3	$y = -0.0007x^2 - 0.0674x + 0.0663$	-0.0007	-0.0674	0.0663
A4	$y = -5E-05x^2 + 0.0007x - 0.0007$	-5.00E-05	0.0007	-0.0007
Recovery	**Equations**	**x2**	**x1**	**constant**
A0	$y = 30.893x^2 - 87.437x + 58.707$	30.893	-87.437	58.707
A1	$y = 2.8885x^2 - 8.0287x + 7.0275$	2.8885	-8.0287	7.0275
A2	$y = -0.2074x^2 + 0.5547x - 0.4786$	-0.2074	0.5547	-0.4786
A3	$y = 0.0037x^2 - 0.0092x + 0.0084$	0.0037	-0.0092	0.0084
A4	$y = -2E-05x^2 + 2E-05x - 3E-05$	-2.00E-05	2.00E-05	-3.00E-05
Safe Stage	**Equations**	**x2**	**x1**	**constant**
A0	y = -7.8657x2 + 9.1193x - 14.723	-7.8657	9.1193	-14.723
A1	$y = 4.1343x^2 - 6.9721x + 30.654$	4.1343	-6.9721	30.654
A2	$y = -0.1155x^2 + 0.2827x - 1.7892$	-0.1155	0.2827	-1.7892
A3	$y = 0.0004x^2 - 0.0031x + 0.035$	0.0004	-0.0031	0.035
A4	$y = 1E-05x^2 - 4E-05x - 0.0002$	1.00E-05	-4.00E-05	-0.0002
Safe Stage	**Equations**	**x2**	**x1**	**constant**
A0	y = 2.74x + 217.08		2.74	217.08
A1	y = -4.289x - 55.536		-4.289	-55.536
A2	y = -2.3347x + 9.0834		-2.3347	9.0834
A3	y = 0.1057x - 0.2902		0.1057	-0.2902
A4	y = -0.0011x + 0.0026		-0.0011	0.0026
Stabilizing Stage	**Equations**	**x2**	**x1**	**constant**
A0	$y = 10.809x^2 - 76.084x + 87.787$	10.809	-76.084	87.787
A1	$y = 0.2236x^2 + 6.749x + 0.2206$	0.2236	6.749	0.2206
A2	$y = 0.2724x^2 - 1.1272x + 0.7247$	0.2724	-1.1272	0.7247
A3	$y = -0.0097x^2 + 0.0359x - 0.0263$	-0.0097	0.0359	-0.0263
A4	$y = 9E-05x^2 - 0.0003x + 0.0002$	9.00E-05	-0.0003	0.0002
Stabilizing Stage	**Equations**	**x2**	**x1**	**constant**
A0	$y = 33.507x^2 - 136.71x + 90.587$	33.507	-136.71	90.587
A1	$y = -11.286x^2 + 47.985x - 26.037$	-11.286	47.985	-26.037
A2	$y = 0.4531x^2 - 1.529x + 0.7396$	0.4531	-1.529	0.7396
A3	$y = -0.0067x^2 + 0.016x - 0.0064$	-0.0067	0.016	-0.0064
A4	$y = 5E-05x^2 - 8E-05x + 6E-05$	5.00E-05	-8.00E-05	6.00E-05
Beyond the critical	**Equations**	**x2**	**x1**	**constant**
A0	$y = -25.83x^2 + 74.344x - 124$	-25.83	74.344	-124
A1	$y = 15.715x^2 - 47.969x + 64.262$	15.715	-47.969	64.262
A2	$y = -0.4206x^2 + 0.1492x - 1.8163$	-0.4206	0.1492	-1.8163
A3	$y = -0.017x^2 + 0.148x - 0.0443$	-0.017	0.148	-0.0443
A4	$y = 0.0003x^2 - 0.0019x + 0.0008$	0.0003	-0.0019	0.0008
Critical Stage	**Equations**	**x2**	**x1**	**constant**
A0	$y = 3.0407x^2 - 27.28x + 24.105$	3.0407	-27.28	24.105
A1	$y = 1.6672x^2 - 0.7752x + 6.5275$	1.6672	-0.7752	6.5275
A2	$y = -0.2615x^2 + 1.3184x - 1.4248$	-0.2615	1.3184	-1.4248
A3	$y = 0.0134x^2 - 0.0694x + 0.0678$	0.0134	-0.0694	0.0678
A4	$y = -0.0001x^2 + 0.0007x - 0.0007$	-0.0001	0.0007	-0.0007

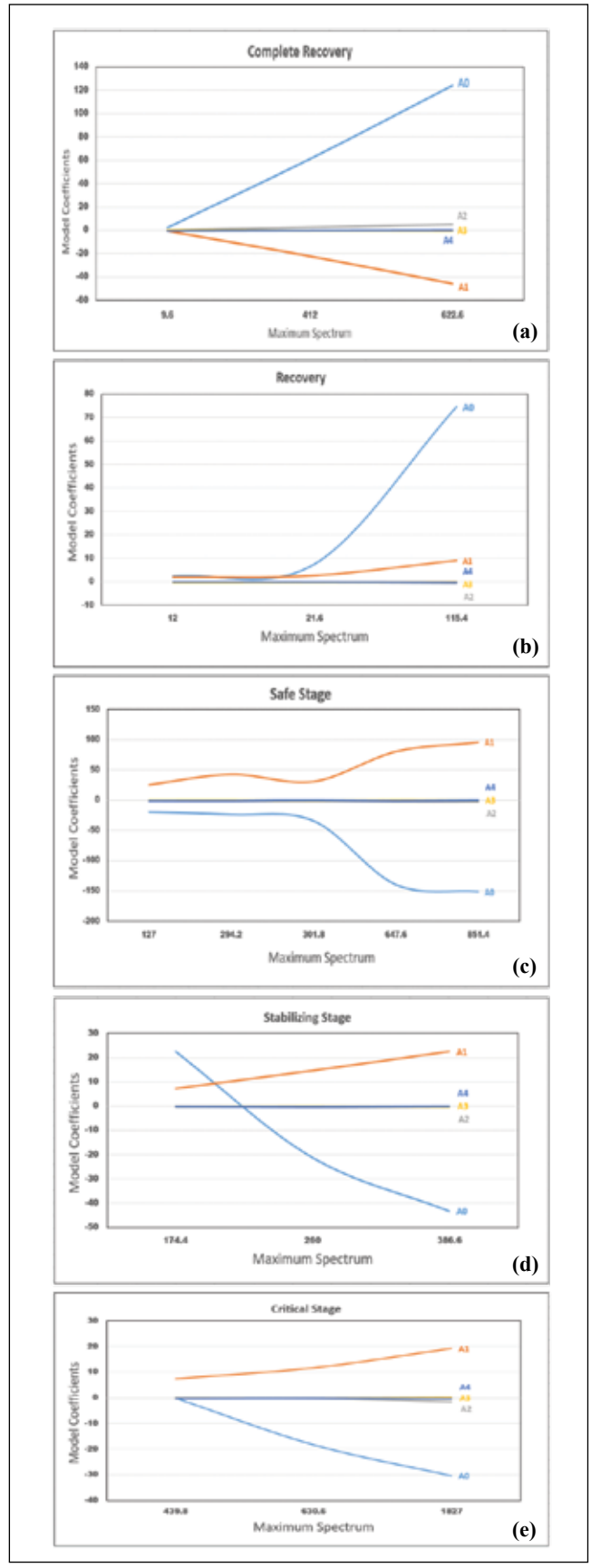


Figure 1: Variation of spectrum model coefficients with spectrum

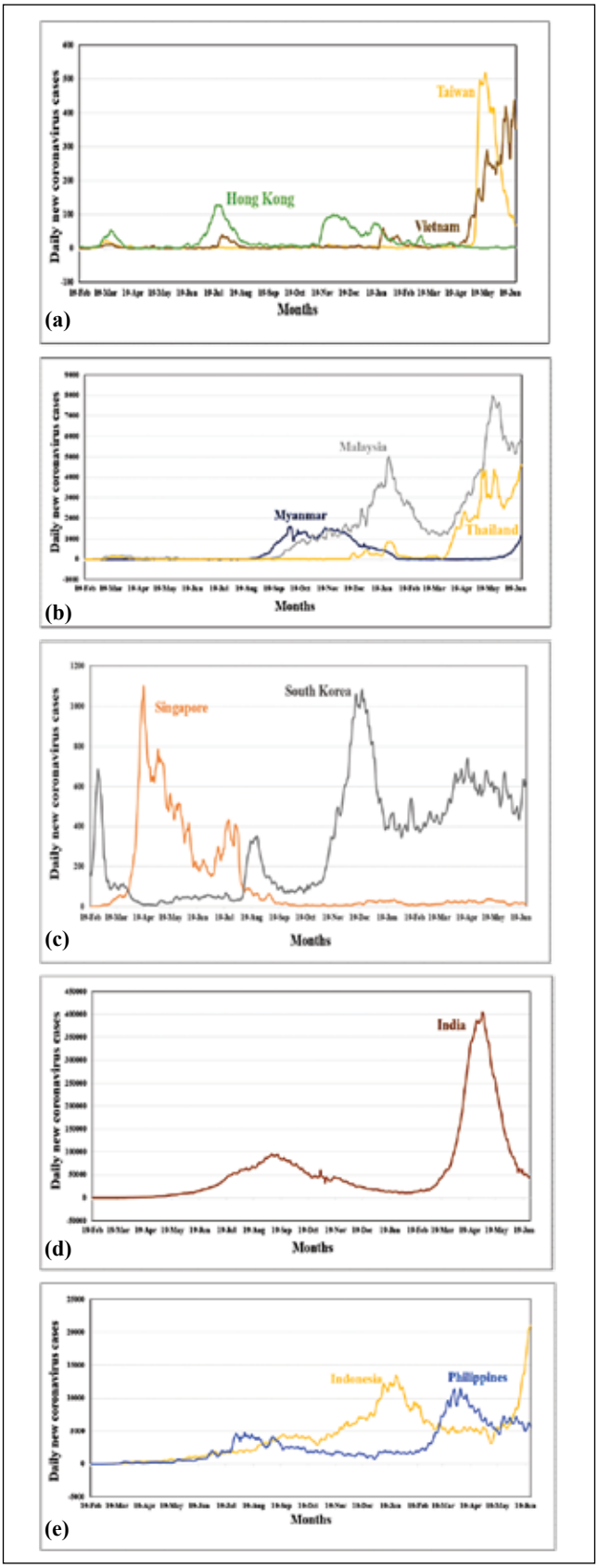


Figure 2: Variation of daily new corona virus cases from 19 February 2020 to 19 June 2021

from 19 February 2020 to 19 June 2021 based on 5-days moving average. Figure 2 (a) shows three peaks of the spectrum for Hong Kong and Vietnam, and two peaks for Taiwan. In the case of Vietnam, the second peak factor was two times higher than the first peak and third peak was ten times higher than the second peak of the corona virus spectrum. Whereas Hong Kong shows second peak two times higher than the first peak of the spectrum and third peak was 0.8 times of the second peak. Further, the corona virus spectrum of Taiwan shows that second peak 50 times higher than the first peak. Figure 2 (b) shows the spectrum of corona virus for Myanmar and Malaysia with two peaks whereas Thailand shows three peaks of the spectrum during the same period. Further the spectrum of Thailand for the second peak was 10 times higher than the first peak and third peak was 6 times higher than the second peak of the spectrum. Whereas, the second peak of Malaysia and Myanmar shows 1.5 times and 1.0 times of the first peak respectively during the same period. Figure 2 (c) depicts the spectrum of South Korea with four peaks whereas Singapore with only two peaks of the spectrum. Further the third peak of the spectrum of South Korea shows three times of the second peak of the spectrum whereas fourth peak and second peak of the spectrum shows of lower peaks compared to the first and third peak respectively. Similarly, the spectrum of second peak of Singapore shows 0.3 times of the level of first peak which shows that the outbreak of the corona virus is controlled. Figure 2 (d) explains the spectrum of corona virus with two peaks for Indian sub continent where the second peak was four times higher than the first peak of the spectrum and number of daily new corona cases peak exponentially increased from 0.1 million to more than 0.4 million cases with sharp second peak spectrum. Figure 2 (e) explains the two peaks of corona virus spectrum for Philippines and Indonesia with second peak two times higher than the first peak. Table 2 depicts the events of different peaks and peak factors for Southeast Asian region.

Varability of healthcare infrastructure in Southeast Asian region

Critical illnesses due to Covid-19 knows no boundaries and affect all human beings as per the exponential and random pattern of the spectrum with multiples peaks, challenging the existing healthcare infrastructure of the countries to control the outbreak. Careful analysis of this diversity of the first and second wave of the corona virus spectrum allows a better understanding of the effect of different healthcare system on patient outcomes and the possible steps in evolving quality healthcare delivery system, which depends on the heterogeneous distribution wealth across Asia's mix of low-, middle-, and high- income countries for the larger variability of healthcare system, which includes doctor to patient ratio, nurse to patient ratio, hospital beds and critical care beds based on population in south east Asian countries than that in continents like Europe. Out of 11 countries of Southeast Asian region, India, Indonesia, Myanmar and Philippines fall under low- and lower- middle income countries based on GDP

per capita, current health expenditure per capita, current health expenditure as percentage of GDP, universal healthcare coverage service coverage index and human development index, compared to high income countries like Hong Kong, Singapore, South Korea and Taiwan, and upper-middle income countries like Malaysia and Thailand (Phua J. etal,2020). Table 3 explains the details of existing healthcare infrastructure of these countries. The quality of healthcare infrastructure is directly related to availability healthcare resource manpower such as doctors and nurses, as well as healthcare physical infrastructures such hospitals beds, critical care beds, medical equipments and supply chain management. These infrastructures plays a catalytic role to control the outbreak during the event of the pandemic like Covid-19, where, the spectrum of daily new Covid-19 cases and mortality depends on the quality of healthcare delivery system to provide lower mortality during the peak of the spectrum. Table-2 depicts the spectrum peak height and spectrum width ratio during first and second wave of Covid-19 and mortality spectrum during the same period further provides different ratio factor of peak height and width in determining the severity of the outbreak. Countries like India, Indonesia, Myanmar and Philippines, ratio factor of spectrum becomes critical around 0.1, whereas, countries like Hong Kong, Singapore, South Korea and Taiwan, this ratio factor of spectrum becomes critical after 2.0, but countries like Malaysia, Thailand reaches the same critical stage beyond the ratio factor 0.5 of spectrum. India is ill equipped medical infrastructure as most of the states of India struggled to make enough hospital beds and ICU's available for patients. India has one of the worst records globally, when it comes to the number of beds, in comparison with population. According to Human Development Report 2020, India ranked 155th in the Index, and there are only 12 countries in the world that have even worse record, which includes Uganda, Senegal, Afghanistan, Burkina Faso, Nepal and Guatemala. Human Development Index is a measure of National health, education and standard of living. Further, 69 % of hospital beds in India are concentrated in urban area. India has abysmally low 0.5 beds per thousand population and mere 1.4 beds including public and private hospitals per 1000 population. The quality of the healthcare delivery depends upon the existing healthcare infrastructure of the country and Supply Chain Management of different components required to deliver the service. It has

