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 XVII, Issue 12, December 2021

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Spatially Smart Wine

Fadhillah Norzahari, Kate Fairlie, Adrian White, Mitchell Leach
New South Wales Young Surveyors

Mark Whitty, Stephen Cossell, Jose Guivant, Jayantha Katupitiya
School of Mechanical and Manufacturing Engineering, University of New South Wales, Australia

'Spatially Smart Wine' is a joint initiative of the International Federation of Surveyors (FIG) Young Surveyors Network, the New South Wales Institution of Surveyors Young Surveyors Group (Australia) and the University of New South Wales Schools of Surveying and Mechatronic Engineering. The project was initiated to improve the networks and skills of young surveyors in the Sydney region, and to generally improve community understanding of surveying (see Figure 1). Additional benefits are increasing surveyors' knowledge of PV!

Land governance

Keith Clifford Bell
World Bank, East Asia Pacific Region Washington DC, USA

The World Bank, in collaboration with other partners, has developed the Land Governance Assessment Framework (LGAF), a tool designed to help countries assess their policies and practices regarding land governance, setting a benchmark for comparison and monitoring of progress. It comprises a set of eighty detailed Land Governance Indicators which are ranked on a scale of pre- coded statements, from the degree of good governance to best practice.

"The NGIS and NSDI complement each other"

says Dr R Sivakumar, CEO NSDI & Head NRDMS Division, Department of Science & Technology, Government of India

The National GIS (NGIS) and NSDI complement each other. NSDI could be an enabling mechanism for providing standards, interoperability, research and capacity building and INGO could provide the national GIS platform for crucial Geo DSS applications based on national GIS Data Asset for governance, enterprise and citizen services.

User requirements analysis for the development of NSDI

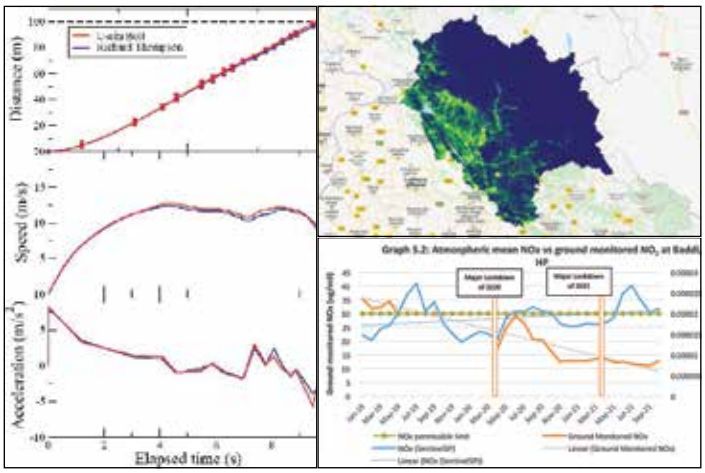
Ahmed Hamood Mohammed Al-Wardi
PhD Student Candidate Faculty of Geoinformation and Real Estate (FKSG),Universiti Teknologi Malaysia

The paper elaborates the geospatial data situation in the Sultanate of Oman by reviewing questionnaire results. The fundamental geospatial data which uses mostly in government and private institutions was specified to be the backbone of Oman NSDI.

Receiver designers should be prepared for a more complicated spectral environment

says Richard Keegan, Senior Principal Engineer, NavCom Technology, Inc., a wholly owned subsidiary of Deere & Company while sharing his views on LightSquared and GPS interference issue

We should strengthen the filtering and processing in GNSS receivers to prepare for an environment in the future that is not as friendly to GNSS as at present



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This issue has been made possible by the support and good wishes of the following individuals and companies
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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.

Hope

With the advent of the vaccines,

Year 2021 was anticipated as a year of recovery.

However, earlier this year it was the ferocious Delta variant of Covid-19,

That devastated the millions in many of the countries,

And now it is the Omicron variant wreaking havoc

Though the world is better equipped to deal with the pandemic,

A fatigue has set in, depression is deepening, and craving for the normalcy lingers.

Hope and wish year 2022 as a year of revival of better times for all of us.

Coordinates wishes a happy and a healthy new year,

To our readers, authors and advertisers.

Bal Krishna, Editor
bal@mycoordinates.org

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How to conceptualize a PPP for land administration services[1]

To successfully operationalize PPPs in land administration, it is critical to examine and assess the commercial feasibility of each proposed transaction inclusion

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[1] *This paper is an updated version of earlier work published under the 2020 World Bank Annual Land and Poverty Conference and the 2020 FIG Working Week – both events having been cancelled due to the COVID-19 pandemic*

Abstract

It's all the buzz, but where do we start? There is a large train moving that suggests that Land Administration Services can be transformed by adopting a public-private-partnership (PPP) model, but when we get into the details, it's not so clear cut for many jurisdictions. The underlying principles and precepts applicable to best practice for PPPs require a deeper understanding of the land administration context, due to the barriers of implementation in a developing country.

During reviews and design of Analytical and Operational Frameworks (World Bank 2020) under the World Bank commissioned Land PPP project, the team noticed a significant gap between a country's readiness and general interest in exploring a PPP approach, and the available data and preparedness to develop a strong and well conceptualised vision. Overlooking critical steps in PPP design and implementation, as well inadequately understanding private sector partner interests and values, are shortcomings that underpin many of the limited available case studies.

This paper uses the experience from drafting the Costing and Financing Land Administration Systems (CoFLAS) Tool (UN-HABITAT, 2015), drafting and piloting the Operational Toolkit, and the Land PPP consultation process (2018-2019), to provide practical take-aways for governments, development partners and private sector implementers. The experience highlighted how essential the conceptualisation of a Land PPP is to project validation, risk evaluation and likelihood of success.

The paper looks at the challenges in two ways and aims by the end to have you answering the question – is your jurisdiction ready? Firstly, it elaborates the Land PPP Conceptualization Tool, and how it informs country Land PPP preparedness, flagging necessary steps to address data needs and gaps. Developed as part of the *Public-Private Partnerships in Land Administration: Analytical and Operational Frameworks* (World Bank 2020), it was considered an essential Toolkit component, enabling development of a clear Land PPP concept attractive to private investment, and promoting project success through clear metrics and scoping. This paper reviews the justification, details and enabling environment for maximum tool effectiveness, through a discussion of the three steps which guide the project concept development process.

Secondly, the paper emphasizes how parties can work to understand both government and private sector motivations, approaches, and attractions at the project conceptualization stage - realizing that an assessment purely from one angle does not allow for informed decisions around project feasibility. Fundamentally, a Land PPP requires both government and private sector willingness and interest to be successful.

Introduction

Public-Private Partnerships (PPPs) have emerged across sectors including transport, water, waste, and energy – and more recently, PPPs in the eGovernment sphere have become increasingly common. PPPs in land administration (henceforth, Land PPPs) have emerged successfully

In developed countries, most projects that have implemented a PPP model for land administration have focused on two factors: technology and efficiency. Land PPPs in developing countries may be less straightforward though, where existing examples have typically required a combination of building the system, extending the coverage, computerizing IT and/or re-engineering business processes.

and less successfully in both developed and developing contexts, and many of these are examples of e-Government PPPs. Across sectors, successful PPPs share a set of common underlying guiding principles and precepts. These principles and precepts, however, require a deeper understanding when applied to land administration systems. PPPs in land administration are not new but their application in developing countries raises many questions about the barriers to implementation.

Existing efforts have largely sought to improve upon existing land administration systems, but there is a need to further investigate potential models that will address the registration gap, which currently stands at approximately 70% in much of the developing world. During land administration system reviews and design consulting experiences a noticeable and often unanticipated gap is getting to the core of land administration systems and practices, particularly in emerging economies, on matters that are critical to the success of a potential PPP. A strong project conceptualisation and an understanding of what motivates the private sector is essential for governments to successfully design transactions which are attractive to the private sector.

This paper builds on work undertaken to develop the World Bank report *Public-Private Partnerships in Land Administration: Analytical and Operational Frameworks* (World Bank, 2020) to share some practical take-aways from the large body of theoretical explanations, targeting an audience of governments and donors. The paper does this in two ways: firstly, by exploring key land administration and PPP concepts from a land administrators' perspective; and secondly, by examining the attractiveness of PPPs from a private sector lens, looking at the overarching perspectives and underlying motivations of all parties.

What and why land PPPs?