Table 2: Covid–19 peak spectrum characteristics

Name of Country	1st Peak	2nd Peak	3rd Peak	2nd Peak Factor	3rd Peak Factor	1st Peak Height/ Width Ratio	2nd Peak Height and Width Ratio
South Korea	February 2020	August 2020	December 2020	0.6	3.0	6.0	1.25
Vietnam	July 2020	January 2021	June 2021	2.0	10.0	0.4	0.5
Hong Kong	March 2020	July 2020	November 2020	2.0	0.8	0.1	0.65
Thailand	March 2020	January 2021	May 2021	10.0	6.0	1.5	-
Taiwan	March 2020	May 2021		50.0		2.67	-
Philippines	July 2020	April 2021		2.2		0.75	-
Indonesia	January 2021	June 2021		2.0		0.5	-
Myanmar	November 2020	June 2021		1.0		0.214	-
Malaysia	January 2021	May 2021		1.5		0.8	2.0
Singapore	April 2020	July 2020		0.3			1.5
India	September 2020	May 2021		4.0			1.75

Table 3: Quality of Healthcare Infrastructure

Name of Country	Population (Million)	Doctor to Patient Ratio Per 1000 (a)	Nurse to Patient Ratio (per 1000) (b)	Nurse to Doctor Ratio (c)	Hospital Beds per 1000 patient (d)	Critical Care Beds per 0.1 million population (e)	F(x) = (a)(b)(d)	F1(x) = (a)(d)(e)	F2(x) = (a)(c)(d)
South Korea	51320595	2.4	7.3	3.1	12.27	10.6	214.97	312.14	91.28
Singapore	5903895	2.3	6.2	2.7	14.5	11.4	206.77	380.19	90.04
Taiwan	23866995	1.7	5.7	13.2	5.7	28.5	55.23	276.16	127.90
Hong Kong	7567771	2.0	7.6	3.9	5.4	7.1	82.08	76.68	42.12
Malaysia	32848238	1.5	3.5	2.3	1.9	3.4	9.975	9.69	6.55
Thailand	70004003	0.8	2.8	3.4	2.1	10.4	4.704	17.47	5.71
Philippines	111277014	0.6	4.9	8.2	0.88	2.2	2.58	1.16	4.32
Vietnam	98357758	0.8	1.1	1.4	2.6		2.288		2.91
Indonesia	276888490	0.4	1.5	3.6	1.49	2.7	0.894	1.60	2.14
India	1395790715	0.9	1.7	2.0	0.5	2.3	0.765	1.035	0.9
Myanmar	54834423	0.7	0.7	1.0	1.0	1.1	0.49	0.77	0.7

the direct linkage of the number of doctors, number of nurses, hospital bed infrastructure as well as critical care infrastructure existing in the country covering the rural and urban area of the country. Based on the analysis of the above factors, the quality of healthcare delivery system is a function of multiplicative function of number of doctors, number of nurses and hospital infrastructure per 1000 populating of the country. Table 3 depicts the existing healthcare infrastructure for South East Asian countries. Further this table describes the function f1, f2, f3 which shows that the best healthcare infrastructure is existing in South Korea, Singapore, Hong Kong and Taiwan whereas adequate infrastructure is available in Malaysia, Thailand, Philippines and Vietnam but India, Myanmar and Indonesia lacks in the adequate healthcare infrastructure as per the WHO recommendations.

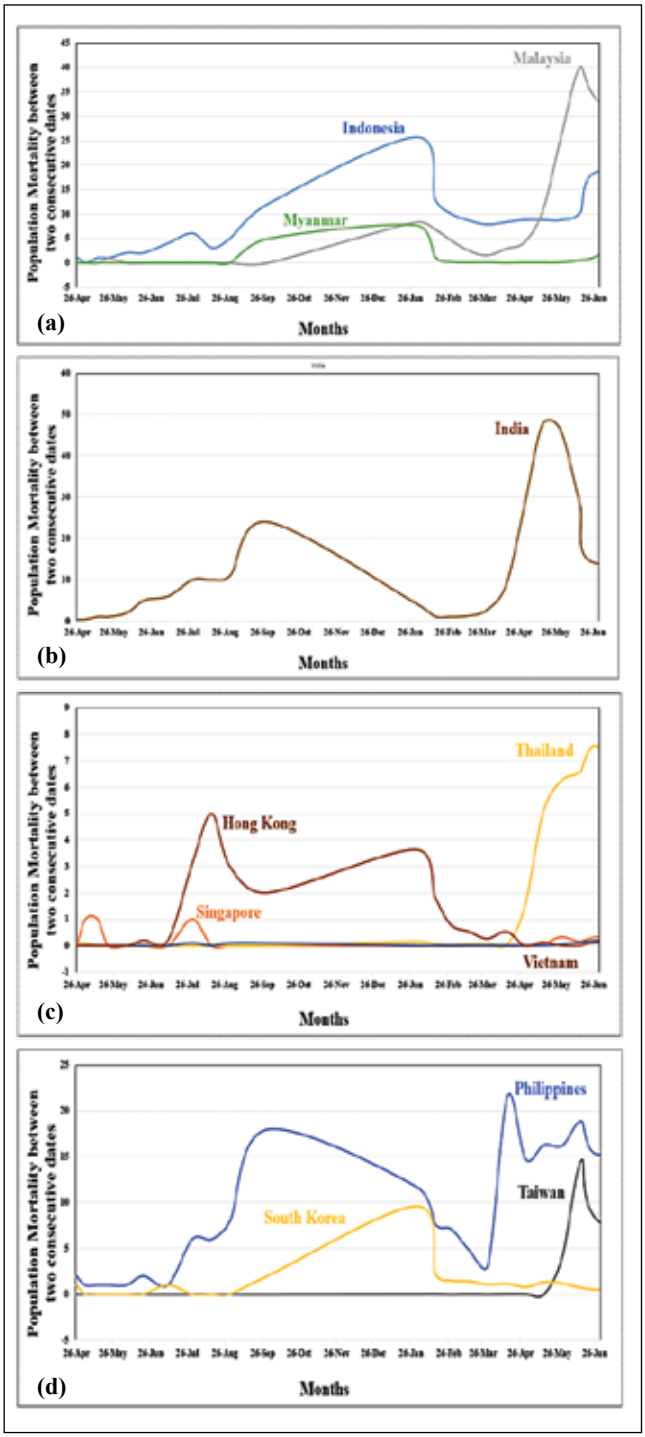


Figure 3: Variation of population mortality spectrum between consecutive dates

Table 2 explains the spectrum peak height and spectrum width ratio based on the data of daily new corona virus spectrum as depicted in Figure 2. This shows that the quality of healthcare infrastructure plays an important role in controlling the outbreak which is evident from the spectrum peak highest and peak width ratio described in the table for South East Asian countries. It shows that if the spectrum peak height and peak width ratio is more than 0.5 then the impact of mortality will be higher. However the countries having non-adequate healthcare infrastructure, this peak height and peak width ratio is effective from 0.1. Table 3 further shows that the mortality the country having quality healthcare infrastructure is able to control the outbreak and mortality during the sharp rise of the spectrum of 1st and 2nd peak with more than 2.0 spectrum peak height to width ratio.

Variation of mortality spectrum for Southeast Asian region

Figure 3 depicts the spectrum of mortality between two consecutive dates based on the population mortality data from 15 April 2020 to 30 June 2021. Figure 3 explains the spectrum of mortalities for Hong Kong, Vietnam and Taiwan which shows that mortality increases exponentially with the increase of daily new corona virus cases. But decreases slowly with the decrease of daily new corona virus spectrum and takes time to control the mortality. Further Taiwan shows very sharp rise of mortality with a sharp peak of the corona virus spectrum. Whereas Vietnam show the control mortality by the measures taken to control the outbreak. Figure 3 depicts the variation of mortality which increases sharply with the increase of daily new corona virus spectrum but decreases slowly even after the control of new corona virus cases. Figure 3 explains the similar rise of the mortality spectrum for Philippines and Indonesia, which increases sharply with the peak of the new corona virus spectrum. Figure 3 shows the mortality spectrum of South Korea and Singapore whereas the mortality during the third peak of the spectrum of South Korea shows sharp increase in the mortality but Singapore spectrum confirms to control the outbreak after the first peak of new corona virus spectrum. Figure 3 shows the mortality spectrum for Indian sub-continent shows a sharp rise in the mortality during first and second peak of the daily new corona virus spectrum whereas the mortality decreases very slowly with the decrease of the new corona virus spectrum of the first and second peak. This confirms that the slow decrease of the mortality spectrum is due to inadequate health care infrastructure

as shown in Table 2. Further Indonesia, Philippines the decrease of the mortality slope shows slow decrease with the decrease of the first peak of the spectrum of new corona virus cases.

Impact of latitude on population mortality

Higher population mortality from Covid-19 observed in Northern Latitude with highest in Italy and exhibiting the population mortality with decreasing north south gradient based on mortality data of 02 April 2020 for 108 countries (Jonathan M.R. et al, 2020). Northern latitudes are associated with vitamin D deficiency for higher population mortality due to low ultraviolet exposure in the northern countries. When population mortality plotted against the Latitude for 130 countries based on mortality data of 15 April 2020 showed marked variation in mortality between different countries that lie below the latitude of 64°N of the hemisphere (Panarese A. and Shahini E., 2020). People do not receive adequate sunlight to maintain vitamin D levels during winter in countries situated beyond the latitude of 35°N. All countries that lie below the Latitude of 35°N showed relatively low population mortality with the correlation coefficient of 0.53 between mortality and Latitudes (Jonathan M.R. et al, 2020; Panarese A. and Shahini E., 2020). Relatively low population mortality from Covid-19 observed for countries situated at Latitudes between 38°N and 35°S based on population mortality from 15 April to 08 June 2020 for 28 countries and 15 April to 15 August 2020 for 52 countries that lie below the Latitude 60°N (Verma A.K. et al, 2020; Verma A.K. et al, 2020), which confirms to higher correlations due to continuance of multiple peaks for countries at the same Latitudes during these periods with increased population mortality.

Population mortality for the Southeast Asian region

Figure 4 depicts the variation of population mortality from Covid-19 for 11 countries of the Southeast Asian region that lie between latitudes 38°N and 6°S based on population mortality data from 15 April 2020 to 30 June 2021. There are significant variations in population mortality for Malaysia, Myanmar, Hong Kong, whereas other countries showed non-significant variations in population mortality. Further, a sudden rise of population mortality observed for Myanmar and Hong Kong during 20 January to 30 June 2021, in addition to the continuance of the rise of population mortality for Indonesia, Philippines, Malaysia and India in the Southeast Asian region.

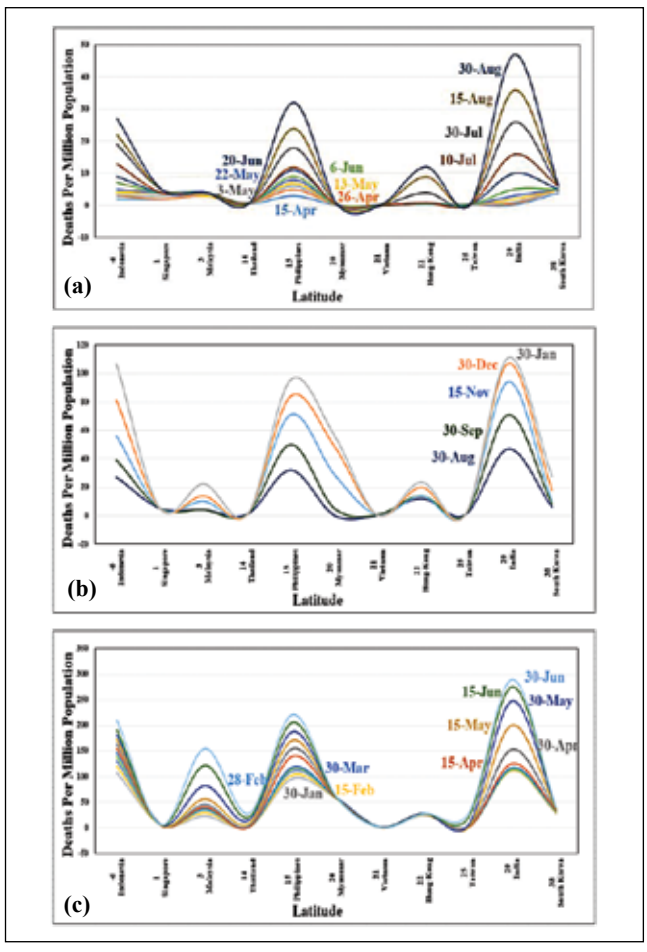


Figure 4: Variation of population mortality with latitude

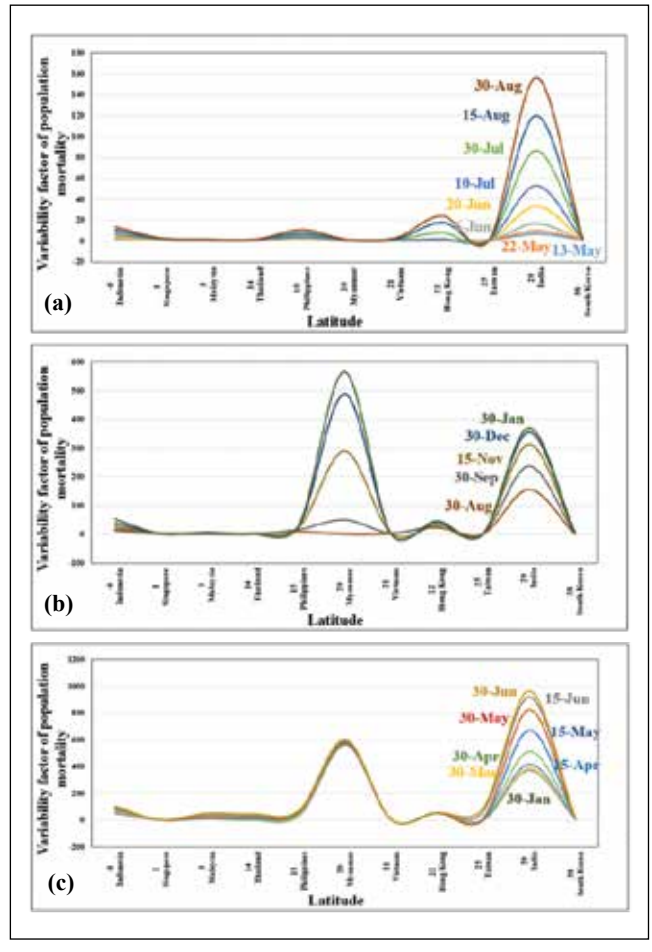


Figure 5: Variability factor of population mortality

This present study describes the effect of spectrum peak and width ratio on the mortalities, which depends on the quality of healthcare infrastructure of Southeast Asian countries. This present study of spatial big data analysis of population mortality, mortality between two consecutive dates and variation of population mortality provides the clear picture of the severity of the outbreak for countries that lie between the latitudes 38°N and 6°S. The impact of spectrum pulse height and width ratio is very important for assessing the vulnerability of the outbreak

Figure 5 (a) shows the variation of variability factor of population mortality from 13 May to 15 August 2020 with respect to population mortality on 15 April 2020. It shows maximum variations of variability factor of population mortality for India in the Southeast Asian region, whereas other countries show non-significant variations. Figure 5(b) shows sudden rise of variability factor of population mortality for Malaysia, Myanmar, Hong Kong and Taiwan during 30 September 2020 to 20 January 2021. 5(c) shows sudden rise of variability factor of population mortality for Myanmar and India during 20 January to 30 June 2021, whereas, other countries stabilizes to control the outbreak.

Conclusion

This present study describes the effect of spectrum peak and width ratio on the mortalities, which depends on the quality of healthcare infrastructure of Southeast Asian countries. This present study of spatial big data analysis of population mortality, mortality between two consecutive dates and variation of population mortality provides the clear picture of the severity of the outbreak for countries that lie between the latitudes 38°N and 6°S. The impact of spectrum pulse height and width ratio is very important for assessing the vulnerability of the outbreak. The ratio factor of 0.1 decides the severity for the countries like India, Myanmar, Indonesia, whereas, the ratio factor of more than 2.0 can be considered as safe factor for countries like Singapore, Hong Kong, South Korea. In order to predict the severity in terms of mortality for the third wave of corona virus, the same ratio factor of spectrum peak height and width ratio cannot be considered, because it varies from 0.1 to 2.0 depending on the existing health care delivery system of the countries in the Southeast Asian region.

References

1. BBC, 2020. Coronavirus: The world in lockdown in maps & charts/ Source: Oxford Covid-19 Government Response Tracker /BBC Research, Available online at: https:// www.bbc.com/news/world-52103747 (Last access date: 10 July 2020).

2. Coronavirus, 2020. Global Covid-19 Data for All Countries, Available online at: https://www.worldmeters.info/coronavirus (Last access date: 10 July 2020).

3. Chenghu Z., Fenzhen S., Tao P., Zhang A., Yunyan D., Bin L., Zhidong C. , Juanle W., Wan Y., Yunqiang Z., Ci S., Jiechen J.X. , Li F., Ma T., Lili J., Fugqin Y., Jiewei Y., Yunfeng H., and Yilan L., 2020. Covid-19: Challenges to GIS and Big Data", Geography Sustainability, 1, pp 77-87.

4. Jonathan M.R., Sreedar S., Eamon L. and Rose A.K., 2020. Low population mortality from COVID-19 in countries south of latitude 35 degree north supports vitamin D as a factor determining severity, Aliment. Pharm. Therap., 51, pp 1438-1439.

5. Panarese A. and Shahini E., 2020. Covid-19 and Vitamin D, Aliment. Pharm. Therap., 51, 2020, pp 993-995.

6. Phua J., Kulkarni A.P., Redjeki I.S., Mendsaikhan N., Sann K.K., Shrestha B.R., Palo J.E.M., Hashemian S.M.R., Nor, Patjanasoontorn B., Ling L., Bahrani M.J.L., Lim C., 2020. Critical Care Bed Capacity in Asian Countries and Regions, Critical Care Medicine Journal, Vol xx, January 2020, pp 1 – 9.

7. Verma A. K., Verma Aditi & Verma Anjul, 2020. Coronavirus Spatial Big Data Predictive Analysis for the Southeast Asian Region, Defence Science & Technology Technical Bulletin, Ministry of Defence, Malaysia, 12 , 2, pp 344- 366.

8. Verma A. K., Verma Anjul and Verma Aditi, 2020. Covid-19 Geo-Spatial Big Data Analysis of Population Mortality for Countries Situated at Latitudes between 64°N and 35°S. 41st Asian Conference on Remote Sensing (ACRS 2020), Organised by Asian Association of Remote Sensing (AARS), 09-11 November 2020, Deqing, China.

The paper was presented at 42nd Asian Conference on Remote Sensing (ACRS2021), 22-24 November 2021, Can Tho University, Can Tho, Viet Nam organized by Asian Association of Remote Sensing (AARS), Japan

Humorous science: Work health and safety

As the world continues to struggle with the COVID-19 pandemic, this paper highlights humorous research investigating medical and musical mysteries, with a focus on applying scientific methods to support work health and safety and our general wellbeing.

Volker Janssen
Publications Officer, Association of Public Authority Surveyors (APAS), New South Wales, Australia

This is the sixth and last in a series of papers celebrating some of the weird and wonderful research findings hidden amongst the scientific literature. It aims to ensure that we remember the funnier side of science and provides answers to questions we may have been too afraid to ask. This study was conducted entirely in the author's spare time and is in no way related to his employer. Here, we examine selected research relating to work health and safety and our general physical and mental wellbeing. It is much appreciated that some journals, such as the *BMJ* (British Medical Journal), *CMAJ* (Canadian Medical Association Journal) and *MJA* (Medical Journal of Australia), routinely include humorous papers in their December issues.

Alonso et al. (2017) investigated the frequency, reasons, perceived risk and punishment of shouting and cursing while driving based on a questionnaire administered to 1,000 drivers in Spain. It was found that 26% of drivers recognise that they shout or insult at the wheel, while 66% say they have never or almost never displayed this type of behaviour. The main reasons for yelling and cursing were in reaction to another driver not meeting their standards or causing them to face a dangerous manoeuvre or stressful situation. Not surprisingly, drink driving and speeding were the main factors perceived to cause a higher risk of accidents. Drivers who often shout and curse were also those who perceive the lowest risk in doing so. While virtually all drivers believed that driving at an excessive or inappropriate speed, with an elevated alcohol level or without insurance are punishable behaviours, not keeping a safe distance and shouting and insulting were not regarded as such by a significant proportion (25% and 65%, respectively).

Hodgetts and Liu (2006) illustrated the impact that even brief exposure to leisure noise can have on a person's hearing. Cumulative sound exposure was measured with a noise dosemeter collecting data at 1 Hz during three games of the ice hockey Stanley Cup final series. It was found that goal scoring showed obvious spikes in the noise level, roughly equivalent to a jet taking flight (Figure 1). Even during the intermissions, the noise remained at a level that would require hearing protection to be worn by law in an equivalent 8 hour/day workplace environment. The maximum allowable daily noise dose was reached in only 6 minutes, i.e. each person not wearing hearing protection received about 8,100% of their daily allowable noise dose over the 3 hours. Hearing tests on two spectators revealed mild ringing tinnitus after the game, and their hearing thresholds deteriorated by 5-10 dB for most frequencies (but up to 20 dB at 4,000 Hz, the frequency known to be most susceptible to noise damage). While this temporary threshold shift usually disappears in a few days, it may become permanent following further noise exposure before full recovery. This emphasises the importance of considering hearing protection not only during work hours but also when attending sporting events, rock concerts or karaoke.

Moving on to the brain, Maguire et al. (2000) investigated the navigation-related structural change in the hippocampus

(the part of the brain that is crucial for learning and memory) of taxi drivers. MRI brain scans of 16 London taxi drivers were analysed using 3D image analysis and compared with those of 50 age- and gender-matched people lacking such extensive navigation exposure. Although no difference was detected in the overall hippocampus volume, its structure in taxi drivers was found to be significantly different, and the regional distribution of its volume correlated with the amount of time spent as a taxi driver. This indicated that the hippocampus stores a spatial representation of the environment and can expand regionally to accommodate people with a high dependence on navigational skills.

Employing statistical analysis of various behavioural tests in addition to MRI brain scans, Maguire et al. (2006) later confirmed these findings by ruling out the potential influence of self-motion, driving experience and stress on the observed pattern of grey matter volume distribution in taxi drivers. This was achieved by comparing a new cohort of 18 London taxi drivers with 17 bus drivers who were matched for age, gender, education, intelligence, driving experience and stress level but differed in that they follow a constrained set of routes.

Head injuries

Consequently, head injuries are of obvious concern to spatial professionals. Kamp et al. (2011) investigated traumatic brain injuries based on more than 700 head injuries occurring in the Asterix comic books. They performed a neurological examination for each head-injured character and correlated the clinical data with information regarding trauma mechanism (mostly blunt force), sociocultural background of victims and offenders, and the circumstances of the trauma to identify specific risk factors. Not surprisingly, the Romans suffered the most head injuries, mainly inflicted by Asterix and Obelix. Injuries were most severe when helmets were not used, emphasising the importance of wearing personal protective equipment (PPE). Astonishingly, no character suffered long-term consequences or death. Characters who took the magic potion caused significantly more severe head injuries, and administration of this drug after sustaining such an injury led to a prompt recovery.

Head injuries in nursery rhymes were examined by Giles and Shea (2003), including 'Humpty Dumpty', 'Hush-a-bye-Baby', 'Ten Little Monkeys', 'Jack and Jill', 'It's Raining, It's Pouring' and 'Ring Around the Rosie'. It was noted that no single character category appears to avoid injury, i.e. babies, teenagers, old men, primates and nondescript characters all suffered. The study found evidence of a dangerous subtext in children's literature as several popular nursery rhymes portray head injuries as inevitable events not requiring medical follow-up. Issues raised included the appropriateness of the response to injury, the importance of seeking a medical opinion, the need for clarity about the events leading up to the injury, and the need to use precise medical terminology. To address these shortcomings, the authors offered a medically sound nursery rhyme providing a realistic and medically accurate account of what happens when a head injury is sustained.

Cyr et al. (2004) studied a unique case of delayed personal development. Tintin, the young reporter whose stories were published between 1929 and 1976, was about 14-15 years old when introduced (with the height of a 7- or 8-year-old), so would have been 60 years old during his final adventure. An exhaustive assessment of Tintin's stories found that he suffered many significant head injuries causing unconsciousness. For each incident, they identified the cause of the trauma, the length of losing consciousness (calculated by the number of frames before Tintin returns to normal activity) and the severity of the trauma (indicated by the number of objects revolving above his head). Never did Tintin shave, grow taller or exhibit signs of pubertal development, suggesting that he suffered from growth hormone deficiency, caused by repeated head traumas leading to injury of the pituitary gland, which regulates growth hormone release. It should be noted that the first two authors are the third author's children, providing an excellent example of engaging young children with science.

Focussing on forensic medicine, Bolliger et al. (2009) determined whether full or empty beer bottles are sturdier and if their fracture-threshold is sufficient to break the human skull. Using multi-slice computed

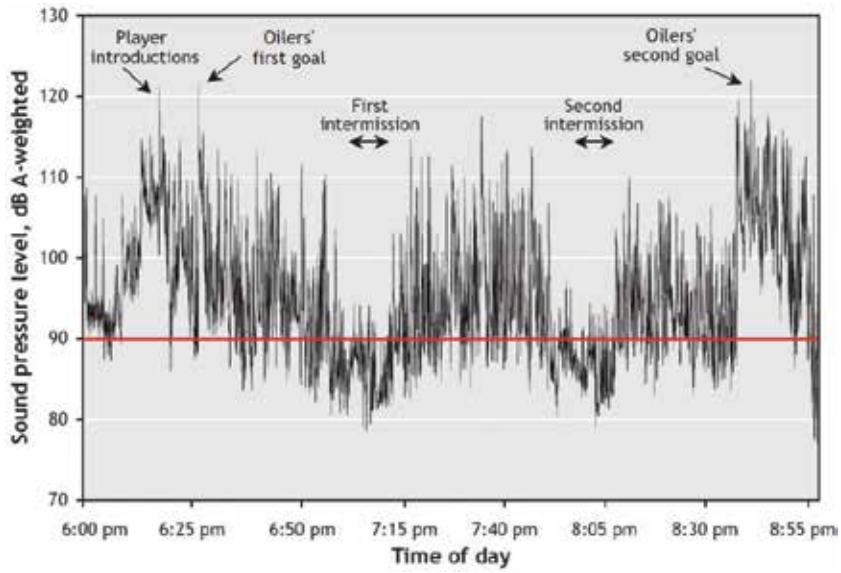


Figure 1: Noise exposure level for game 3 of the 2006 Stanley Cup finals, with key points of interest indicated and the red line at 90 dB representing the derived safe level of this 3-hour game (Hodgetts and Liu, 2006).

tomography, the thickness of standard European 0.5-litre bottles was measured to be between 2.0 mm and 3.6 mm. They fixed a small pinewood board to one side of the bottles using a thin layer of modelling clay, which not only served as fixing material but also as a substitute for the soft tissues of the scalp. The bottles were then fixed horizontally to the bottom of a baby-bathtub, and a 1 kg steel ball was dropped from different heights (between 2 and 4 m) onto the beer bottles in a drop tower specifically designed for the testing of materials (Figure 2). Despite the small sample size, this showed that empty beer bottles are sturdier, tolerating more energy before breaking due to beer being an almost incompressible and carbonated fluid. Regardless of being full or empty, they are easily capable of fracturing the human skull and inflicting serious head injuries. This knowledge may be of particular interest to spatial professionals regularly visiting pubs while conducting field work for several days at a time.

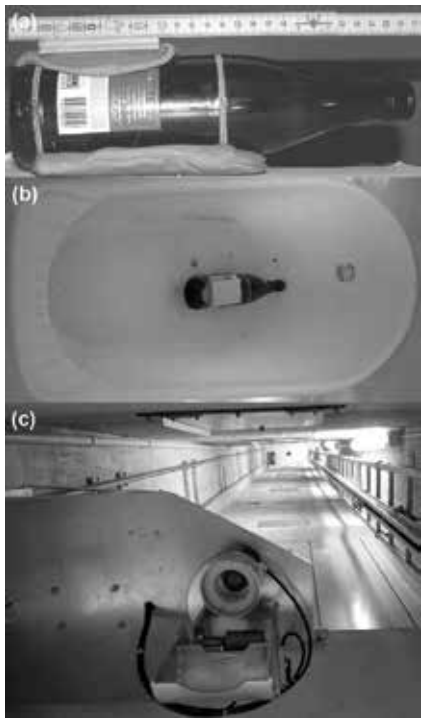


Figure 2: (a) Pinewood board fixed to the bottle using modelling clay, (b) bottle placed in a baby-bathtub, and (c) drop tower release as seen from below (Bolliger et al., 2009).

Evolving workplace procedures

Hanley and Hanley (2000) investigated the efficiency of stethoscope placement when not in use. They compared the traditional method of wearing it like a tie (earpieces around the back of the neck) to the contemporary, cool method of wearing it like an open scarf (earpieces and chest piece resting on opposite shoulders). Measuring the time taken by 100 healthcare professionals in each group to transfer the stethoscope to its functional position revealed that the cool group was 1.3 seconds slower despite their younger age (mean time of 3.2 and 1.9 seconds, respectively, with standard deviations of about 1 second in both cases). Furthermore, two hands were required by the cool group, while the traditional group usually achieved a one-handed transfer (leaving the other hand free to fend off or hold down disobedient patients). By extrapolation across medical practitioners and students in Canada and assuming that the cool position is favoured by 80% of these, it was shown that this wasted time could cause a substantial loss of productivity and financial burden on the healthcare system. This illustrates that evolving workplace procedures do not always improve their practical application, serving as a reminder to policy makers that their actions often have unexpected and undesired consequences downstream.

Noting the importance of information provided to patients being comprehensive, accurate and understandable (to them), Jones et al. (2007) examined the accuracy of comparing bone quality to chocolate bars for patient information purposes. The use of confectionary visual aids in patient education is widespread, e.g. when comparing healthy bone to the finely honeycombed structure of a Crunchie chocolate bar and abnormal, osteoporotic bone to the coarser structure of an Aero bar. The authors studied the fracture risk for each chocolate bar by dropping samples from increasing heights onto a typical, tiled kitchen floor (assumed to be representative of the home environment where many fractures occur). Despite the apparently more robust structure of a Crunchie, it was more likely to fracture than an Aero (Figure 3). They concluded that using these chocolate bars to explain bone structure and fracture risk to patients is visually attractive but inaccurate. This study highlights the difficulty of conveying scientific information to a general audience by simplification and generalisation without losing the accuracy and correctness of technical content.