So, what, if anything, makes Land PPPs different? In contrast to infrastructure or e-governance PPPs, Land PPPs must recognise that land is a fundamental resource that is managed under typically long-established policy and legislative frameworks. This 'stewardship' must address broad and diverse political, economic, social and environmental objectives for both the current population and for the benefit of future generations. Land administration systems (LAS) provide an important framework that enables governments to address and understand 'land' across these broad objectives. However, whilst there are generic approaches or methodologies adopted in a land administration system, such as the options of deed or title registration, there is great variety in both in how these systems are ultimately implemented in practice, as well in individual country or region requirements from a Land PPP. This variation further complicates a standard Land PPP approach. For example, countries with less well-developed LASs may face the cost of first establishing a LAS with broad geographic cover and the records and procedures to support it ("first registration"), in addition to the direct cost of providing LAS services to those requesting services. Other countries may seek to digitise hardcopy information or undertake a process to convert deeds to title systems. These important contextual factors – and their implications - need to be recognised and addressed in any attempt to develop a Land PPP concept.

Potential advantages and drivers of land PPPs

While there are potential complexities of using Land PPPs in land administration, there are a number of potential advantages:

- The ability to bring private sector capital and finance to improvements, technology, modernization, and updates,
- The ability to bring outside knowledge and technical skills to improvements,
- The ability to maximize efficiencies and cost savings through private sector expertise and management practices,
- The improvement of procedures for setting up land registration in countries in transition,
- Increased flexibility of land registration services,
- Promoting the use of geospatial base data for additional (e.g., private sector) customer groups,
- Improved customer orientation of land administration services.

These potential advantages also highlight that technology is rarely the sole driver in determining when to implement a Land PPP. Other, arguably more common drivers include:

- Lack of financial resources for investment in capital expenditure to replace legacy systems,

- Lack of other resources, such as qualified staff, to implement legal or procedural change,
- Identified reduction in future operating costs,
- A reduction of the risk in investment, and
- Introduction of process efficiencies delivered via technology.

With the growth of PPP adoption in other sectors, the perceived attractiveness of PPPs may also be a factor.

What services can land PPPs cover?

In developed countries, most projects that have implemented a PPP model for land administration have focused on two factors: technology and efficiency. Land PPPs in developing countries may be less straightforward though, where existing examples have typically required a combination of building the system, extending the coverage, computerizing IT and/or rendering the process more efficient. Extending upon existing examples, there are a range of land administration system services and activities that a PPP structured financing model could apply to:

- First registration
- Data digitization and conversion
- Land transactions (including certified extracts)
- Development/building permits
- Registration of professionals (lawyers, surveyors)
- CORS positioning services (main client: surveyors)
- Provision of land valuation information (main client: financial institutions, real estate brokers, valuers, etc.)
- Land use system, maps, etc.
- Mass appraisal for taxation (main client: central and local government)
- Preparation of tax rolls and/ or tax collection (main client: central and local government)
- Land use system, maps etc. (main user: local government)
- Bulk transfer of tax records for government use (main client: central and local governments)

How land PPP conceptualization informs country preparedness

Given the range of land administration services and variations compared to the (relatively limited) range of existing Land PPPs, developing a clear concept for a Land PPP remains a defining challenge. The land conceptualization tool was developed as a framework for both developing a concept as well as validating an existing concept. This tool is set out in Section 3 of the Operationalization Toolkit, World Bank (2020). Three key steps for developing a specific concept for a Land PPP are described below.

Defining land administration service modes

The first step is defining the land administration services to be potentially provided through a Land PPP, and identifying any necessary changes to the legal, institutional, or operational environments. Land administration services can typically be delivered in several different modes or channels. It is important that these different modes are understood as the current arrangements can impact on a Land PPP concept. Key factors to be considered include:

i. The services that will be provided through the possible Land PPP and confirmation that these services can be provided by a PPP operator under the existing legal framework.
ii. The number and location of offices that currently provide land administration services.
iii. Whether land administration services are provided by isolated offices that include both front and back offices or the offices supplying services operate as front-offices with some central office or offices providing back-office support.
iv. The proposed scope of the Land PPP (whole jurisdiction or part jurisdiction).
v. The projected number of transactions and revenue generated based on decisions made on the services to be provided and the scope of the proposed Land PPP.
vi. The number of staff currently providing land administration services (employment status, qualifications).
vii. The status of the ICT system supporting the provision of land administration services.
viii. The institutional arrangements and mandates for the provision of land administration services (including consideration of current arrangements for key services such as ICT, collection and allocation of land-related fees and charges and the provision of professional services by notaries, private surveyors and others).
ix. Forecast of requirements for investment in first registration, ICT and other necessary equipment and facilities; and
x. A summary of the key rationale for considering a Land PPP (lack of capital, lack of resources, difficulties with institutional roles and mandates, etc.).

The Land PPP Conceptualisation Tool (World Bank, 2020) provides an overview of guiding questions and information necessary to collect to answer these questions. Entities requiring further support and structure, to e.g., project revenue and forecast requirements, should refer to the CoFLAS tool (UN-Habitat, 2015) and supporting Framework for Costing and Financing Land Administration Services (UN-Habitat, 2018) for additional guidance and more preliminary tools. As mentioned below there is scope for national (or sub-national) governments to seek support from development partners to assist with project conceptualisation.

A key outcome from this analysis should be the identification of any changes in institutional roles and mandates and in staff employment arrangements that might be necessary to arrive at a viable Land PPP concept.

Defining the appropriate structure for a land PPP

A second step to developing a Land PPP concept is the consideration as to which PPP model and structure is most suitable, given the identified services to be provided and context in which the Land PPP will be situated. Some of the structures most likely to be applicable to Land PPPs include joint ventures or concessions. Joint venture structures see public and private sector partners share revenue, costs and risks, and for Land PPPs this would likely involve government taking an equity stake ("shares") in a project company. In this instance, government has both a role as a regulator and shareholder in the project company. Joint ventures could be applicable across the suite of land administration services, including software development, IT hardware and software operations, surveying and back office and customer service responsibilities. Concessions, on the other hand, are a more traditional model of PPP, typically used in the toll or availability payment context, whereby a private operator is remunerated on the basis of user payments or performance measures. Government still maintains a regulatory role and may need to provide other guarantee or risk measures. A concession model may be most applicable to contexts of comprehensive technology upgrading, and/or full commercial operation of land registries or related functions.

Much has been written on the many PPP structures (and sub-structures) in practice, and their principal characteristics – more than can be encompassed in this short paper. Further information to assist in deciding between and ultimately designing these can be gathered by referring to commercial contracting information. Broader information is available from the World Bank PPP Legal Resource Center (e.g. https://ppp.worldbank.org/public-private-partnership/agreements/joint-ventures-empresas-mixtas, World Bank 2020) or documents available from the World Bank PPP Library (e.g. HM Treasury, 2010; PPIRC, 2008; World Bank 1998; EBRD 2008). Given the relative youth of Land PPPs, governments and practitioners will likely need to refer to information from related sectors, including ICT and e-governance.

A Framework for developing the land PPP concept

Finally, the third step entails elaborating the Land PPP Concept. This can be developed by considering the following topics and critical questioning:

- *Project Objective*: What issue does the project address? What does the project aim to achieve? Improved access to services? Reductions in times taken for processing?
- *Targeted Services and/or Functions*: What services and/or functions does the project aim to provide?
- *Stakeholders*: What stakeholders are involved? Consider the public sector, the private sector, financiers, operators, and users. What are their roles and responsibilities in the project?
- *Project Demand*: Is there a demand for the services or functions offered by the project? Is the demand sufficient to justify the project?
- *Economic Benefits*: What are the tangible economic benefits of this project? Who benefits? Are the potential economic issues posed by the project implementation?
- *Legal and Regulatory Regime*: What legal and regulatory regime would govern the project? Does it adhere to these requirements?
- *Capital Investment Costs*: What are the estimated capital investment costs of the project?
- *Operating Costs*: What are the estimated annual operating costs for the project? This would include the running of facilities, staff, and other such costs.
- *Revenue Estimates*: What is the estimated annual revenue of the project?
- *Environmental and Social Impact*: What is the environmental and social impact of the project?
- *Project Risks*: What are the risks involved in the project?
- *Proposed PPP Model*: What PPP model would be used for this project?

Following conceptualisation, the next step is to assess the viability of undertaking a land administration project as a PPP. Further detail on Concept Viability Assessment is available in the Operational Framework component of the *Public-Private Partnerships in Land Administration: Analytical and Operational Frameworks* (World Bank, 2020). It is in this step that the availability and quality of data to provide a sound viability basis becomes evident – reemphasising the need for gathering this data at the Land PPP Concept stage. The absence of data, too, provides information in itself – what data is missing and why, what processes are necessary to start collecting/collating this information (as a preparator step to a Land PPP), and is there political will to make such information publicly and/or commercially available. There are tools available to assist governments and staff to collect this data, including CoFLAS (UN-HABITAT, 2015) and the World Bank's Land Governance Assessment Framework (Deininger, Selod and Burns, 2011)

A key component of assessing concept viability (the next step) is determining the commercial feasibility and appetite for involvement. While a Land PPP project concept may make sense from a government perspective, and may demonstrate technical validity, it is critical for a concept to also demonstrate a degree of commercial feasibility as the project is developed. This will be explored in the following section.