Shah et al. (2011) compared the travel time between hospital floors using stairs or elevators. Four people aged between 26 and 67 years completed 14 walking trips each, ranging from one to six floors both ascending and descending, and a total of 336 elevator trips. Statistical analysis determined that the mean travel time between floors was 13 seconds by stairs and 36.5 seconds by elevator, the difference being caused by waiting for the elevator's arrival. Not surprisingly, elevator travel time varied depending on the time of day and day of the week. All participants were able to continue their duties without resting after taking the stairs, so fatigue was not an issue. Acknowledging the small sample size, it was concluded that taking the stairs can save 15 minutes each day, which could translate into improved productivity and increased fitness. Obviously, these findings can also be applied to other workplaces, albeit with the likely assumption of fewer trips per day. This should encourage us all to use the stairs whenever possible.

In a very timely contribution, Chapman and Thamrin (2020) characterised how the working arrangements and productivity of Australian medical researchers changed during the COVID-19 pandemic, with particular attention to wearing pyjamas. Over a 3-week period, more than 160 staff and students at five medical research institutes in Sydney self-assessed their productivity and mental health. The most frequent working-from-home arrangements were the kitchen or dining table (42%) and individual (28%) or shared (22%) home offices, while five respondents (3%) resorted to working in their bathroom. Interruptions to teleconferences included internet

problems, children, other household members, pets, the doorbell, phone calls, toilet breaks and one instance of sleepwalking. Only a few participants confessed to wearing pyjamas while working, which was not associated with lower productivity but linked with poorer mental health (Figure 4). People working at home with young children reported lower productivity but no deterioration in mental health, and early career researchers were less productive than established researchers. Hopefully, these findings will help remove the stigma attached to wearing pyjamas during work hours and improve flexible working policies. A broader promotion of National Pyjama Day in the workplace may be a good starting point in this regard.

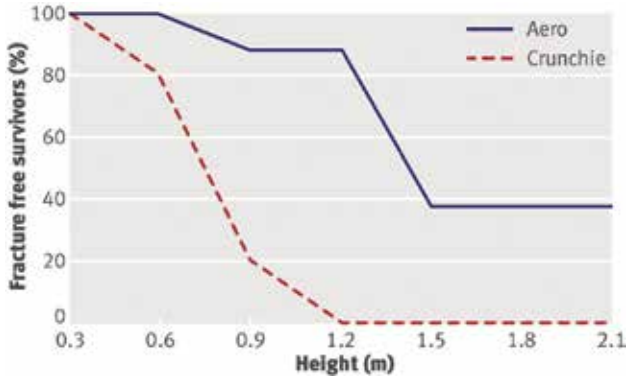


Figure 3: Fracture-free survival curves for Crunchie and Aero chocolate bars (Jones et al., 2007).

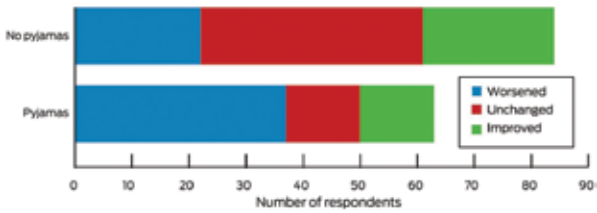


Figure 4: Wearing pyjamas and changes in mental health while working from home (Chapman and Thamrin, 2020).

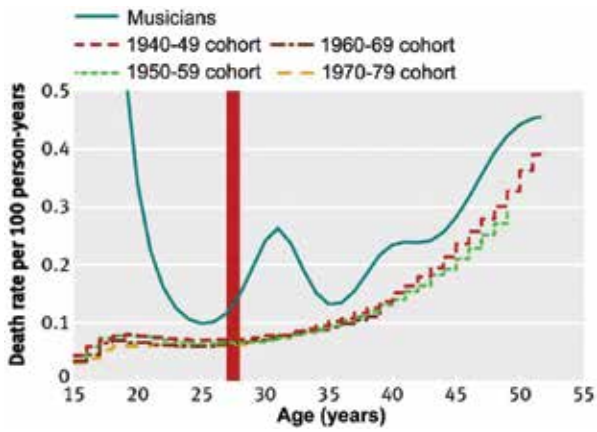


Figure 5: Death rates in the general UK population per 100 person years by age and decade of birth (cohort) and smoothed death rate per 100 musician years, with a vertical red line indicating age 27 (Wolkewitz et al., 2011).

Musical mysteries

Aside from being a profession, playing and listening to music is an important component of our mental wellbeing and can even be used to improve certain medical disorders. For example, Puhan et al. (2006) showed that regular didgeridoo playing is an effective alternative treatment for snoring and obstructive sleep apnoea syndrome (intermittent airflow blockage during sleep). Four months of didgeridoo playing (participants practised an average of 6 days a week for 25 minutes) reduced daytime sleepiness in patients and sleep disturbance in their partners. This was explained by didgeridoo playing effectively training the muscles of the upper airways, which control airway dilation and wall stiffening. One of the challenges in the treatment of sleep disorders is poor compliance, thus new treatments not only need to be effective but motivate people enough to use them (which didgeridoo playing seemed to do).

Focussing on musicians and noting that a seemingly unusual number of them have died at age 27, Wolkewitz et al. (2011) examined whether 27 really is a dangerous age for famous musicians. Estimating the mortality risk by age of musicians that had a number 1 album in the UK using a flexible spline, they identified three deaths at age 27 amongst 522 musicians at risk, showing no evidence of a peak in risk at this age. Instead, the smoothed death rate showed a peak at age 32. The mythical '27 club' therefore appears to exist by chance, being an example of confirmation bias where people focus on results that support their hypothesis and ignore those that oppose it. However, it was noted that the mortality risk for famous musicians throughout their 20s and 30s was 2-3 times higher than for the general UK population (Figure 5), which may be attributed to the excesses of fame.

Using tools from experimental economics, Oxoby (2009) attempted to determine who may be the better singer of the rock band AC/DC (Bon Scott versus Brian Johnson) in regard to affecting efficient decision making among listeners. In an ultimatum game, individuals were randomly paired and assigned the roles of either proposer or responder. Proposers were allocated a sum of money from which they had to choose an amount to extend as an offer to the responder. Upon learning of this offer, the responder could either accept or reject the offer. If the offer was accepted, the responder received the offer (in cash), and the proposer was given the original sum of money less the offer. If the offer was rejected, both participants received nothing.

However, as discussed by Janssen (2019), the design of the experiment undertaken to conclude in favour of Brian Johnson was not ideal because the two participating groups were treated to different songs. To rigorously determine a singer's ability to

implement efficient behavioural outcomes among listeners, the same song should have been played to both groups (using live versions as Bon Scott died in 1980, aged 33). Additional tests could have investigated the effects of song tempo (bluesy versus hard rocking) and how song lyrics may influence business decisions.

Janssen (2019) went on to analyse the AC/DC phenomenon by examining song lyrics, the band's work rate, the passion of hardcore fans and the marketing of the AC/DC brand. He found that the word 'rock' is by far the most prominent in AC/DC song titles but lyrically almost half of all songs revolve around sexual encounters. While the frequency of album releases slowed considerably over time, the band generally played 150 live gigs following each studio album in increasingly larger venues. Bon Scott songs continue to make up 45% of typical AC/DC concert setlists, demonstrating the immense respect for his contribution, the quality of the early song material and the timelessness of AC/DC's music. Hardcore fans generally preferred the older material, experienced their first gig during early adulthood and enjoyed up to 124 gigs since. Applying scientific rigour to an entertaining topic, this paper demonstrated how one can collect, analyse, interpret and present data by effectively utilising tables, pie charts, time series, histograms and maps.

Finally, Fancourt et al. (2016) investigated the role of music in the operating theatre, using the surgical board game Operation. After a brief introduction, 352 participants were randomised to listen through noise-cancelling headphones to either the sound of an operating theatre, rock music (AC/DC) or classical music (Mozart) while removing three organs from the board game patient using surgical tweezers. Statistical analysis revealed that rock music led to significantly slower operating speed and more surgical mistakes in men, while women appeared unaffected. Classical music was associated with lower perceived distraction, but this effect was weakened when factoring in how much people liked the music as generally only people who particularly liked Mozart found it beneficial.

Conclusion

While not directly related to surveying, mapping and the spatial sciences, the methods applied to collect, process and analyse data to investigate the medical and musical mysteries presented here are similar. The highlighted studies address important work health and safety issues and help improve our general physical and mental wellbeing. Furthermore, most findings discussed can be equally applied to other professions, tongue in cheek or not.

References

Alonso F., Esteban C., Serge A. and Ballestar M.L. (2017) Shouting and cursing while driving: Frequency, reasons, perceived risk and punishment, *Journal of Sociology and Anthropology*, 1(1), 1-7.

Bolliger S.A., Ross S., Oesterhelweg L., Thali M.J. and Kneubuehl B.P. (2009) Are full or empty beer bottles sturdier and does their fracture-threshold suffice to break the human skull? *Journal of Forensic and Legal Medicine*, 16(3), 138-142.

Chapman D.G. and Thamrin C. (2020) Scientists in pyjamas: Characterising the working arrangements and productivity of Australian medical researchers during the COVID-19 pandemic, *Medical Journal of Australia*, 213(11), 516-520.

Cyr A., Cyr L.-O. and Cyr C. (2004) Acquired growth hormone deficiency and hypogonadotropic hypogonadism in a subject with repeated head trauma, or Tintin goes to the neurologist, *CMAJ*, 171(12), 1433-1434.

Fancourt D., Burton T.M.W. and Williamon A. (2016) The razor's edge: Australian rock music impairs men's performance when pretending to be a surgeon, *Medical Journal of Australia*, 205(11), 515-518.

Giles S.M. and Shea S. (2003) Head injuries in nursery rhymes: Evidence of a dangerous subtext in children's literature, *CMAJ*, 169(12), 1294-1296.

Hanley W.B. and Hanley A.J.G. (2000) The efficacy of stethoscope placement when not in use: Traditional versus "cool", *CMAJ*, 163(12), 1562-1563.

Hodgetts W.E. and Liu R. (2006) Can hockey playoffs harm your hearing? *CMAJ*, 175(12), 1541-1542.

Janssen V. (2019) Let there be rock: The AC/DC phenomenon, *Proceedings of Association of Public Authority Surveyors Conference (APAS2019)*, Pokolbin, Australia, 1-3 Apr, 106-125.

Jones P., Jones S. and Stone D. (2007) Accuracy of comparing bone quality to chocolate bars for patient information purposes: Observational study, *BMJ*, 335(7633), 1285-1287.

Kamp M.A., Slotty P., Sarikaya-Seiwert S., Steiger H.-J. and Hänggi D. (2011) Traumatic brain injuries in illustrated literature: Experience from a series of over 700 head injuries in the Asterix comic books, *Acta Neurochirurgica*, 153(6), 1351-1355.

Maguire E.A., Gadian D.G., Johnsrude I.S., Good C.D., Ashburner J., Frackowiak R.S.J. and Frith C.D. (2000) Navigation-related structural change in the hippocampi of taxi drivers, *PNAS*, 97(8), 4398-4403.

Maguire E.A., Woollett K. and Spiers H.J. (2006) London taxi drivers and bus drivers: A structural MRI and neuropsychological analysis, *Hippocampus*, 16(12), 1091-1101.

Oxoby R.J. (2009) On the efficiency of AC/DC: Bon Scott versus Brian Johnson, *Economic Inquiry*, 47(3), 598-602.

Puhan M.A., Suarez A., Lo Cascio C., Zahn A., Heitz M. and Braendli O. (2006) Didgeridoo playing as alternative treatment for obstructive sleep apnoea syndrome: Randomised controlled trial, *BMJ*, 332(7536), 266.

Shah S., O'Byrne M., Wilson M. and Wilson T. (2011) Elevators or stairs? *CMAJ*, 183(18), E1353-E1355.

Wolkewitz M., Allignol A., Graves N. and Barnett A.G. (2011) Is 27 really a dangerous age for famous musicians? Retrospective cohort study, *BMJ*, 343(7837), d7799.

FPGA implementation of a NavIC-disciplined 10MHz reference for SATCOM networks

We have implemented the circuit design comprising of phase detector, limiter, loop filter, NCO and clock divider in hardware using FPGA. The disciplined 10MHz is measured to have a long term (10,000 sec) stability of 1.7 x 10^{-10}. In case of non-availability of NavIC 1PPS, the circuit is designed to work with an internal 1PPS signal.

Kriti Khatri
Scientist, Space Applications Centre (SAC), Indian Space Research Organization, India

M R Sujimol
Delhi Earth Station, Space Applications Centre (SAC), Indian Space Research Organization, India

Urvashi Bhat
Delhi Earth Station, Space Applications Centre (SAC), Indian Space Research Organization, India

K Shahana
Head , Delhi Earth Station, Space Applications Centre (SAC), Indian Space Research Organization, India

Introduction

Satellite communication network can be established using microwave signals with accurate, stable and low noise frequencies. Many frequency-based devices with independent local oscillators are used in an Earth Station to generate and convert carrier frequencies and modulate/demodulate data. Even RF measurement instruments like Frequency Counters, Signal generators, Spectrum Analyzers have reference oscillators that need periodic calibration. It is essential to connect these instruments to a common reference, with low phase noise and long term stability of an atomic frequency standard in order to minimize frequency drift issues and for supporting higher data rates [1][2].

SATCOM networks generally use the GPS 1PPS signal for synchronization. The motivation of this work is to design and develop a circuit to generate a 10 MHz reference output derived from the NavIC 1PPS signal as the primary reference, thus reducing the dependency on a foreign system for an assured indigenous system guaranteed to be available to Indian users.

The organization of the paper is as follows. Section II explains the design and implementation of the proposed disciplining circuit. Test results are presented in section III along with a discussion, with section IV concluding the paper.

FPGA design and implementation

For the synchronization of an Earth Station, a typical scheme uses a GNSS (NavIC) receiver to derive the timing solution in the 1 PPS format, which is then used to obtain the desired 10MHz stable input (see Figure 1). The disciplining 10MHz using NavIC 1 PPS signal is based on a phase detector to sense the difference of it from internal 1 PPS derived from a local OCXO (as in figure 2). The phase frequency detector (PD) measures the phase and frequency difference between the external NavIC 1PPS clock reference and the internally generated 1PPS from the Numerically Controlled Oscillator (NCO)[3], [4].

In this design, phase-lock detection using a magnitude comparator and a re-triggerable counter is implemented in VHDL. The magnitude comparator measures error count of the limiter. The counter counts down when the error count is less than a fixed threshold value. It is retriggered if the error count exceeds the threshold.

Phase detector (PD) works on the principle of comparing the timing relationship between the internal and external signals to increase and decrease the Frequency Control Word (FCW).

Case 1 ensures that Frequency Control Word (FCW) does not change when the phase/frequency difference is zero,

Case 2 increases the frequency of the digital oscillator when the external timing signal leads the internal signal and

Case 3 decreases the frequency of the digital oscillator when the external timing signal lags the internal signal.

The 32 bit FCW controls the output frequency of the DDS as per the equation [5]:

$$f_{DDS} = \frac{FCW}{2^M} f_s \quad (1)$$

Where, M = phase width, 32bit
f_s = Source Frequency, 100 MHz
f_{DDS} = Required frequency, 10MHz

A limiter is used to adjust the frequency of the digital oscillator arising from initial phase errors. The limiter limits the amount of change applied to the FCW of the digital oscillator per period of the external timing signal. Following the limiter is a loop filter which is a discrete standard filter and the digital oscillator is implemented using a DDS IP core. The FCW controls the frequency of the DDS, which is an accumulator (integrator) that adds the phase error output of the filter to itself. The digital output from the DDS is converted to analog using a 16-bit Dual channel DAC providing In phase (I) and Quadrature phase (Q) analog outputs with a 90^0 phase shift.

To generate disciplined 10MHz analog signal, different techniques like Direct Digital Frequency Synthesizer (DDS), Phase Lock loop (PLL), Clock generators on FPGA to dynamically program the output of a DAC etc. were considered. The best option of using DAC interfaced with FPGA was considered as per the comparative assessment shown in Table 1 [6].

Specifications for the NavIC-Disciplined 10MHz reference are identical to the existing (GPS-based) system and are given in Table 2. FPGA implementation in

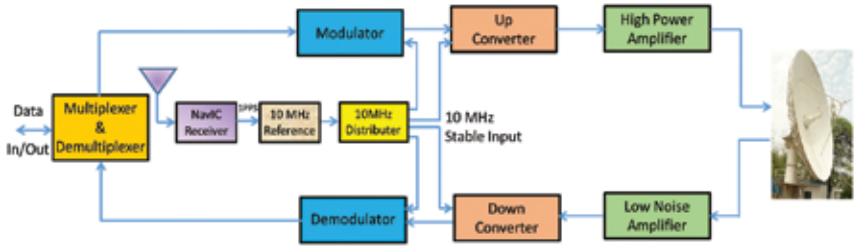


Figure 1: Earth Station Synchronization using NavIC-derived 1 PPS Signal

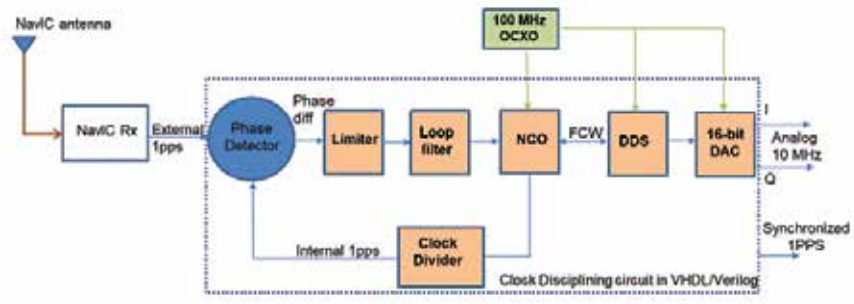


Figure 2: Circuit Schematic Diagram of Clock Disciplining Circuit

Table 1: Options considered for design

	Analog PLL	Discrete DAC + FPGA	DDS
Spectral Performance	High	Medium-High	Medium
Power Requirements	High	High	Low
Digital Frequency Tuning	No	Yes	Yes
Tuning Response Time	High	Low	Low
Waveform Flexibility	Low	Medium	High
Remarks	Difficult to Tune	Ability to Tune	Easy to Tune

Table 2: Specifications of NavIC disciplined 10MHz Reference

NavIC Receiver	
Frequency Band	L5
1PPS Accuracy	60 ns
TTFF	≈120 sec (Cold Start)
Update Rate	1 Hz
OCXO Timebase	
Oscillator Type	Oven controlled, SC-cut Crystal
Temp. Stability	$\pm$ 30 x 10^{-9}
Ageing	$\pm$ 2x10^{-9} per day
Warm up time	3 min to reach within $\pm$ 0.01ppm
10MHz Output	
Amplitude	+2.5 dBm
Harmonic Level	-60dBc
Frequency Stability @ 25°C	short term stability (1 sec): 2.1 x 10^{-10} Long term stability (10,000 sec): 1.7 x 10^{-10}
Phase Noise	
10Hz	-98.15 dBc/Hz
100Hz	-101.64 dBc/Hz
1KHz	-106.74 dBc/Hz
100KHz	-108.14 dBc/Hz

Figure 3: Hardware test setup

Figure 4: NavIC Receiver 1PPS

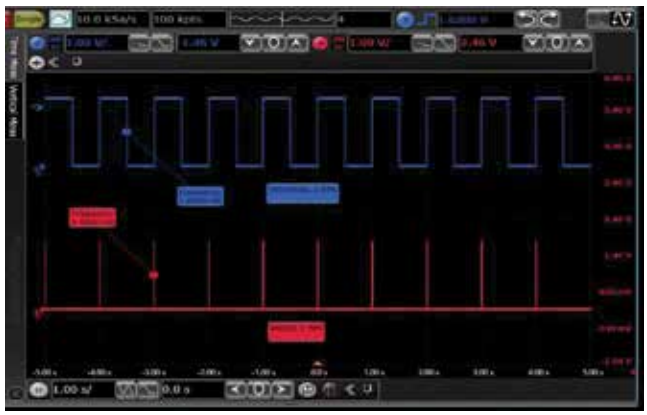


Figure 5: Synchronized NavIC and Internal 1PPS

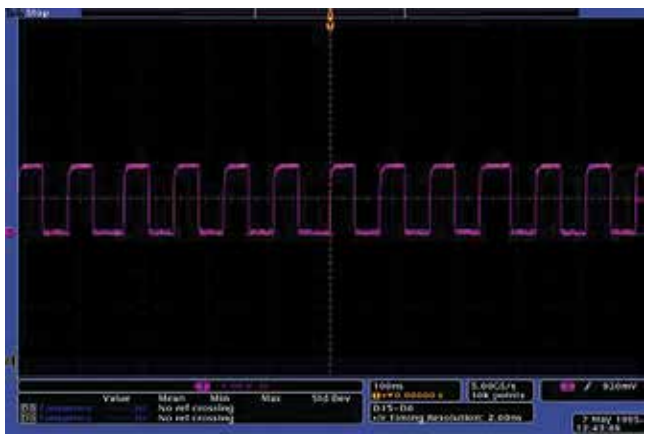


Figure 6: 10 MHz Digital Output

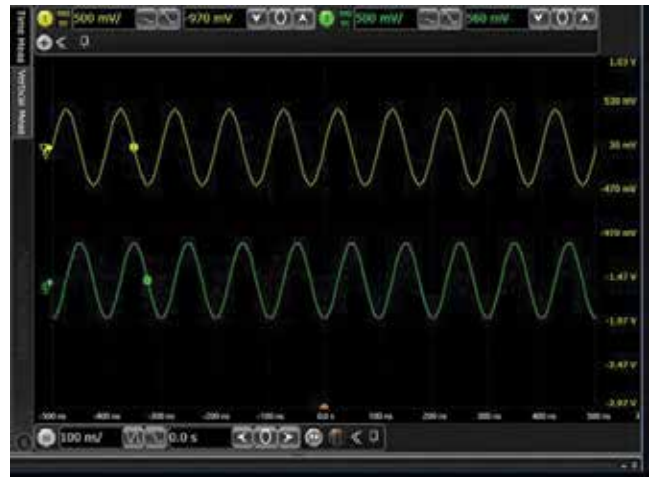


Figure 7: 10 MHz Analog Output

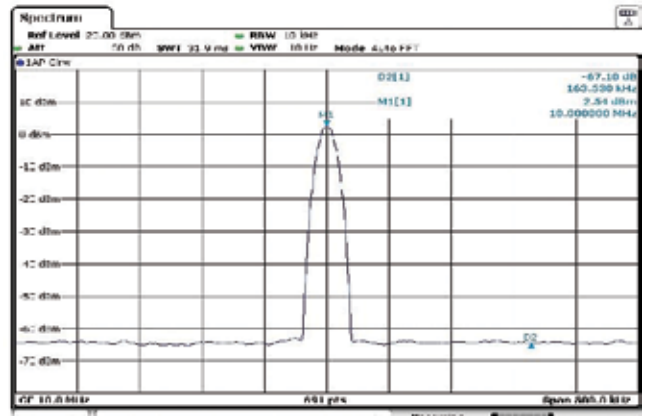


Figure 8: 10 MHz Analog Output measured on a spectrum analyzer.

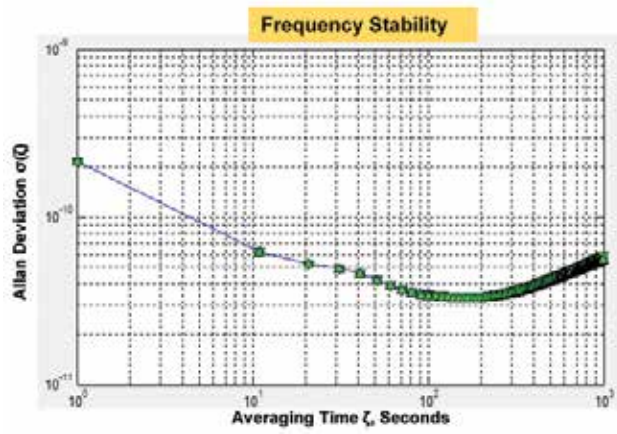


Figure 9: Frequency Stability Measurement

Table 3: Phase Noise of 10MHz Signal vs Industry standards

Carrier Frequency Offset	IESS 308/309 maximum allowable phase noise	NavIC Disciplined 10MHz Signal phase noise
10Hz	-30 dBc/Hz	-98.15 dBc/Hz
100Hz	-60 dBc/Hz	-101.64 dBc/Hz
1KHz	-70 dBc/Hz	-106.74 dBc/Hz
100KHz	-90 dBc/Hz	-108.14 dBc/Hz

sync with NavIC 1PPS was realized using NavIC Receiver [7] and COTS hardware viz., Kintex KC705 FPGA [8], FMC-150 (dual, 16-bit D/A) [9] and 100MHz OCXO [10] (Figure 3). The DDS IP core in FPGA and a Discrete DAC were used to generate a sinewave output with a specified frequency of 10MHz and phase (adjustable at runtime). The FMC-150 Daughter card has two 16-bit D/A Channels which give output in the range of 1V p-p.

The single band 11 channel NavIC SPS receiver based on ASIC (Figure 4) is fabricated by ISRO's 180nm CMOS foundry located at SCL Chandigarh. It has an acquisition and tracking sensitivity of 36 dBHz and 28 dBHz respectively with a 1PPS accuracy of around 60 ns.

Results and discussion

The synchronized 1 PPS FPGA output derived from NavIC indicates a coincidence with the trailing edge of the pulses (Figure 5). The corresponding 10MHz Digital and Analog outputs provide the desired waveforms (Figures 6 & 7) with a power level of +2.5dBm (Figure 8). The power consumption at the hardware in steady state is 5.71 W.

Frequency stability of clock, oscillators is measured using two-sample variance, the Allan variance (AVAR) method as represented in equation (2) & (3) [11]. The frequency stability of 10 MHz output is recorded (in CSV) using a frequency counter [12] with 12 digits/sec resolution and then processed using MATLAB code. The obtained stability values arrived at from the Allan deviation [12] plot show excellent performance (figure 9).

Allan Variance,

$$\sigma_y^2(\tau) = \frac{1}{2}\langle \left(\overline{y}_{n+1} - \overline{y}_n\right)^2 \rangle \qquad (2)$$

Allan deviation,

$$\sigma_y(\tau) = \sqrt{\sigma_y^2(\tau)} \qquad (3)$$

Where τ is the observation period, $\bar{y}_n$ is the n^{th} fractional frequency average over observation time τ.

The Intelsat Earth Station Standards IESS 308/309 [13], [14], [15] are adopted for the maximum acceptable phase noise levels in Earth stations. By designing systems which comply to these standards, the system reliability and interoperability could be assured. The disciplined output phase noise results are seen to be clearly better than these industry-specified standards (see table 3).

The disciplining process calibrates the oscillator by continuously compensating for the, frequency drift, environment effects and aging. In case of non-availability of the NavIC 1 PPS, the long-term stability of the output follows that of the 100MHz OCXO.

Conclusion

NavIC 1 PPS signal was used to discipline a 100MHz OCXO frequency source to generate a reference frequency output of 10MHz. Implementation was carried out using Kintex KC705 FPGA, FMC-150 DAC board, 100MHz OCXO and in-house developed NavIC Receiver. The disciplined 10MHz output has a short term (1 sec) stability of 2.1×10^{-10} and a long term (10,000 sec) stability of 1.7×10^{-10} with phase noise better than Industry-standards. The 10MHz signal was fed as an external reference to Ka-band LNBC (Ka-L down converter in downlink chain) and Spectrum Analyzer, with both the setups performing well giving the expected outputs.

Acknowledgements

Acknowledgements are due to Director SAC, Associate Director SAC and Deputy Director SSAA for their motivational support, encouragement and Mr. Rakesh Kumar Bijarniya, Mr. Wikneswaran Pillai and Ms Anita Panday for guidance related to programming. The authors would also like to acknowledge support from various members of Technology Development Program team at SAC.

References

[1] https://www.furuno.com/en/gnss/case/communitybroadcasting

[2] "Introduction to Timing and Synchronisation", White Paper, Chris Farrow, Chronos Technology.

[3] https://github.com/dfannin/gpsdo

[4] https://en.wikipedia.org/wiki/GPS_disciplined_oscillator

[5] "Direct Digital Synthesizer IP Core", Martin Kumm, December 2008.

[6] "DDS Devices Generate High-Quality Waveforms Simply, Efficiently, and Flexibly." Brendan Cronin, Analog Dialogue 46-01, January (2012).

[7] https://www.isro.gov.in/sites/default/files/irnss_sps_icd_version1.1-2017.pdf

[8] KC705 Evaluation Board User Guide, UG810 (v1.7) July 8, 2016

[9] FMC150 User Manual, Abaco systems, July 2013.

[10] http://www.andhraelec.com/httpdocs/catalogue/OCXO%202055.pdf

[11] https://en.wikipedia.org/wiki/Allan_variance

[12] https://www.keysight.com/in/en/assets/7018-02642/data-sheets/5990-6283.pdf

[13] https://itso.int/wp-content/uploads/2018/04/Intelsat-ITSO-Trinidad-Earth-station-equipment.pdf

[14] http://www.intelsat.com/wp-content/uploads/2017/03/IESS-308E11.pdf

[15] http://www.intelsat.com/wp-content/uploads/2017/03/IESS-309E.pdf

In Coordinates

10 years before...

mycoordinates.org/vol-8-issue-1-January-2012

It cannot go on forever... We have to find a solution!

Durk van Willigen
Delft University of Technology, em. Prof Dr Reelektronika BV, CEO, The Netherlands

A solution shall be found as both, GPS and telecom networks are essential parts of today's economies. GPS might shrink their spectrum needs and the GPS industry/providers/users could start paying for the spectrum. Both solutions, at present, are most likely just wishful thinking. So, the only remaining solution is to improve GPS receivers so that they can withstand the new powerful neighbours. However, this may cause a costly operation and logistically nearly impossible to realize in a couple of years.

"The compatibility between the EU system and other GNSS systems is our main concern"

says Antonio Tajani, Vice President, European Commission in an interview with Coordinates

Space policy is an instrument serving the Union's internal and external policies. We all use space based applications throughout our daily lives. Galileo, EGNOS and GMES are part of the EU Space Policy. The EU invests in space for the benefit of the citizens. It also supports the EU as a global economic power. Clearly, space is part of our identity. This is recognized by the recent Lisbon Treaty which confirmed the important role for the EU in space matters.