Private sector appetite for PPPs

For a PPP transaction to be attractive to potential private sector operators and investors, the project should demonstrate commercial feasibility. To do so, estimated project inflows should cover projected project outflows. Essentially, the revenues and funding for the project should be able to cover all capital expenses (CAPEX), operational expenses (OPEX), financial obligations (interest, debt service, and equity paybacks), and taxes. In this

context, CAPEX includes (but may not be limited to) the following: development of IT solutions; investment in first registration and/or digitization of land records; purchase of equipment, vehicles, and furniture; the costs of fitting out offices and facilities; and the purchase of buildings. OPEX, on the other hand, refers to operational and maintenance costs. This could include staff salaries, trainings, office rent, consumables (such as field supplies and office supplies), and the maintenance of IT systems.

Financial modelling for pre-feasibility

A pre-feasibility or feasibility study should be undertaken to accurately determine these calculations. Project preparation must include financial modelling for various scenarios to calculate the total inflows and outflows over the life of the project. The accuracy of this analysis is dependent on the validity and availability of data to inform model assumptions (such as those informing the calculation of revenue amounts and costs over the life of the project). The payment mechanism proposed under the project structure will require different forms of analysis – primarily either a user-pays or a government-pays payment mechanism. The *PPP Reference Guide 3.0* (World Bank et al, 2017) defines these two models as follows:

- **User-pays payment mechanisms** are where *"the private party provides a service to users and generates revenue by charging users for that service. These fees (or tariffs, or tolls) can be supplemented by government payments—for instance, complementary payments for services provided to low-income users when the tariff is capped, or subsidies to investment at the completion of construction or specific construction milestones. The payments may be conditional on the availability of the service at a defined quality level."*
- **Government-pays payment mechanisms** are where *"the government is the sole source of revenue for the private party. Government payments can depend on the asset or service being available at a contractually-defined quality (availability payments)—for example, a free highway on which the government makes periodic availability payments. They can also be volume-based payments for services delivered to users—for example, payment from hospital care effectively delivered."*

(World Bank et al., 2017)

Such mechanisms may be augmented via bonuses, penalties or fines due as specified outputs or associated standards are – or are not – met.

Commercial feasibility assessment

The results of financial modelling analysis will inform the commercial feasibility assessment, which will reflect the overall attractiveness of the project to the private sector. The commercial feasibility assessment considers two perspectives – debt providers and equity providers.

Debt provider perspective

Debt, or lenders, scrutinize the bankability of the project, which measures the ability of the project to service and repay debt in line with set terms. In assessing bankability, the level of revenues and total amounts required to service debt, available collateral security, and stability of revenue are considered. Specifically, appraisal studies look at the Debt Service Coverage Ratio (DSCR), which examines if the project can generate profits capable of servicing debt each year over the duration of the project. The Loan Life Coverage Ratio (LLCR) and Project Life Coverage Ratio (PLCR) are also analysed, which examine the Net Present Value (NPV) of cash flows and the outstanding debt over the project duration (with LLCR considering ratio over the duration of the loan and PLCR considering ration over overall project life). (ADB et al., 2016)

Equity provider perspective

Equity providers, on the other hand, are investors. Investors consider not only the bankability of the project, but also the estimated returns of the project. From this lens, the Net Present Value (NPV) of the project must be calculated with consideration of the Internal Rate of Return (IRR) and discounted cash flow. The results of this analysis should meet the minimum rate of return expected by equity investors – the so-called "hurdle rate". Project risks will impact these calculations, with higher risks incurred by the investor resulting in the desire for higher returns or additional guarantees from the public sector partner or other implementing partners, such as bilateral and multilateral donors.

Financing and payment approaches to improve private sector appetite

If the Land PPP concept is not commercially sustainable (e.g., due to low demonstrated revenue) but there are clear reasons to adopt a PPP approach (e.g. to implement process efficiencies, bring in technical skills) then governments may wish to consider mechanisms to improve commercial appeal. Consideration and design of these steps would be informed by the results of the pre-feasibility and/or feasibility studies, in particular the level and degree of government funding inputs required to make the project commercially viable. Support to improve private sector appetite would typically only be expected when a project is expected to have a significant economic, environmental, or social impact, but financial returns are relatively low. It should also be noted that fiscal regulations may also limit the extent to which direct funding mechanisms by public authorities can be used.

Examples of government and hybrid (government and user) payment mechanisms include viability gap funding, sovereign guarantees, service payments, availability payments, grants, and subsidies. An overview of these mechanisms is included below:

- **Availability payments** are based on ongoing service provision or transactions. For example, a private partner might deliver and administer infrastructure for a public authority

Accurately assessing the commercial feasibility of transactions is a common challenge for public entities considering a PPP, especially within the land sector. It is not enough for a project to just breakeven over the duration of the project. Investors and private partners need to obtain a reasonable return when considering the opportunity cost of failing to invest in other more lucrative ventures

and be compensated via regular, performance based (i.e.: level and quality of service, depending on agreed terms) payments. Such payments might also include gender and pro-poor key performance indicators. Alternatively, and mirroring approaches adopted for other infrastructure and service PPPs, compensation could take the form of an availability payment per transaction, with the intent to ultimately cover total project cost – including financing and investor returns.

- A system of **guarantees** for transactions in land administration systems can be established in a manner that bounds responsibility and provides certainty to private sector operators. Guarantees can be provided based on professional liability insurance, gap financing through development partners and/or existing or newly developed public guarantee systems (eventually financed through user fees).
- **Viability gap financing** (i.e.: where user or government-pays and/or hybridised models of these prove insufficient) might come in the form of a capital **grants** or **subsidies,** payments for preliminary necessary services or other mechanisms that address commercial appetite, reduce the initial financier/private party investment and/or enable lower costs to be passed along to users. Viability gap financing is a particular area for development partners to play a role in Land PPPs, and financing can be tied to contractual or structural elements that support equitable or other aims. For example, governments needing to undertake first registration or digitization work with the private operator prior to establishing and/or upgrading the land administration system, may seek support to fund the commercial viability gap from a development partner. Viability gap financing is also relevant where private partners need additional confidence in overcoming key project risks – for example, where a culture of formal land registration has not been established, and revenue generation from land administration service fees is considered a significant uncertainty by the private sector. Viability gap financing through development partners could particularly play a role in supporting the development of pre-feasibility and feasibility assessment studies.

Fundamentally, mechanisms such as the above may form part of a multitude of blended finance solutions that increase the viability of Land PPP projects and enable inclusive targets that have been historically atypical in commercial projects.

Coming to a common understanding for land PPP investment

The greater the commercial returns, the more investor interest will be generated. Strong market interest will enable a competitive procurement process among a pool of qualified bidders, which is essential to increasing the likelihood of receiving technically sound and cost-competitive proposals.

Accurately assessing the commercial feasibility of transactions is a common challenge for public entities considering a PPP, especially within the land sector. It is not enough for a project to just breakeven over the duration of the project. Investors and private partners need to obtain a reasonable return when considering the opportunity cost of failing to invest in other more lucrative ventures. Unless a clear business case underpinning the commercial viability of a given project is established before procurement, it is likely that market interest will remain limited at best.

Conflating the economic value and the commercial value of projects is common among land agencies, leading to misunderstandings of the investment appetite of the private sector for certain projects. A project of high economic value does not necessarily also have a high commercial value. This understanding of the commercial case for a project is critical for governments considering PPPs in land administration and should be used as a lens when considering potential partnerships with the private sector.

The fundamental motivation of an investor is not to optimize the economic impact of a project – it will be to generate profit. Consequently, careful project appraisal and structuring are imperative to properly understanding the financial footprint of any given investment. Moreover, clear and comprehensive obligations and standards of service are critical to contractually addressing concerns over rights and responsibilities and risk allocation (such as the coverage of low turn-over rural areas, for example). Contractual incentives and penalties can be tied to the private partner meeting certain milestones or key performance indicators (KPIs). Drafting a contract with these stipulations and assignments of roles and responsibilities is fundamentally dependent on rigorous project appraisal and structuring.

Understanding the risks and alternatives to land PPPs

The following section draws upon the Land Administration Information and Transaction Systems: State of Practice and Decision Tools for Future Investment, prepared for the Millennium Challenge Corporation (Land Equity International, 2020).

Understanding stakeholder risks to land PPPs

Whilst only briefly mentioned above, risk is a key component of private sector appetite that needs to be understood when considering investments in land administration systems. Risks may include those typically associated with investments in information technology – for example, issues arising from unclear and changing scope, schedule, resources and technology. They may also be associated with the typical timeline of development partner projects (if involved) or related to general institutional risks, including legislative gaps, incomplete/poorly maintained existing systems, limited technical and other resourcing capacity, etc. A State of Practice publication developed for the Millennium Challenge Corporation (LEI, 2020) briefly summarises the major risks to stakeholders of investing in land administration system projects. Table 1 recognises the different perspectives on the risks of investing in land administration systems (noting the emphasis in the document on technology projects). These risks should be considered upfront during identification, feasibility and design stages of a project, though many associated with the Provider may ultimately be addressed through project implementation. For example, national governments will wish to consider the extent of coherence with existing policies and will likely have decision-making impacted by election timeframes. Similarly, development partners will also be restricted by typical project timeframes and will further wish to ensure initiatives that demonstrate sustainability and compliance with safeguards. Providers, on the other hand, will want to see demonstrated certainty around payment measures, government commitments and handover measures (as appropriate). The list of risks in Table 1 is not intended to be comprehensive, instead it provides an overview of the different risks, and perspectives on risk, that need to be taken into consideration within a PPP, and, furthermore, within a PPP that seeks additional development partner support.

Understanding land PPP alternatives to finance land administration services

The financing of land administration services, and mechanisms to prepare to do so, is covered extensively in the *Costing and Financing of Land Administration Services* Land Tool (UN-Habitat, 2015) and discussed in Section 5.3 of the State of Practice Paper (Land Equity International, 2020). Based on international experience, an efficient land administration agency that provides affordable and valued services can generate significant revenue from user fees and charges – and typically much more than the expenditure necessary to maintain the systems and provide services to government and users. It is hence entirely possible for land administration agencies to become self-financing, and achievement of this can be realised through restructuring of the agency to become semi-autonomous (with a degree from freedom from standard civil service procedures and flexibility to adopt new practices in line with self-sufficiency) or state-owned enterprises (with possible external support or subsidy for services deemed to have a public good, and recognising the need for a supervisory board, or similar to set and approve user fees and charges, and set annual busines plans and budgets). The success of self-financing agencies has been seen in World Bank-funded land sector projects in the European and Central Asia (ECA) region.

Conclusions – Is your jurisdiction ready?

The breadth of land administration services, combined with the complexities of land administration in developing countries and existing practice, demonstrates how important a clear Land PPP concept is to ensure the right commercial partner and promoting future success. Even more important, is ensuring that there is adequate information available to formulate the concept, recognising the need to be commercially attractive. Cognisant of the knowledge gap that exists around Lands, this paper targets the conceptualisation of Land PPPs to provide a clear picture to national and sub-national governments on the steps

Table 1: Example risks by stakeholder perspective.

Government (Policymaker)	**Government** (land agency)	**Development Partner** (financier)	**Provider** (contractor)
• Policy coherence (land policy, e-Governance, etc.) • Effecting necessary changes in policy and legislation • Financial commitments • Short-term results (before next election)	• Impact on statutory responsibilities and reporting requirements • Feasibility of successfully completing project • Change management and behaviour change related to new systems and procedures within the agency • Assurance of ongoing financial support	• Sustainability • Reputation • Compliance with procedures and safeguards • Coordination with other DPs • Ability to complete project in set timeframe	• Getting paid • Stability of government • Exchange rate fluctuations • Use of government infrastructure • Government commitments (staff, office, funds, etc.) • Clear hand-over of the Land IT System to the agency.

required for a Land PPP proposal and the preliminary information needed prior to further PPP life-cycle design steps.

To successfully operationalize PPPs in land administration, it is critical to examine and assess the commercial feasibility of each proposed transaction inclusion. By considering the perspectives of debt and equity providers, governments can understand the underlying market interest for the proposed project and consider potential structuring options to optimize the chances of a competitive and successful bidding process.

To do so, governments must conduct investment due diligence and market sounding during project structuring and appraisal. Pre-feasibility and feasibility studies can provide the required datasets to inform critical decisions regarding the project payment mechanisms and risk allocation. These analyses rely on the accuracy and availability of data to inform key assumptions underlying the financial modelling. When local capacity is lacking to prepare the necessary indicators and reports, external advisors (including through development partners) can be engaged to provide technical advisory support. However, access to agency data remains essential. This preparation will also lay the basis for the formulation of the PPP contract encompassing the allocation of responsibilities and obligations and standards of service, which will guide implementation throughout the project duration.

So, is your jurisdiction ready? The answer depends on the outcomes of your preliminary analytical assessment. National or sub-national governments considering a Land PPP should commence first with a Readiness Assessment (see World Bank, 2020, p.75) before proceeding to the Conceptualisation that this paper discusses. Once the Land PPP concept is developed, still further work is necessary to ensure concept viability. This preparatory work, getting into the detail now – and ensuring the quality and availability of underlying data – will provide the foundations for successful partnerships in the future.

Underlying all PPPs is consideration of both governments and the private sector perspectives, and importantly, understanding the investment motivations to optimally structure PPP transactions within the land administration sector.

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Humorous science: Exploring our physical world

This paper highlights humorous research employing physics and mathematics to analyse and explain intriguing problems encountered in our professional or everyday lives, including examples related to gravity, astronomy and sports.

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This is the fifth 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 explore studies employing physics and mathematics to analyse and explain issues that we may be grappling with in our professional or everyday lives.

Gravity

Despite defying the laws of physics, B. Volfson was granted a US patent in 2005 for inventing a space vehicle propelled by a superconducting shield, which alters the curvature of space-time outside the craft in a way that counteracts gravity. This inspired Cyr and Lanthier (2007) to present a cost-utility analysis of abolishing the law of gravity. Using a hidden Markov model (a statistical model in which the system is assumed to be a Markov process with unknown parameters), they estimated that 2 million quality-adjusted life years would be saved as a consequence and determined the cost-effectiveness of adapting Volfson's anti-gravity machine for use on Earth. It was argued that a microgravity environment could have important positive impacts, such as stopping climate change by reducing the use of fossil fuel by 90% because cars would no longer be needed with transportation only required for overseas travel. However, they also noted that several negative side effects were ignored, e.g. extended microgravity exposure on the human body and technical problems related to the absence of gravity (including the use of wigs, intravenous fluids and toilets). Nevertheless, the study proved that a combination of technological, statistical and medical jargon can convince intelligent people to read a manuscript (and have a chuckle along the way).

Noting that only a few legged species on Earth manage to run on water, Minetti et al. (2012) conducted experiments with humans running in place on water at simulated reduced gravity. They used a hydrodynamic model to predict the gravity levels required for humans to run on water (about 20% of the Earth's gravity) and then tested these predictions in the laboratory using a reduced gravity simulator. Progressive body weight unloading of a person running in place on a wading pool confirmed that a person could run on water at lunar (or lower) gravity levels using relatively small rigid fins. 3D motion capture of reflective markers on major joint centres revealed that humans keep the head-trunk segment at a nearly constant height, in spite of the high stride frequency and the intensive locomotor effort required to move their body through space. These results showed that a hydrodynamic model for lizards running on water can also be applied to humans, despite the enormous difference in body size and shape.

Astronomy

Pedbost et al. (2009) identified a peculiar

new class of galaxy cluster using data from the Galaxy Zoo project. It is well known that galaxies are not randomly distributed throughout space but tend to cluster together. However, it was a surprise to find several high-density clusters exhibiting rather unusual characteristics such as the shapes and colours of its component galaxies (blue colours and spirals are unexpected for high-mass clusters), the entire cluster being rather linear and box-like, and (most surprisingly) individual galaxies and close systems approximating the geometric shapes of letters in the modern Latin alphabet. Although galaxies displaying morphologies corresponding to Latin characters have been noticed before (S and Z being particularly common), a localised collection of this size arranged in sub-groups was highly improbable. In one example, these shapes and sub-groups were interpreted as "we apologise for the inconvenience" (Figure 1).

Noting that this may indicate the existence of intelligent extra-terrestrial life, the scale of the message would require a life-form with extraordinary powers. Two other clusters demonstrated additional features, including punctuation, capital letters, a numeral, an abbreviated unit and left-justified sub-groups, with messages interpreted as "caution! structure formation in progress" and "Delays possible for 7 Gyr". When considered collectively, these appeared to suggest a common theme reminiscent of road works. This not only implies the existence of other intelligent beings (inconvenienced by said road works) but also may cause concern for Earth potentially having to make way for an intergalactic super-highway.