PPP using combined GPS/ GLONASS measurements

Mohamed Azab
Visiting graduate student (Ph.D.), Department of Civil Engineering Ryerson University Toronto, Ontario, Canada

Dr Ahmed El-Rabbany
P.Eng. Professor, Geomatics Engineering Graduate Program Director, Department of Civil Engineering, Ryerson University, Toronto, Ontario, Canada

Dr M Nabil Aly Shoukry
Professor, Surveying and Geodesy Department of Civil Engineering, Faculty of Engineering, Alexandria University, Alexandria, Egypt

Dr Ramadan Khalil
Professor, Surveying and Geodesy, Department of Civil Engineering Faculty of Engineering Alexandria University Alexandria, Egypt

This study investigates the effect of combining GPS and GLONASS dual-frequency measurements on the static PPP solution and its sensitivity to different processing strategies

LIDAR for visualization of 3D geological models

Reginaldo Macedônio da Silva , Leonardo Campos Inocencio , Larissa Jacobi, Débora Lamberty, Francisco Manoel Wohnraht Tognoli and Mauricio Roberto Veronez
Universidade do Vale do Rio dos Sinos, Brazil

This study has shown that LIDAR/ TLS is an efficient technique for geological purposes. DOMs are an efficient tool for helping in the planning a field activity as well as in high accuracy measurements of geological features such as thickness of beds, size of clasts and orientation of fractures.

2020 World Population Data as KML, GeoJSON, Shapefile

A free world population point layer with 2020 population counts at 1km intervals is now available for download, providing the ability to analyze population anywhere on earth. The point locations can be explored with the tools and data already included with Maptitude mapping software, such as drive-time rings and market area reports. The data are also available as shapefile, KML, KMZ, or GeoJSON for a fee. *www.caliper.com*

BLUIS Odisha wins 'Gold'

The Bhubaneshwar Land Use Intelligent System, or BLUIS, run by the state government of Odisha, India has been selected to be awarded 'Gold' under Category V that is 'Excellence in adopting emerging technologies' in the National Awards for e-Governance.

BLUIS has been developed for safeguarding government lands in Bhubaneswar city by leveraging space technologies and geo informatics. Its web-portal and mobile app is developed by Odisha Space Applications Center (ORSAC) using Space Technology, Artificial Intelligence/Machine Learning (AI/ML) based image processing, Geo-ICT and Web Technologies as per the requirement of the Bhubaneswar Development Authority and Bhubaneswar Municipal Corporation (BMC). BLUIS aims at detecting unauthorized constructions on pieces of land that are under the control of the General Administration Department, BMC and Bhubaneshwar Development Authority. *https://odishabytes.com*

Digital Twin City Dashboard by a Dutch consortium

The European Union awards an €800,000 (approximately $900,000) grant for the "Smart City Monitor" project, making it available to a Dutch consortium of six commercial, governmental, and educational parties. Offering innovative use of insights into visitor and traffic flows in the inner city, Smart City Monitor positively influences the city's attractiveness, health, and accessibility. The development of the Smart City Monitor, a modern dashboard come to life as a Digital Twin City, is currently in the hands of the municipality of Den Bosch, the city of Breda, the Jheronimus Academy of Data Science, the Breda University of Applied Sciences, and intelligent data companies Argaleo and Geodan.

In addition to providing insight into visitor and traffic flows, the monitor also provides statistics on air quality, visitor experience, and more. Linking the different data includes essential predictions, providing evidence-based solutions for intelligent provisioning, sustainable transport, and further greening. Other benefits include entrepreneurs having the tools to adjust their planning and marketing based on anticipated traffic. *www.argaleo.com*

Esri India launches 'Indo ArcGIS'

Esri India have launched Indo ArcGIS to address the need for ready-to-use GIS based solutions and geospatial content for the GIS users in India. It includes solution products in the areas of Forest Management, Disaster Management, Electrical Utilities, Land Records and Property Tax Management. Solution Products for several other segments are under development. These solutions can easily be deployed by ArcGIS users. Esri India is also providing more than 300 layers of data through the Indian edition of ArcGIS Living Atlas.

TerraPulse to map forest

TerraPulse has been selected by the countries of Belize, Costa Rica, and the Dominican Republic to map forest cover as part of a sweeping forest activity study funded by The World Bank. Through the program, it will apply scientifically peer-reviewed AI to nearly forty years of satellite imagery to support the countries' monitoring of forest assets. The approach fuses data from local sources with global satellite data from NASA; the results will enable carbon modeling and the development of greenhouse gas inventories for the United Nations' Land Use, Land-Use Change and Forestry (LULUCF) land sector initiative. *www.terrapulse.com*

Autodesk to acquire ProEst

Autodesk, Inc. shall be acquiring ProEst, a cloud-based estimating solution that enables construction teams to create estimates, perform digital takeoffs, generate detailed reports and proposals and manage bid-day processes. Autodesk plans to integrate ProEst with Autodesk Construction Cloud. The acquisition will strengthen Autodesk Construction Cloud's preconstruction offerings and empower construction teams to manage all their critical preconstruction and construction workflows on one platform. *www.autodesk.com*

Public dialogue on location data ethics published

The Geospatial Commission has published the findings of an independent public dialogue on location data ethics. The project was launched in March and co-funded by the Geospatial Commission and UK Research and Innovation's Sciencewise programme.

The dialogue is one of the U.K.'s first on location data and was delivered by public engagement specialists Traverse and researchers from the Ada Lovelace Institute. Today's report provides evidence on public perceptions about location data use, offering valuable insights into what citizens believe are the key benefits and concerns.

The report was launched at a virtual event by the Alan Turing Institute, the national institute for data science and artificial intelligence. This public dialogue opened a conversation with 85 members of the public from all four nations to gather evidence on public perceptions about location data use. The dialogue was supported by an independent and expert Oversight Group, which provided expert support and quality assurance from a diversity of perspectives. *www.gov.uk*

Emergency room GIS system to detect infectious diseases

National Taiwan University Hospital (NTUH) has partnered with National Taiwan University's (NTU) Department of Geography to develop a geographic information system (GIS) based on emergency room (ER) patient data that actively detects the spread of infectious diseases early on. According to NTU Department of Geography professor Wen Tzai-hung, ERs are the first place to detect epidemics when they happen. By detecting abnormal ER traffic and combining the information with patients' symptoms, disease onset times, and location of residence, one would be able to actively analyze features of infectious diseases, predict spread patterns, or even trace the origin of the diseases before large-scale outbreaks occur.

According to Wen, the latest GIS includes syndromic and pathogen information so that one can cross-reference medical and spatial data, which helps public health authorities pinpoint the source of epidemics and take preventative measures as soon as possible. The GIS developers have analyzed historical data from 2018's respiratory and gastrointestinal syndromes with the system and plan to better train its prediction abilities by actively detecting and analyzing data from the current COVID pandemic next. The team hopes to test the system in hospital ERs this year and deploy it to detect COVID-19 infection clusters in 2022. *www.taiwannews.com*

Bentley Systems announces Seequent's acquisition of AR2Tech

Bentley Systems' Seequent business unit has acquired Denver-based Advanced Resources and Risk Technology, LLC (AR2Tech), a developer of geostatistical software applications. The acquisition provides Seequent with state-of-the-art geostatistics algorithms, technology, and IP for complex geospatial problem solving, complementing its geological modeling solutions and workflows, to help solve earth, environmental, and resources challenges. *www.bentley.com*

ISRO and OPPO India to work towards providing NavIC messaging services

NavIC system, in addition to its primary function of providing PNT services, is also capable of broadcasting short messages. This messaging service is being used for broadcasting safety-of-life alerts in areas with poor or no communication, particularly in the oceans.

Indian Space Research Organisation has entered into Memorandum of Understanding (MoU) with OPPO India to exchange technical information of NavIC messaging services. This will enable integrating NavIC messaging service with the mobile handset platform keeping in mind the need of Indian users.

Secretary, DOS / Chairman, ISRO appreciated the efforts of OPPO India in scaling NavIC application through their innovative R&D initiatives. He also urged them to include NavIC in all their upcoming mobile platforms that use location based solutions. *www.isro.gov.in*

5G deployment by FAA

The Federal Aviation Administration (FAA) released the list of 50 airports that will have buffer zones when wireless companies turn on new 5G C-band service on January 19. The agency sought input from the aviation community where the proposed buffer zones would help reduce the risk of disruption. Traffic volume, the number of low-visibility days and geographic location factored into the selection.

Many airports are not currently affected by the new 5G deployment, even though they are not on this list. These include airports not in the 46 markets where the new service will be deployed and airports that do not currently have the ability to allow low-visibility landings.

The wireless companies agreed to turn off transmitters and make other adjustments near these airports for six months to minimize potential 5G interference with sensitive aircraft instruments used in low-visibility landings.

The FAA continues to work with the aerospace manufacturers and wireless companies to make sure 5G is safely deployed and to limit the risk of flight disruptions at all airports. *www.faa.gov*

BeiDou conducts laser communication experiment

China has conducted a pioneering high-speed communication experiment using lasers, rather than the usual radio signals, between satellites in its BeiDou navigation system and ground stations on Earth.

The method could allow a satellite to beam data to the ground at several gigabytes per second, rather than kilobytes at present, according to researchers involved. BeiDou's fastest communication performance in the experiment remains classified.

China and the United States are in an intense race to establish laser communication networks in space. Nasa recently announced that, after a two-year delay, it would soon month launch an experimental satellite to conduct similar experiments, testing data transmission via laser beam at 2.8GB per second. *www.thestar.com*

GPS tracking of all public transport vehicles in Puducherry, India

The Union Ministry of Road Transport and Highways (MORTH) in India has authorized an outlay of ₹3.25 crore to the Union Territory of Puducherry for establishing a GPS Monitoring Center in accordance with its guidelines.

The fund will be used for setting up the infrastructure, development, customization, deployment, and management of State-wise Vehicle Tracking Platform for safety and enforcement as per the specification under the 'Nirbhaya framework' (a set

of initiatives aimed at enhancing the safety and security for women in the country). As many as 14,000 public transport vehicles will be tracked once the GPS Monitoring Center is put in place by the Transport Department.

While all new vehicles registered with the regional transport offices in the territory from January 1, 2019 are mandated to be fitted with GNSS, the vehicle location tracking device and emergency button shall be retrofitted by vendors approved by MORTH for the older vehicles which were registered before January 1, 2019. *www.thehindu.com*

The Galileo constellation grows bigger after successful launch 11

Two new Galileo satellites were successfully launched from the European spaceport in Kourou, French Guiana on 4 December 2021, bringing the number of Galileo satellites launched to a total of 28 satellites, thereby enabling the provision of more robust services and precise signals across a range of industries.

The Soyuz launcher VS-26, successfully lifted off from Kourou, French Guyana, for a nearly four-hour voyage till the separation of the Galileo satellites 27-28 from the rocket. The Galileo Launch 11 is the first of a series of 6 launches (with two satellites per launch), which will allow Galileo to deliver greater accuracy to existing users and open up new market opportunities.

The Galileo satellites are currently managed by the EU Agency for the Space Programme (EUSPA) and its industrial team, in charge of the satellite operations from the separation of the Launch vehicle onwards, as part of the Launch and Early Orbit Phase (LEOP). The LEOP is one of the crucial phases of a space mission during which the spacecraft is launched and put into the correct orbit and the first satellite elements are gradually switched on and tested. *euspa.europa.eu*

First UK-generated national satnav signal to be delivered in test project

Inmarsat, the world leader in global, mobile satellite communications is working on a UK Space Agency-funded test project with the European Space Agency, alongside British partners Goonhilly Earth Station Limited and GMVNSL Limited, to deliver the first UK-generated satellite navigation (satnav) signal. The project provides a potential platform for the UK to enhance its capabilities in the Positioning, Navigation and Timing (PNT) domain post-Brexit.

Repurposing a transponder from the Inmarsat-3 F5 (I-3 F5) satellite, the test project – UK Space Based Augmentation System or UKSBAS – will provide an overlay signal to augment the United States Global Positioning System (US GPS) satellite navigation system. This can refine the precision of the signal from a few metres to a few centimetres in accuracy.

UKSBAS will provide a basis to assess its future development into an operational capability to support safety-critical applications such as aircraft approaching and landing at airports or navigating ships through narrow channels, especially at night and in poor weather conditions. Goonhilly will provide the uplink for the system from Cornwall and software from GMVNSL, based in Nottingham, will generate the ground-based navigation signal. This is a similar system to that already in use in Australia and New Zealand, supported by Inmarsat. UKSBAS will be the first UK-generated national satnav signal.

This project could be crucial for UK users who need accurate, high-integrity navigation capabilities to enable their operations, initially covering aviation and maritime operations but with potential extension into rail and other land vehicle applications. For example, UKSBAS will be International Civil Aviation Organization (ICAO) standards-compliant.

The UK no longer has access to the European Geostationary Navigation Overlay Service (EGNOS) Safety of Life services since leaving the European Union (EU) and is not involved in the EU's Galileo programme for similar reasons. Therefore, this new national capability supported by current and future Inmarsat satellites could offer a new option for high-integrity, precision navigation across the country, in its airspace and within surrounding waters.

I-3F5 is in geosynchronous orbit at 54° west, ensuring that its signal covers the UK as part of its Atlantic Ocean region service overlay. This makes it an ideal candidate to participate in this test. The satellite was manufactured by Inmarsat's Athena partner Lockheed Martin and launched in 1998.

"This project demonstrates British innovation at its best," said Nick Shave, Vice President of Strategic Programmes for Inmarsat Global Government. "Working with Goonhilly Earth Station and GMVNSL, supported by UK funding via the ESA Navigation Innovation and Support Programme (NAVISP), enables us to extend the long life of Inmarsat's I-3 F5 satellite with additional new services designed two decades after launch.

We look forward to exploring the potential for this project and the benefits it could deliver to the UK with more precise, high-integrity, resilient navigation services, whilst also exploring future capabilities on new satellites through Inmarsat's fully funded technology roadmap. This work also has the potential to be exported to other nations around the world, benefitting the UK economically as well as technologically." *www.ukspace.org*

Incentives for setting up of Semiconductors Fabs and Display Fabs in India

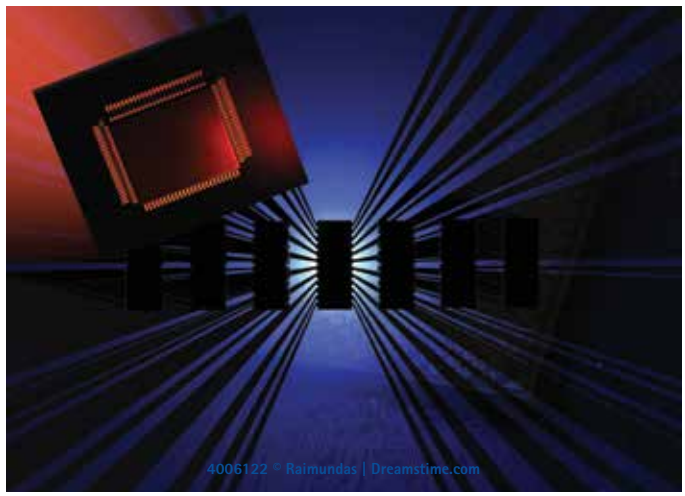
In furtherance of the vision of Aatmanirbhar Bharat and positioning India as the global hub for Electronics System Design and Manufacturing, the Cabinet approved the comprehensive program for the development of sustainable semiconductor and display ecosystem in the country with an outlay of Rs.76,000 crore (>10 billion USD). The programme will usher in a new era in electronics manufacturing by providing a globally competitive incentive package to companies in semiconductors and display manufacturing as well as design. This shall pave the way for India's technological leadership in these areas of strategic importance and economic self-reliance.

Semiconductors and displays are the foundation of modern electronics driving the next phase of digital transformation under Industry 4.0. Semiconductors and display manufacturing is very complex and technology-intensive sector involving huge capital investments, high risk, long gestation and payback periods, and rapid changes in technology, which require significant and sustained investments. The programme will give an impetus to semiconductors and display manufacturing by facilitating capital support and technological collaborations.