Armstrong (2012) reported on the non-detection of the Tooth Fairy at optical wavelengths. It appears that the Tooth Fairy obtains a child's tooth with minimal difficulty and undetected, despite potential barriers such as bolted front doors and bad-tempered dogs. The only observational evidence of the being's transient presence is the disappearance of the tooth and the small gift left behind in its place. Attempting to finally detect the Tooth Fairy, the MDM Astronomical Observatory's 1.3-metre McGraw-Hill telescope near Tucson, Arizona, was used for optical observations of the author sleeping about 47 metres away on the roof of the neighbouring observatory, with a freshly removed wisdom tooth under her pillow. The telescope was programmed to obtain an 8-hour time series of a 2-metre radius circle centred on Armstrong's sleeping bag. At the end of the night, the wisdom tooth could not be located (neither could the pillow, which had tumbled down the sloped roof and come to rest against a tumbleweed).

Standard data processing failed to detect evidence of the Tooth Fairy. However, given the tooth's disappearance, it was concluded that she indeed paid a visit. Preliminary evidence therefore suggests that the Tooth Fairy is transparent at optical wavelengths. The lack of a gift being left behind was attributed to the creature possibly feeling offended at this deliberate attempt to invade her privacy. Noting the limiting time resolution of 4 seconds for both the exposures and dead time between the observed images, the findings also indicate that the Tooth Fairy may be operating at much faster speed than previously assumed.

Krugman (2010) extended interplanetary trade theory to an interstellar setting, determining how interest rates on goods travelling at close to the speed of light should be computed. Following Einstein's theory of relativity, this is of course a problem because the time taken in transit appears less to an observer travelling with the goods than to a stationary observer. After explaining the physical background by considering trade between Earth and Trantor, he derived a solution from economic theory and proved "two useless but true theorems" of interstellar trade: (1) When trade takes place between two planets in a common inertial frame, the interest costs on goods in transit should be calculated using time measured by clocks in the common frame and not by clocks in the frames of trading spacecraft, and (2) If sentient beings may hold assets on two planets in the same inertial frame, competition will equalise the interest rates on the two planets. Interestingly, the paper was written in 1978 but not published until 32 years later, proving that persistence does pay off.

Figure 1: Colour composite image of an unusual galaxy cluster identified by Galaxy Zoo participants (Pedbost et al., 2009).

Sports

At the Beijing 2008 Olympic Games, Usain Bolt shattered the 100 m world record by finishing in 9.69 seconds to win the gold medal. Most impressively, after accelerating away from the rest of the field, he started celebrating with two seconds (20 metres) to go. This led to an intriguing question: What would the world record have been if Bolt had not slowed down towards the end? Eriksen et al. (2009) provided an answer by measuring Bolt's position as a function of time using video footage of the run, based on the bolts (pun intended) of a rail-mounted moving camera along the track and fitting a smooth spline to the data (Figure 2).

The resulting motion profile was then extrapolated into the last two seconds of the race, based on two different assumptions. First, it was conservatively assumed that Bolt could have maintained silver medallist Richard Thompson's acceleration. Second, given his clearly stronger acceleration around 6 seconds, they assumed that Bolt could have kept an acceleration of 0.5 m/s^2 higher than Thompson. Consequently, the new world

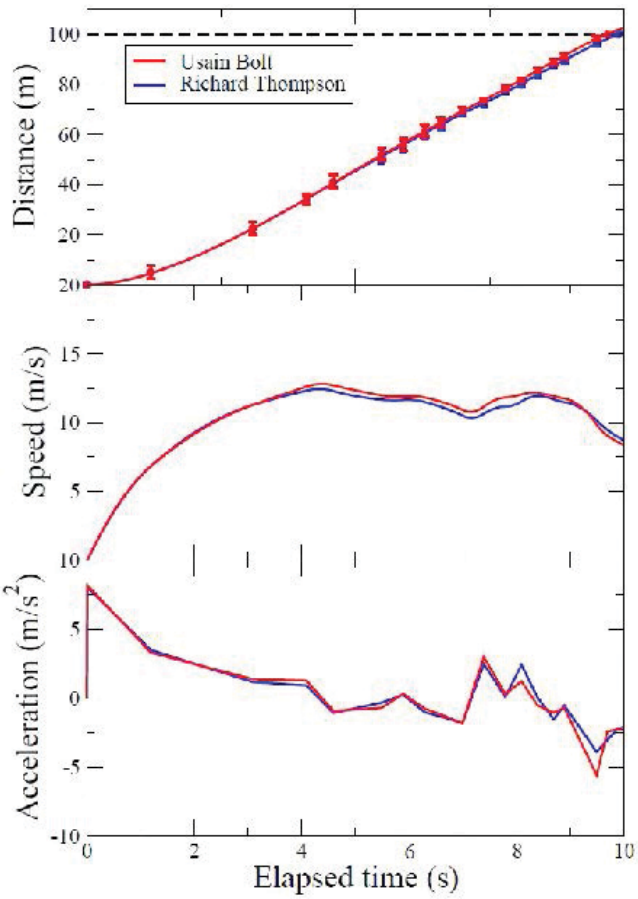

Figure 2: Estimated position, speed and acceleration for Bolt (red) and Thompson (blue) as a function of time, with actual distance measurements indicated in the top panel with 5σ error bars and Bolt's deceleration after 8 seconds clearly visible in the bottom panel (Eriksen et al., 2009).

Uncovering the mystery of what makes banana peels so slippery, Mabuchi et al. (2012) determined the frictional coefficient under banana skin using an experiment to simulate a slipping accident. Friction (or slipperiness) under banana skin was measured on a flat panel of common floor material (linoleum) during the sliding motion of a shoe and compared to a banana-free situation.

record would have been 9.61 and 9.55 seconds, respectively (both with uncertainties of 0.04 seconds at the 95% confidence level). Maybe to prove this result, Usain Bolt went on to set the still current world record of 9.58 seconds in 2009, which nicely falls into the calculated range and reiterates that he could have already broken the 9.6-second barrier at the Olympics.

Gettelfinger and Cussler (2004) investigated whether humans would swim faster or slower in syrup. To this end, water in a swimming pool was thickened with guar gum to make it about twice as viscous as water, while the density and therefore the buoyancy changes were insignificant. Analysing data collected by 10 competitive and 6 recreational swimmers for different strokes, they determined that swimming in guar does not change swimming speed. Fluid mechanics revealed that the viscosity must increase at least 1,000 times to have an effect. Such an increase would cause a viscosity-dependent drag coefficient, but the increased drag caused by the frontal area of the body would at least be partially balanced by the increased drag on the hands and forearms.

Applying statistical analysis to international football (soccer) scores and results, McSharry (2007) assessed the effect of altitude on match results and physiological performance of players. Using an extensive database of 1,460 football matches in 10 countries across South America spanning 100 years, it was shown that altitude provides a significant advantage for high-altitude teams who score more and concede fewer goals. Each additional 1,000 m of altitude difference increases the goal difference by about half a goal. The probability of the home team winning for two teams from the same altitude is 0.537, whereas this rises to 0.825 for a home team with an altitude difference of +3,695

m (e.g. Bolivia vs. Brazil) and falls to 0.213 when the altitude difference is -3,695 m (e.g. Brazil vs. Bolivia). However, it was noted that the high level of skill in the lowland national teams (Brazil, Argentina and Uruguay have so far won nine World Cups between them) disguises this advantage somewhat.

Balasubramaniam and Turvey (2004) studied the coordination modes in the dynamics of hula hooping. This skill is based on the conservation of angular momentum, with the performer exerting small but carefully regulated impulses on a small portion of the interior edge of a short section of the hoop. Based on a series of experiments with seven participants, a systematic analysis of balancing a hoop at the waist was performed under variations in hoop size and oscillation frequency. Movements were recorded using a magnetic motion tracking system, with six tracking receivers placed on the hips, knees and ankles, collecting data at 40 Hz (Figure 3). This revealed that the multiple degrees of freedom of the lower limbs can be reduced to two: one to sustain fore-aft oscillations (largely involving hip-ankle movements) to maintain the hoop motion and another to organise the vertical suspension of the body (largely involving knee-joint rotations) to counteract the force of gravity.