The programme aims to provide attractive incentive support to companies / consortia that are engaged in Silicon Semiconductor Fabs, Display Fabs, Compound Semiconductors / Silicon Photonics / Sensors (including MEMS) Fabs, Semiconductor Packaging (ATMP / OSAT) and Semiconductor Design.

Following broad incentives have been approved for the development of semiconductors and display manufacturing ecosystem in India:

Semiconductor Fabs and Display Fabs: The Schemes for Setting up of Semiconductor Fabs and Display Fabs in India shall extend fiscal support of up to 50% of project cost on pari-passu basis to applicants who are found eligible and have the technology as well as capacity to execute such highly capital and resource intensive projects. Government of India will work closely with the State Governments to establish High-Tech Clusters with requisite infrastructure in terms of land, semiconductor grade water, high quality power, logistics and research ecosystem to approve applications for setting up at least two greenfield Semiconductor Fabs and two Display Fabs in the country.



Semi-conductor Laboratory (SCL): Union Cabinet has also approved that Ministry of Electronics and Information Technology will take requisite steps for modernization and commercialization of Semi-conductor Laboratory (SCL), Mohali. MeitY will explore the possibility for the Joint Venture of SCL with a commercial fab partner to modernize the brownfield fab facility.

Compound Semiconductors / Silicon Photonics / Sensors (including MEMS) Fabs and Semiconductor ATMP / OSAT Units: The Scheme for Setting up of Compound Semiconductors / Silicon Photonics / Sensors (including MEMS) Fabs and Semiconductor ATMP / OSAT facilities in India shall extend fiscal support of 30% of capital expenditure to approved units. At least 15 such units of Compound Semiconductors and Semiconductor Packaging are expected to be established with Government support under this scheme.

Semiconductor Design Companies: The Design Linked Incentive (DLI) Scheme shall extend product design linked incentive of up to 50% of eligible expenditure and product deployment linked incentive of 6% - 4% on net sales for five years. Support will be provided to 100 domestic companies of semiconductor design for Integrated Circuits (ICs), Chipsets, System on Chips (SoCs), Systems & IP Cores and semiconductor linked design and facilitating the growth of not less than 20 such companies which can achieve turnover of more than Rs.1500 crore in the coming five years.

India Semiconductor Mission: In order to drive the long-term strategies for developing a sustainable semiconductors and display ecosystem, a specialized and independent "India Semiconductor Mission (ISM)" will be set up. The India Semiconductor Mission will be led by global experts in semiconductor and display industry. It will act as the nodal agency for efficient and smooth implementation of the schemes for setting up of Semiconductor and Display Fabs. *www.meity.gov.in*

CHORUS Earth Observation mission

MDA Ltd has announced its next generation commercial Earth observation (EO) mission will be named CHORUS. It will initially include C-band and X-band Synthetic Aperture Radar (SAR) satellites. A collaborative multi-sensor constellation, CHORUS will bring together multiple diverse and unique perspectives in harmony, opening the aperture and the art of the possible to provide a new level of real-time insight about our planet.

The powerful C-band SAR satellite will provide broad area coverage in concert with a smaller trailing X-band SAR satellite for higher resolution data collection and Near Real-Time (NRT) cross-cueing day or night and in all weather conditions. The X-band satellite will fly in the same mid-inclination orbit with the identical ground track as the MDA-built C-band SAR satellite. *https://mda.space/en*

Airbus imagery and elevation data now in Azure Maps

Airbus satellite imagery and elevation data will now be available in Microsoft Azure Maps, which is a collection of geospatial services and Software Development Kits (SDKs) that use fresh mapping data to provide geographic context to web and mobile applications.

Under the agreement between Airbus and Microsoft, Airbus will feed Azure Maps with its SPOT, Pléiades and Pléiades Neo satellite imagery and WorldDEM4Ortho elevation data. These premium data services will empower the Azure Maps users to build location intelligence solutions for Internet of Things and Artificial Intelligence and create data visualizations for web and mobile apps. *www.airbus.com*

New Symphonie consortium wins EC call for tender

New Symphonie, the recently established consortium of 22 European companies, has won the European Commission call for tenders entitled "New Space solutions for long-term availability of reliable, secure, cost-effective space-based connectivity".

Selected for its exceptional innovation and familiarity with leading-edge technologies, the consortium led by UNSEENLABS and EUROCONSULT will be awarded a six-month study contract for a total amount of 1.4m euros. Through the study, the consortium members will investigate and recommend to the EC the most optimal infrastructure for secure connectivity markets. The study aims at defining the secure connectivity requirements that could be addressed by a European multi-orbit satellite system to be conceptually designed with innovative technologies for an attractive business plan. *www.euroconsult-ec.com*

NASA selects Orbital Reef to develop Space station replacement

Orbital Reef, led by partners Blue Origin and Sierra Space, was selected by NASA for a funded Space Act Agreement for collaboration to design a commercially owned and operated space station in low Earth orbit (LEO). NASA's Commercial LEO Development program aims to shift NASA's research and exploration activities in LEO to commercial space stations, helping stimulate a growing space economy before the International Space Station is retired. The Orbital Reef team includes Boeing, Redwire Space, Genesis Engineering Solutions, and Arizona State University. *www.orbitalreef.com*

Spaceport SARABHAI – India's first Space think tank

Spaceport SARABHAI (S2) is India's 1st dedicated Space think tank that aspires to be global, collaborative, and inclusive. Though S2 was launched on 2 October 2021 at the Bangalore International Center, a formal launch announcement was made recently.

The think tank is based in Bangalore, with satellite presence in New Delhi, Berlin, Sendai, and San Francisco. During the launch, Dr. Susmita Mohanty, Director-General S2, said, "S2 embraces the multi-dimensional nature of human space endeavors. The S2 lens includes, among others, the geopolitical, scientific, economic, legal, safety, security, sustainability issues related to outer space activities." She also informed that S2 would be engaging with ISpA and IN-SPACe and will undertake research to size the Indian Space economy.

The think tank name is an homage to the founder of India's space program: Dr. Vikram Sarabhai, a physicist, a visionary, and a renaissance man. S2 is conceived as a launchpad for ideas for a shared future.

Focus on RS satellite development in Malaysias' national space blueprint

Malaysia is developing a national space blueprint to drive the growth of its space sector, particularly the manufacturing of remote-sensing satellites, satellite components and data-driven downstream services.

During a Dec. 13 parliamentary hearing, a deputy minister shared the latest update on the "Malaysia Space Exploration 2030" blueprint being fleshed out by Malaysia's Ministry of Science, Technology and Innovation. The blueprint outlines a 10-year strategy in line with Malaysia's National Space Policy 2030. The policy, adopted in 2017, recognizes the importance of space technologies for the country's economic growth and national security. *https://spacenews.com*

China, Russia scaling up cooperation in space, energy sector

China and Russia are boosting cooperation in space exploration, in the energy segment and in the trade sphere, President of China Xi Jinping said in the New Year greetings telegram to Russian President Vladimir Putin.

"China and Russia achieved new records in bilateral trade; we are scaling up cooperation in major strategic projects in the energy sector and in the aerospace sphere," the Chinese leader said. China and Russia have successfully completed the year of scientific and technical cooperation, he noted. *https://tass.com*

Multiclass object detection algorithms for ships, aircraft and vehicles

Orbital Insight has launched multiclass object detection algorithms within its GO platform. It uses advanced computer vision algorithms to identify and differentiate between classes of ships, aircraft and vehicles within satellite imagery. The state-of-the-art multiclass ship detection algorithms will bring immediate benefits to the defense and intelligence community for security, supply chain and other critical needs.

Orbital Insight's flagship GO platform is purpose-built for the DoD/Intelligence Community to deliver insights in a cloud-agnostic, secure and readily deployable environment. It combines information from the world's sensors—including satellite, aerial, AIS and IoT devices—to analyze economic, societal and environmental trends at scale. *www.orbitalinsight.com*

ST Engineering invests in hiSky

ST Engineering Ventures Pte Ltd has led a US$30m Series A round in Israel-based hiSky Ltd., developer and provider of affordable and agile satellite Internet of Things (IoT) networks and solutions, with participation from SDF (Strategic Development Fund), the investment arm of Tawazun Holding, and hiSky's existing shareholders. The investment in hiSky enables ST Engineering iDirect, to leverage the former's cost-effective and easy-to-install IoT network. *www.hiskysat.com*

Siemens expands collaboration with AWS

Siemens Digital Industries Software and Amazon Web Services, Inc. (AWS) announces an expansion of their collaboration, which combines Siemens' deep industry expertise with cloud services from AWS to help industrial companies accelerate digital transformation in the cloud. Both plan to drive adoption of Siemens' Xcelerator as a Service and make Siemens' Xcelerator portfolio of integrated software, services, and application development platform more accessible, scalable, and flexible. *www.sw.siemens.com*

Collaboration between Sensible 4 Oy and MOOVE GmbH

Acollaboration between MOOVE GmbH and Sensible 4 Oy has been announced. Together the companies are aiming to bring a new self-driving serial-produced shuttle bus to the European market in 2023. Finnish self-driving technology company Sensible 4 will automate the PeopleMover, a customizable vehicle that can carry up to 19 passengers. *https://themoove.com*

Targomo expands location analytics to 24 countries

Berlin-based location intelligence startup Targomo is in the midst an international expansion of its location analytics platform. Users now have access to information on locations in a total of 24 countries, seven of them outside Europe, and including the US. Much of Targomo's expansion success is driven by German-based customers who are also taking advantage of the analytics platform in their international expansion, whether in retail, quick commerce, or planning for gyms, restaurant chains, and Ghost Kitchens. *www.targomo.com*

TomTom IndiGO

TomTom IndiGO is the world's first open digital cockpit software platform for carmakers. It brings users' digital lives and access to car functions seamlessly and safely into the in-dash experience. Itoffers a holistic user experience, performing as an extension of the driver's digital life. The new digital cockpit platform recognizes the driver's profile automatically from their phone, personalizing the driver menu with their preferences, apps, and syncing the driver's calendar to guide them effortlessly to their next appointment. *www.tomtom.com*

OneWeb launches 36 satellites

Bharti backed OneWeb, the Low Earth Orbit (LEO) satellite communications company, is launching 36 more satellites by Arianespace from the Baikonur Cosmodrome. This latest launch, and the 9th since December 2020, will bring OneWeb's in-orbit constellation to 394 satellites. This will represent 60 percent of OneWeb's planned 648 LEO satellite fleet that will deliver high-speed, low-latency global connectivity.

In the past month, OneWeb has signed distribution partner agreements with Airbus to provide LEO services for military and governmental use in Europe as well announcing a new Canadian-headquartered distribution partner, Network Innovations and Vocus to expand enterprise connectivity in Australia. *https://oneweb.net*

Solution for the homologation of autonomous vehicles

KPIT Technologies, dSPACE, and Microsoft have teamed up to offer a unique solution for OEMs and Tier-1s seeking homologation (self-certification in the USA) for advanced driver assistance systems and autonomous driving.

Certification for autonomous vehicles requires millions of miles of testing, which can only be achieved through data-driven simulation., This is a fairly new field that requires multiple skills and tools to manage petabytes of data (e.g., domain expertise, software development capabilities, unique tools, and infrastructure). A collaborative approach among experts in infrastructure, autonomous driving, and solution expertise will deliver efficiency and effectiveness through a one-stop solution for OEMs, thereby optimizing technology spends. KPIT, dSPACE, and Microsoft combine all of these competencies to provide a one-stop solution for the mobility industry. *www.kpit.com*

R750 – New GNSS base station

Trimble has introduced the R750 GNSS Modular Receiver, a connected base station. It can be used to broadcast Real-Time Kinematic (RTK) corrections for a wide range of applications, including seismic surveying, monitoring, civil construction, precision agriculture and more. Access to all available satellite signals provides improved performance and reliability when used with a Trimble ProPoint™ GNSS rover.

Sensor integration and support for geospatial monitoring solution

Trimble has introduced the latest version of its core geospatial automated monitoring software—Trimble® 4D Control™ version 6.3. It provides automated movement detection to enable informed decisions about infrastructure for surveying, construction and monitoring professionals. Version 6.3 adds new capabilities for the software to work in combination with the Trimble SX Series Scanning Total Stations' advanced imaging and measurement capabilities.

eCognition Suite Version 10.2

eCognition Suite 10.2 by Trimble Geospatial offers a variety of exciting new tools and features that will streamline existing workflows and open the doors for new types of data analysis. A revolutionary deep learning based point cloud classification that removes all previous rasterization steps have been introduced. *www.trimble.com*

Swift Navigation support STMicroelectronics Teseo V

Swift Navigation recently announced its support of the new STMicroelectronics Teseo V. The Teseo V family is a single-chip GNSS triple-frequency device for automotive use. Swift's team has been working with ST to ensure the optimization of Swift's precise positioning solution—comprised of the Starling® positioning engine and Skylark™ precise positioning service—when paired with the STA8135GA Teseo V, the first single-chip triple-band GNSS IC (Integrated Circuit). *swiftnav.com*

Telit's LTE Cat 1 module for IoT applications

Telit has announced the LE910S1-ELG, a new LTE Cat 1 module designed for IoT applications in Latin America (LATAM). With an embedded GNSS receiver, the cost-optimized LE910S1-ELG is ideal for tracking applications such as fleet management, stolen vehicle tracking and recovery, as well as other mobile IoT applications that need to maintain a reliable connection when moving around in a country, region or multiple regions. *www.Telit.com*

ASL Introduces Upward-looking Sonar for Ice-infested Waters

ASL Environmental Sciences has announced the combining of its Acoustic Zooplankton Fish Profiler (AZFP) with its Ice Profiling Sonar (IPS) to provide a comprehensive solution for ice thickness detection and water column profiling of fish, zooplankton, bubbles and suspended sediments in ice-infested waters.

The AZFP6-ice is the next generation in high resolution, low power, continuous recording subsurface instruments that are capable of long-term deployments of a year or more. Built into the ice profiling sensor is a logarithmic detector that resolves both strong and weak acoustic targets. In practice, this means that the signal from strong reflections such as the water-air interface at close range does not saturate, and weak targets such as the water-ice interface at long range are still measurable. https://aslenv.com NovAtel delivers ROSTM 2 compatible drivers to the OEM7® receiver

NovAtel released its second purpose-built driver, powered by the latest series of the Robot Operating System, ROS 2. The NovAtel OEM7 drivers are developed and managed by NovAtel engineers to provide an optimised interface for autonomy projects. The drivers allow for quick incorporation of NovAtel's OEM7 receivers into custom ROS 2 based applications. As the integration of NovAtel's OEM7 receiver increases in autonomy projects, algorithms for academic investigations, ride-share programs and agricultural autonomy solutions, NovAtel continues to support the growing needs of the robotics community. *novatel.com/oem7*

Core Mate Complete for Final GPS III Space Vehicle

The 10th and final GPS III Space Vehicle under the original GPS III contract recently completed a production milestone known as "core mate" to assemble it into a full satellite, and its name is "Hedy Lamarr."