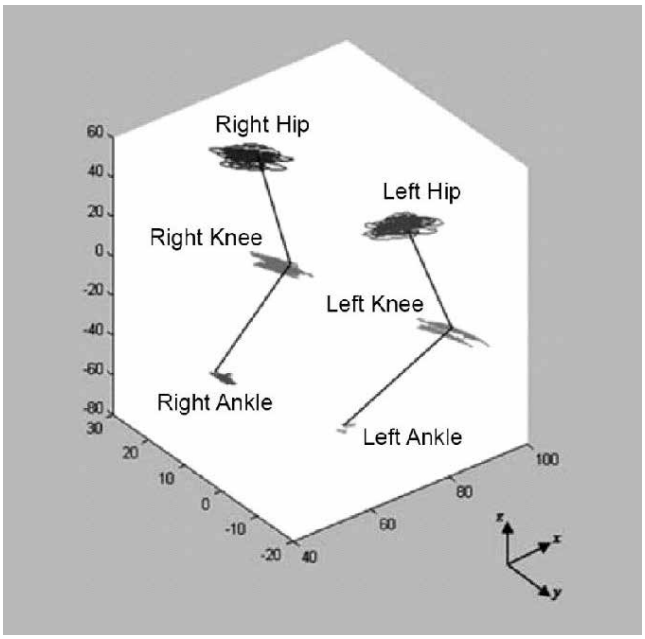

Figure 3: Positional displacements for a person engaged in hula hooping for 20 seconds (Balasubramaniam and Turvey, 2004).

Figure 4: Experimental set-up to measure the friction coefficient under banana skin and the coordinate system used (Mabuchi et al., 2012).

Everyday phenomena

The randomness of a coin toss was investigated by Clark and Westerberg (2009), using an experiment where 13 participants attempted to flip the coin to achieve a heads result. Based on 300 attempts, all achieved more heads than tails, with 7 participants having significantly more heads results. The highest proportion of heads achieved was 0.68 at the 95% confidence level. This showed that some people can successfully manipulate the coin toss with minimal training, raising concerns about its validity to determine a chance result. Devoted training would probably increase the number of (significantly) successful participants and the magnitude of the manipulation.

In Germany (of course), Leike (2002) demonstrated the exponential decay law using beer froth. A cylindrical beer mug with a diameter of 72 mm was filled immediately after opening the bottle, showing that froth reaches its maximum height within a few seconds and then lasts for several minutes. Experimenting with three types of beers and applying the exponential decay law revealed that the decay constant is dependent on beer type, and the lifetime of the froth can be used to distinguish between different beers. Apart from being essential education for beer drinkers, this study also demonstrated the data analysis techniques commonly applied in science, including consistency checks of theoretical models with observed data, parameter estimation and determination of confidence intervals.

Mulet et al. (1999) discovered that ultrasonic velocity in Cheddar cheese is highly correlated with temperature. The decrease in ultrasonic velocity with increasing temperature reflected thermal transitions of fat within the cheese structure. The most convenient temperature span to determine velocity was found to be 0°C to 17°C, with velocity decreasing by 3.3 m/s per 1°C temperature increase. Velocities measured near 7°C were deemed suitable for studies of structural changes because this is a common curing temperature for cheese. Benedito et al. (2000) went on to determine that the ultrasonic velocity was related to the square root of the deformability modulus and the slope in puncture. The increase of velocity during maturation showed the feasibility of using an ultrasonic device to non-destructively monitor Cheddar cheese maturity, including assessment of its moisture content.

Uncovering the mystery of what makes banana peels so slippery, Mabuchi et al. (2012) determined the frictional coefficient under banana skin using an experiment to simulate a slipping accident. Friction (or slipperiness) under banana skin was measured on a flat panel of common floor material (linoleum) during the sliding motion of a shoe and compared to a banana-free situation. A force

transducer detected the applied forces in three dimensions at 100 Hz (Figure 4). They found that the tiny sacs of gooey substance lining the inside of banana skins burst when stepped on, forming a lubricated surface ideal for slipping. Compared to other fruit, banana peels were by far the most slippery. It was also shown that a banana skin is less slippery when the inside of the peel is in contact with the shoe because the irregularity of the shoe sole tends to break the lubricating film. A follow-up paper provided further information and explained the connection between slipping on banana skin and the mysterious world of mucus, based on the similarity of the lubricating function in banana peels and the joints of a rabbit (Mabuchi et al., 2016).

Noting that visual space perception is influenced by bending the body, tilting the neck and raising or lowering the eyes, Higashiyama and Adachi (2006) investigated the perceived size and perceived distance of targets seen from between the legs. Five rectangular targets, varying from 32 to 162 cm in height, were presented at viewing distances between 2.5 and 45 m, and a total of 90 observers verbally judged the perceived size and distance of each target. Firstly, 15 observers inverted their heads to view the targets between their legs, while another 15 observers viewed them while standing normally. This revealed that inverting the head lowered size constancy (the tendency to perceive an object as being the same size regardless of the viewing conditions) and compressed the scale for distance.

Secondly, comparing observers standing upright and seeing the targets through prism goggles that rotated the visual field by 180° with observers viewing the targets through hollow goggles showed that size constancy prevailed and perceived distance was a linear function of physical distance under both goggle conditions. Thirdly, comparing observers wearing the 180° rotation goggles and viewing the targets between their legs with observers viewing them through hollow goggles and lying on their belly lowered the degree of size constancy and compressed the scale for distance. This proved that perceived size and distance are affected by the inversion of the body orientation and not of the retinal image orientation, which was explained by humans learning visual space perception over time mainly with the head and body being upright. Applying path analysis and partial correlation analysis to the entire data, perceived size was found to be independent of perceived distance.

Conclusion

The laws of physics play a crucial role not only in surveying, mapping and geodesy but also in our general understanding of the world in which we work and play. The highlighted studies have provided amusing examples of researchers applying serious science to peculiar problems, often integrating spatial considerations and tools, to reveal how and why things work in a particular way but also to show that science can be a lot of fun. After all, considering the student's point of view, it is always easier to learn when you are enjoying the experience.

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Satellite based mapping of air pollution using Google Earth Engine for Himachal Pradesh, India

It has emerged that satellite retrieved mean pollutant concentration recorded relatively lower concentration during the year 2020 in comparision to 2019 and 2021 indicating the impact of lockdown due to Covid 19 pandemic

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Abstract

The paper aims to investigate the spatiotemporal pattern of three types of air pollutants by using Sentinel 5p satellite data namely absorbing aerosol index (AAI) broadly indicated as particulate matter, nitrogen oxides (NOx) and carbon monoxides (CO) for roughly three consecutive years from January 2019 to October 2021 (34 months) for north-western Himalayan State of India namely Himachal Pradesh. These data are further compared with the ground monitored data of State Pollution Control Board for the same period. In addition, total yearly mean emission of NOx is calculated and retrieved by converting mol/m^2 to ton/m^2 using Sentinel-5p offline NO_2 stored in Google Earth Engine (GEE) JavaScript API for 2019, 2020 and 2021. From the analysis, it has emerged that satellite retrieved mean pollutant concentration recorded relatively lower concentration during the year 2020 in comparision to 2019 and 2021 indicating the impact of lockdown due to Covid 19 pandemic.

1. Background

Himachal Pradesh is one of the north-western Himalayan States of India. The state also shares an international border with the Tibet of China towards east. It is popularly known as *'Dev Bhoomi'* or 'Land of God'. Two very famous river basins namely Indus and Ganges drain the territory of Himachal Pradesh. The State constitutes about 1.7 percent of geographical area of the country and elevation ranges from 465m to over 7,000m above sea level. As per the record of the Govt. of Himachal Pradesh, the State is home to 5721 faunal species and 3295 plant species. Forests constituted about 27.72% of the state's geographical area in 2019, which was higher than the national average. Being home to such a diverse and rich ecosystem and located in the lap of Himalayas, protection of the rich biodiversity of the State and providing pollution free environment is our shared responsibilities and is of paramount importance.

1.1 Air pollution parameters

Air pollution is a global environmental health concern that is responsible for approximately 7 million death each year. Keeping in view of its gravity, Central/State Pollution Control Boards/ Committees of India are mandated with monitoring key pollutants on daily basis. During the year 2009, Govt. of India had notified the revised National Ambient Air Quality Standards for 12 parameters – PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, Pb, Ni, As, Benzo(a)pyrene, and Benzene (CPCB 2009). Himachal Pradesh State Pollution Control Board being the nodal agency for pollution control & environment protection undertakes ground level monitoring of following air pollutants viz., Sulphur Dioxide (SO_2),

Oxides of Nitrogen as NO_2, Respirable Suspended Particulate Matter (RSPM / PM_{10}) and Fine Particulate Matter ($PM_{2.5}$) in addition to other parameters on day to day basis at 25 locations covering 11 cities/towns across the State. Out of 11 cities/towns monitored, seven (07) towns had been classified/identified by the Central Pollution Control Board (CPCB) as Non-Attainment[1] Towns in Himachal Pradesh with respect to PM_{10} which were exceeding National Ambient Air Quality Standards (NAAQS) during FY - 2010 – 2015. These towns were *Baddi, Nalagarh, Parwanoo, Kala Amb, Paonta Sahib, Sundernagar & Damtal*. Of above, Damtal is not a town as per the census but a large village adjoins Pathankot of Punjab in the west.

It is worthwhile to note that point-source based stationery monitoring has both advantages and limitations. Keeping in view the limitation in terms of spatial coverage in point-source monitoring, organizations are also taking the assistance of satellite based non-point source monitoring such as satellite. Of late, there are few satellites which have started monitoring of atmospheric constituents on daily basis. In this series, the Copernicus Sentinel-5P satellite was launched in October 2017 to map a multitude of air pollutants around the globe. The Tropomi instrument on-board Sentinel 5p as a spatial resolution of 3.5 x 7.0 km, compared to coarser resolution of 24 × 13 km achieved through the Ozone Monitoring Instrument on NASA's Aura mission.

2. The study area and methodology

2.1 STUDY AREA

Himachal Pradesh – the north-western Himalayan State of India has been selected as the study area. Multi time-series sentinel 5p Satellite (S5P) data (from January 2019 to October 2021) were processed using Google Earth Engine (GEE) JavaScript API. In addition, other requisite vector data were obtained from other secondary sources and uploaded into the Asset section of GEE for spatiotemporal analysis.

2.2 GEOSPATIAL ANALYSIS BY GOOGLE EARTH ENGINE

Google Earth Engine (GEE) is a rapidly growing geospatial processing service and offers platform for scientific analysis and visualization of geospatial datasets for users ranging from academic, non-profit, business to government. Earth Engine hosts huge amount of satellite imageries and stores it in a public data archive that includes historical earth images going back more than forty years. The images, ingested on a daily basis, are then made available for global-scale data mining. Earth Engine also provides APIs and other tools to enable the analysis of large datasets.

3. The satellite & sensor – Sentinel-5 Precursor and TROPOMI

The Sentinel-5P (S5p) – is the first Copernicus mission dedicated to monitoring our atmosphere. The satellite carries the Tropomi instrument to map a multitude of trace gases such as nitrogen dioxide, ozone, formaldehyde, sulphur dioxide, methane, carbon monoxide and aerosols. Some basic facts about the satellite sensor are indicated in Table-1.

The mission objectives of S5P are to globally monitor air quality, climate

Figure-1: Study area: the State of Himachal Pradesh

Table – 1 Information on Tropomi Sensor

Properties	Info
Spatial resolution	Up to 5.5* km x 3.5 km.
Sensor	Tropospheric Monitoring Instrument (TROPOMI), a spectrometer measuring ultraviolet and visible (270–495 nm), near infrared (675–775 nm) and shortwave infrared (2305–2385 nm) light.
Revisit time	Less than one day.
Spatial coverage	Global coverage.
Data availability	Since April 2018.
Common usage/ purpose	To provide global information on a multitude of atmospheric trace gases, aerosols and cloud distributions affecting air quality and climate.

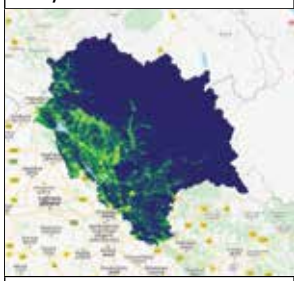
(Source: https://docs.sentinel-hub.com/api/latest/data/sentinel-5p-l2/)

Table – 2 Product parameters

Product/ Band	Physical Quantity (units)	Sentinel Hub Units	Typical Range	Notes
AER_AI	UV aerosol index from 380 and 340 nm (unitless)	INDEX	-1 - 5	Aerosol index
CO	Carbon monoxide total column (mol/ m2)	MOL_M2	0 - 0.1	Certain events (wildfires) may cause these limits to be exceeded.
NO2	Nitrogen dioxide tropospheric column (mol/m2)	MOL_M2	0 - 0.0003	Peak values for polluted cities may reach two or three times the upper value.

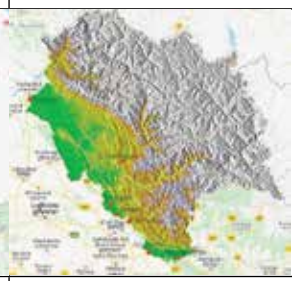
(Source: https://docs.sentinel-hub.com/api/latest/data/sentinel-5p-l2/)

Figure– 2: Population distribution during the year 2020



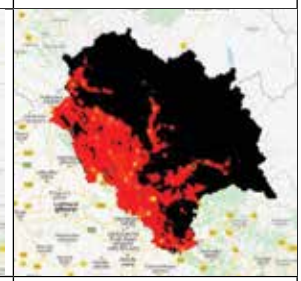
(Source: https://www.worldpop.org/)

Figure– 3: Topographic characteristics & locations of NACs in Himachal Pradesh



(Source: https://srtm.csi.cgiar.org/)

Figure– 4: Night Time Light observance



Source: noaa/dmsp-ols/ nighttime_ lights)

and the ozone layer in the time period during 2017 to 2023. The first 6 months of the mission were used for special observations to commission the satellite and the ground processing systems. The operational phase started in April of 2018. Sentinel 5P monitors not only troposphere, which is the lowest layer of Earth's atmosphere but also stratosphere - the second layer of the atmosphere as you go upward. The troposphere is very important because we breathe the air in this layer of air. Hence the study focusses on tropospheric pollutants. The units of the products/bands being analysed in the paper are indicated in Table 2.

4. Spatial Correspondence between Population Density & Topography and Pollution Concentration

Spatiotemporal pattern of pollution concentration is spatially correlated with anthropogenic activities in the State and consequently flat-lands and valleys where economic activities are more pronounced record relatively higher concentration of pollutants. Anthropogenic activities can, in best way, be reflected through the GEE datasets of population density and nightlight observance demonstrated through the population density/pattern using *Worldpop.org*, topographic variations using *Surface Radar Terrain Model* (SRTM) dataset and nightlight observed through a *NOAA/DMSP-OLS satellite*, which inter-alia correlate with pollution concentration pattern of particulate matter, nitrogen oxides and other trace gases. The intention of putting all following maps are to draw a parallel with anthropogenic/ economic activities and spatial pattern of pollutants, which are highly correlated as indicated in subsequent analysis.

5. Pollution parameters analysed

5.1 Absorbing Aerosol Index (AAI) / Particulate Matters:

The AAI of Sentinel 5p is based on wavelength-dependent changes in Rayleigh scattering in the UV spectral range for a pair of wavelengths. The difference between observed and modelled reflectance results in the AAI. **When the AAI is positive, it indicates the presence of UV-absorbing aerosols like dust and smoke.** It is useful for tracking the evolution of episodic aerosol plumes from dust outbreaks, volcanic ash, and biomass burning. The wavelengths used have very low ozone absorption, so unlike aerosol optical thickness measurements, AAI can be calculated in the presence of clouds. Daily global coverage is therefore possible. For this L3 AER_AI product, the Absorbing Aerosol Index is calculated with a pair of measurements at the 354 nm and 388 nm wavelengths (*https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_NRTI_L3_AER_AI*). The Aerosol Index (AI) is a qualitative index indicating the presence of elevated layers of aerosols with significant absorption. An advantage of the AI is that it can be derived for clear as well as (partly) cloudy ground pixels (https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/level-2/aerosol-index).

Aerosols are generated by human activities such as vehicular and industrial emissions, dust particles generated in mining, transport, and urban smog. However, it is worthwhile to note that satellite datasets do not yield accurate ground-level pollutant concentrations, which have a significant impact on human health (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8372483/).

5.1.2 Spatiotemporal pattern

Theoretically, the State records negative value of AAI indicating absence of any aerosol related concentration.

Nevertheless, it records some spatial pattern in thin layer of concentration of aerosol in troposphere. Following maps of AAI indicate that a very thin blue patch of aerosol is observed in 2019 followed by complete absence during 2020. However annual mean of AAI of 2021 displays the presence of aerosol towards west in flatlands of the State. However, besides anthropogenic activities playing important roles in the spatial pattern of AAI, natural sources and its trans-boundary movement also seem to play equally important roles in western parts of the State.

Monthly mean concentration of aerosol is depicted in the following month-wise maps prepared through GEE indicating higher concentration of aerosol in early-half of 2019 and later-half of 2021. The lower concentration pattern during 2020 can be attributed to the Covid-19 pandemic lockdown during a longer period of time during 2020 and further increase due to lifting of curbs during later-half of 2021. AAI images seem to have error related to surface snow and ice cover over Himalayas, which are masked in the mapping of AAI for better results as indicated by Figures-5-6.