Traditionally, core mate marks the "birth" of a satellite and it gets a nickname – chosen by the U.S. Space Force -- to honor its completion. All nine previous GPS III satellites built by Lockheed Martin have been named after trailblazers, and GPS III SV10 is no exception. The core mate is one of the most intricate and critical operations of a satellite's build. Completing the process requires teamwork and experience. *www.lockheedmartin.com*

Rohde & Schwarz and NOFFZ collaboration

Rohde & Schwarz and NOFFZ Technologies collaborate on the integration of the field-proven R&S Compact Antenna Test Range (CATR) reflector technology and advanced radar echo generator R&S AREG800A into NOFFZ's versatile End-of-Line (EoL) radar sensor test system, the UTP 5069 CATR. This creates a fast, accurate and efficient test system optimized for production that facilitates the transition from radar sensor development to mass production.

Radar is the key technology for Advanced Driver Assistance Systems (ADAS) and Automated Driving (AD). For an improved SAE L3 (Society of Automotive Engineers level 3) experience on the way towards autonomous driving, radar sensors have to accommodate much more complex

traffic scenarios. Consequently, imaging radar sensors have been developed with significantly finer spatial resolution and this requires much larger antenna apertures. *www.rohde-schwarz.com*

Low power GNSS positioning technology by Sequans

Sequans Communications S.A. has announced the availability of low-power GNSS positioning capability on its Monarch 2 LTE-M/NB-IoT platform. The integrated GNSS solution offers Sequans' IoT customers accurate positioning with lower power consumption, removing the need of an external positioning chipset for an overall higher performing, lower cost tracking solution. The new technology is available on Sequans' Monarch 2 GM02SP module, a pin-to-pin compatible variant of Sequans' Monarch 2 GM02S module, with an added GNSS antenna RF input, enabling existing Monarch 2 GM02S customers to take advantage of the added low power GNSS capability easily. *www.sequans.com*

Ligado and Point One Navigation to deliver ubiquitous precise location

Mobile communications company Ligado Networks and Point One Navigation announced that Ligado will provide pervasive, high-performance satellite capacity to support Point One's Polaris GNSS correction service. The partnership will initially provide L-Band service to electric vehicles with advanced driver assistance systems (ADAS) and will expand to additional sectors in the coming years.

Point One expects to deploy the mobile satellite-enabled service to commercial electric vehicles to start, beginning in early 2022 and in additional automotive, transportation, agricultural, and other mobile robotic platforms over the course of the multi-year agreement between Point One and Ligado. The companies will also collaborate to further advance and optimize GNSS augmentation delivery using the unique beamforming capabilities of Ligado's SkyTerra satellite network. *ligado.com*

Galileo High Accuracy Service for hydrographic survey

GEOTAG Engenharia, Brazilian hydrographic company has selected the ANavS® Multi-Sensor RTK/ PPP & Galileo HAS receiver for precise and reliable position, velocity and 3D-attitude (heading, pitch, roll and heave) information.

Using Galileo's free-of-charge high-accuracy Precise Point Positioning corrections service HAS directly via satellite will allow a real-time position accuracy better than 20 cm (horizontal) and let GEOTAG become one of the first users of the Galileo HAS corrections in South America. *www.dredgingtoday.com*

Sonardyne selected for underwater target tracking

Advanced Acoustic Concepts has chosen underwater positioning technology from maritime technology company Sonardyne to work for the US Department of Defense (DoD).

It selected Sonardyne's portable Micro-Ranger 2 Ultra-Short Baseline (USBL) system, which can track up to 10 targets to over 3,000 ft (995 m) and comes complete with a surface-deployed Micro-Ranger Transceiver, a GNSS antenna, and two of Sonardyne's smallest transponders, the Nano. *sonardyne.com*

BAE Systems awarded a $316 million contract

The Defense Logistics Agency (DLA) has executed a $316 million contract option for BAE Systems' advanced M-Code GPS modules, raising the contract funding to $641 million. The modules provide dependable positioning, navigation, and timing for ground troops, vehicles, aircraft, and precision munitions. The contract will ensure the availability of Common GPS Modules (CGM) for advanced military GPS receivers with anti-jamming and anti-spoofing capabilities that enable operation in contested environments. *www.baesystems.com*

Orolia debuts global PNT academic program

Orolia has created the Orolia Academic Partnership Program (OAPP) to build a community to help foster global PNT research and collaboration at top engineering schools and research institutions. It will provide qualified institutions with access to the company's signature Skydel GNSS Simulation Engine. Supporting its vision to form an interactive community focused on the future of GNSS and PNT research and education, Orolia created an online forum (learn.orolia.com) that allows users to interact with other users and Orolia experts. *www.orolia.com*

Intermap wins prime contract from the US Air Force

Intermap Technologies announced a new prime contract with the US Air Force to support the Air Force Research Laboratory (AFRL) in its development of navigation solutions for GPS-denied environments. This is Intermap's eighth government contract of 2021.

Military operations require precise positioning, navigation and timing (PNT). The US Department of Defense (DOD) is exploring different approaches for absolute positioning and navigation in challenging environments to enable their multidomain operations. For most platforms, GPS is the sole source of PNT. Disruptions or corruptions in GPS signals can affect timely decision making, mission security, weapons systems, operations, and critical infrastructure. AFRL leads the discovery, development and integration of affordable warfighting technologies for air, space and cyberspace forces. *www.intermap.com*

Hexagon's R-evolution expands its sustainability agenda

Hexagon AB has announced R-evolution's efforts to map the threatened seagrass meadows of the Caribbean islands, beginning with the coastal waters of the Bahamas. In collaboration with Beneath The Waves – a leading, global,

SUBSCRIPTION FORM

YES! I want my Coordinates

I would like to subscribe for (tick one)

☐ 1 year	☐ 2 years	☐ 3 years
12 issues	24 issues	36 issues
Rs.1800/US$100	Rs.3000/US$170	Rs.4300/US$240

SUPER saver

First name .....

Last name .....

Designation .....

Organization .....

Address .....

.....

City ..... Pincode .....

State ..... Country .....

Phone .....

Fax .....

Email .....

I enclose cheque no. .....

drawn on .....

date ..... towards subscription

charges for Coordinates magazine

in favour of **'Coordinates Media Pvt. Ltd.'**

Sign ..... Date .....

Mail this form with payment to:

Coordinates
A 002, Mansara Apartments
C 9, Vasundhara Enclave
Delhi 110 096, India.

If you'd like an invoice before sending your payment, you may either send us this completed subscription form or send us a request for an invoice at iwant@mycoordinates.org

non-profit organization dedicated to protecting marine environments – R-evolution is leveraging Hexagon's airborne bathymetric LiDAR technologies to detect, map and capture critical details about this vital habitat, including its extent and composition.

Blue carbon ecosystems refer to coastal and marine vegetated habitats, such as seagrass meadows, salt marshes, and mangrove forests, that sequester and store carbon from the atmosphere and ocean. These powerful carbon sinks are rapidly disappearing in many parts of the world. Seagrass meadows, the most common among them, are crucial to solving environmental challenges yet remain among the least recognized and least protected ecological habitats.

As part of a long-term shark monitoring project to study and protect the oceans, Beneath The Waves discovered that tiger sharks spend a large portion of their life patrolling and foraging dense seagrass meadows. A combination of sensor tagged sharks, satellite data, marine vessel surveys and scuba divers drove the ongoing discovery and mapping of the extensive seagrass meadows of the Caribbean. But to protect and restore these blue carbon sinks, the findings must be validated with high positional accuracy and datasets that can provide efficient, year-on-year change detection and monitoring. *https://hexagon.com*

Terrasolid maps the world in 3D

For consistent and precise digital GIS and photogrammetry workflows, raw data must first be converted into integrable and thus valuable information components that meet the requirements of the respective application environments. The 3D point cloud processing modules from the Finnish software provider Terrasolid, such as TerraScan, TerraModeler, TerraMatch, TerraPhoto and TerraStereo, are highly developed, intelligent and powerful applications. They are able to process and model laser points with their XYZ coordinates at high speed and can also display the result in 3D-stereo. During the last 20 years, the capabilities of the available LiDAR hardware has developed rapidly together with the capabilities of the processing software, with Terrasolid applications at the forefront. *www.3d-pluraview.com*

Helix Geospace raises £3m seed funding

Helix Geospace has raised £3million (approximately $4 million) seed funding in a round led by Bloc Ventures, and supported by the UK Innovation and Science Seed Fund (UKI2S). Helix builds precision antennas designed and manufactured to the highest specifications that enable GNSS product designers to create the smallest, most accurate positioning, navigation and time synchronization products. *https://helixgeospace.com*

MARK YOUR CALENDAR

March 2022

Munich Satellite Navigation Summit 2022
7-9 March
Munich, Germany
munich-satellite-navigation-summit.org

IGRSM 2022
8-9 March
Virtual Conference
Kuala Lumpur Malaysia
www.igrsm.org

The 10th Land Administration Domain Model Workshop
31 March - 2 April 2022
Dubrovnik, Croatia
http://isoladm.org/LADM2022Workshop

July 2022

IGARSS 2022 (hybrid form)
17-22 July 2022
Kuala Lumpur, Malaysia
https://igarss2022.org

September 2022

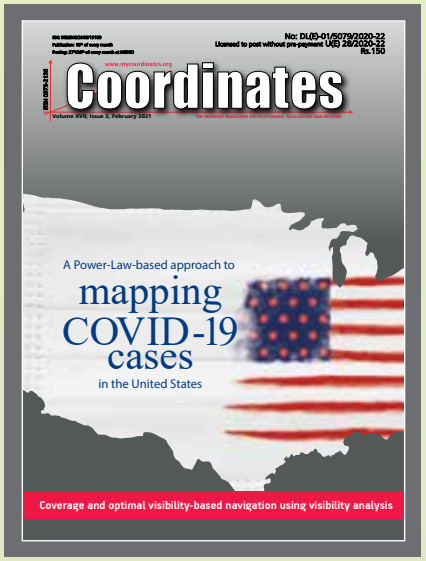
Commercial UAV Expo Americas
6-8 September 2022
Las Vegas, USA
www.expouav.com

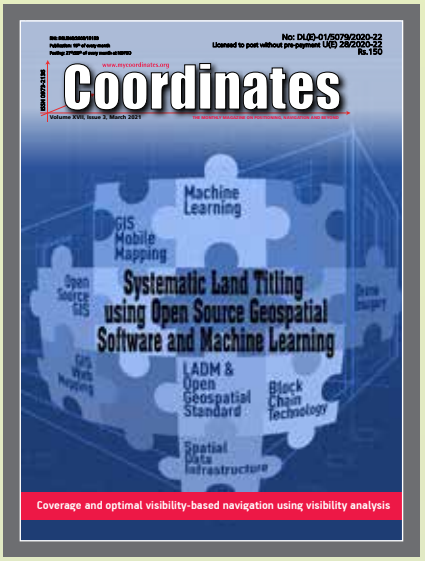
October 2022

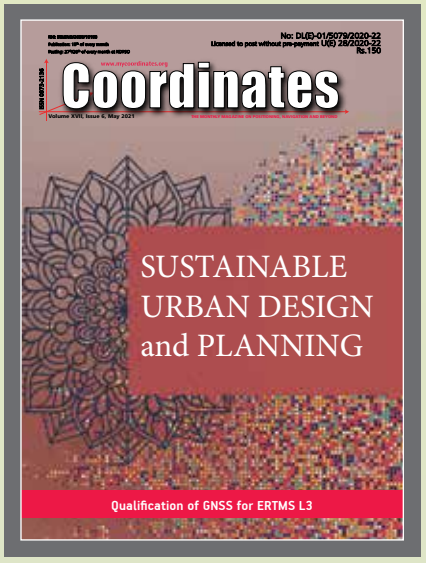
Intergeo Hybrid
18-20 October 2022
Essen, Germany
www.intergeo.de

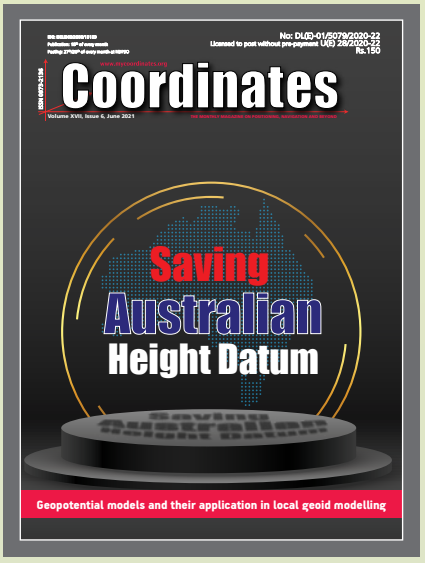
November 2022

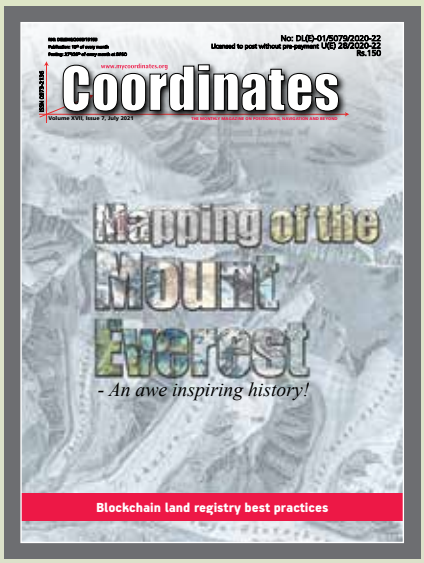
Trimble Dimensions+
7-9 November 2022
Las Vegas, USA
https://dimensions.trimble.com

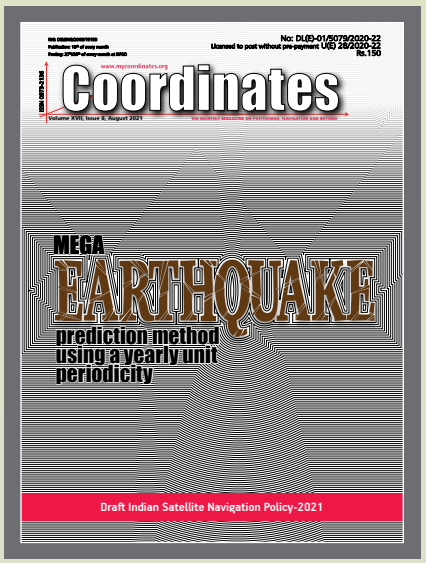


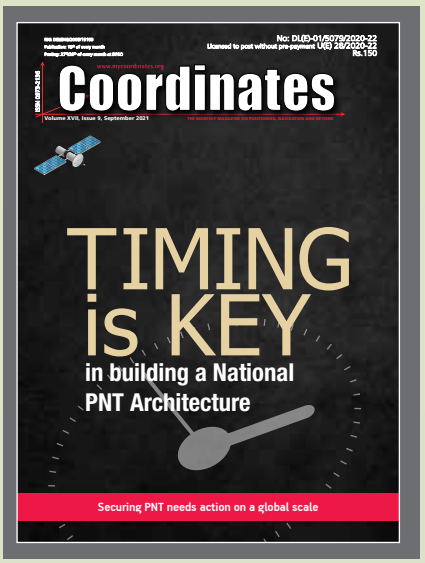












"The monthly magazine on Positioning, Navigation and Beyond"

Download your copy of Coordinates at www.mycoordinates.org

LabSat

Need to create custom GNSS test scenarios?
Simulate anywhere with **SatGen**

SatGen simulation software generates bespoke GNSS test scenarios at the time, date and location of your choice:

- Compatible with all LabSat simulators
- Multi-Constellation
- Multi-Frequency
- Static or high-dynamic scenarios (including space simulations)
- Real-time simulations (only available with LabSat Real-Time simulator)

LabSat GNSS simulators – **Test Anywhere**

labsat.co.uk