5.1.3 Comparison between satellite vs ground monitored data of PM^{10}

The mean monthly ground monitored data of one of the non-

> The spatial distribution, direction, and magnitude of PM changes near the surface are substantially different from those of the tropospheric aerosols assessed via satellite data, indicating the significance of monitoring ground-level changes in air pollution compared to satellite-retrieved spatial patterns and trends. Hence, data monitored by the Pollution Control Boards are more relevant and concerned to human health

Figure – 05: Mean yearly Absorbing Aerosol Index of Himachal Pradesh

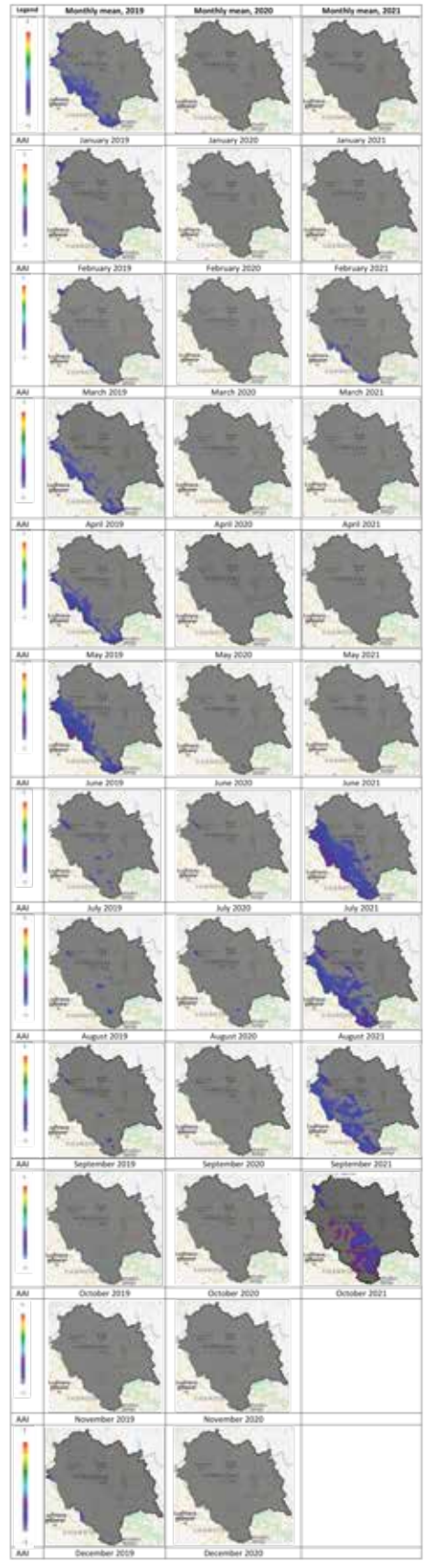


Figure – 06: Mean monthly Absorbing Aerosol Index of Himachal Pradesh

attainment towns namely Baddi – the industrial hub of Himachal Pradesh is compared with the tropospheric air pollutants obtained from the satellite data for the period during 2019 to 2021. The primary axis of the Graph-1 exhibits ground monitored data while secondary axis demonstrates values of AAI values extracted from AER data of Sentinel 5p. Both trend lines of ground and atmospheric observations show declining trends and complement each other. The negative value of AAI ideally indicate the absence of aerosol, however there are some thin patches of concentration observed towards the western parts.

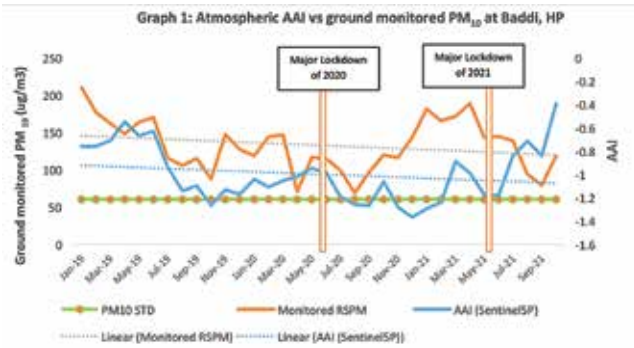
5.2 Nitrogen Oxides (NOx)

5.2.1 Health impact

The major source of NO_2 is combustion processes. Burning fossil fuels, heat, and transportation contribute to NO_2 based air pollution. As per the CPCB report, NO_2 is showing alarmingly high increasing trend in Indian cities due to increase in number of vehicles (https://app.cpcbccr.com/ccr_docs/FINAL-REPORT_AQI_.pdf). On inhalation, 70–90% of NO_2 can be absorbed in the respiratory tract of humans, and physical exercise increases the total percentage absorbed (Miller et al., 1982). NO_2 exposure can cause decrement in lung function (i.e. increased airway resistance), increased airway responsiveness to broncho-constrictions in healthy subjects at concentration exceeding 1 ppm (WHO 2000).

5.2.2 Atmospheric concentration (tropospheric_NO2_column_number_density)

Nitrogen oxides (NO_2 and NO) are important trace gases in the Earth's atmosphere, present in both the troposphere and



(Source: Calculated from ground monitored monthly average of PM_{10} of Himachal Pradesh Pollution Control Board Shimla & AAI of Sentinel 5p)

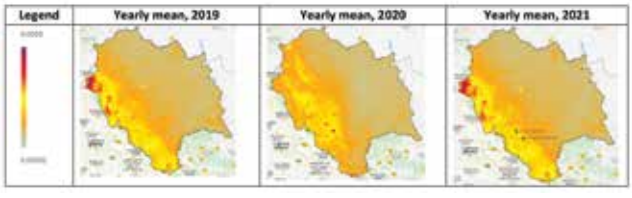


Figure – 07: Mean monthly Absorbing Aerosol Index of Himachal Pradesh

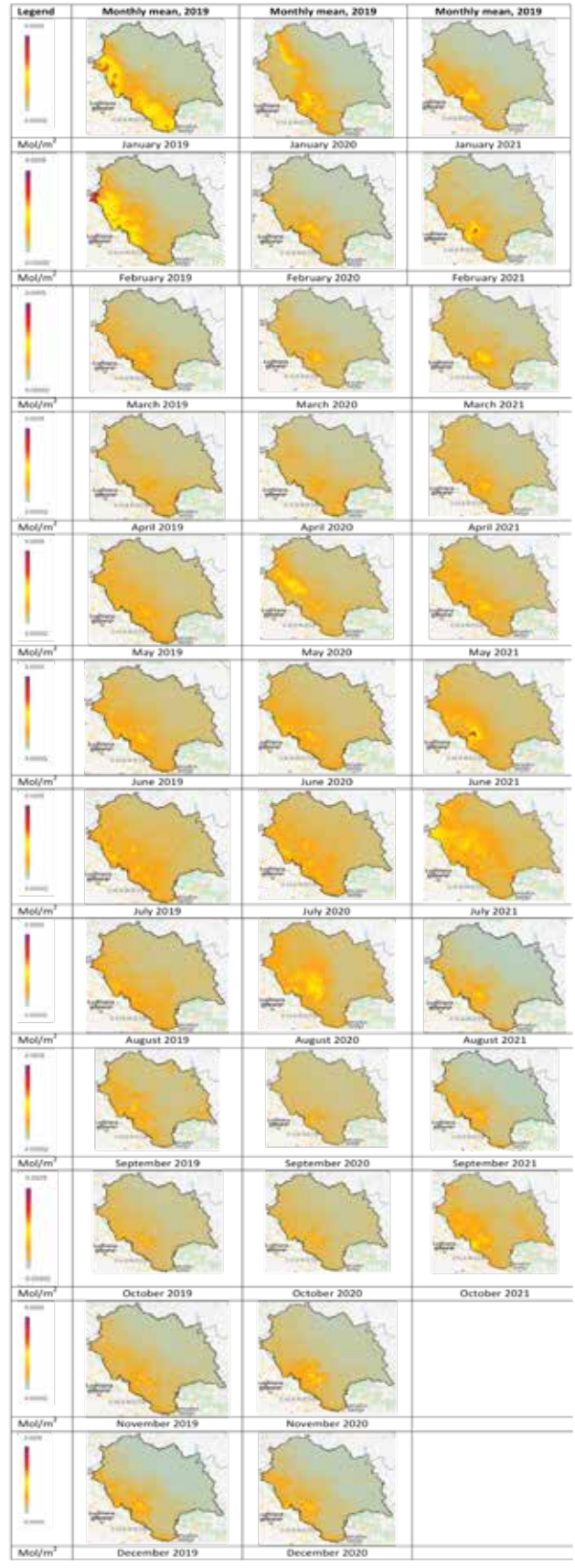
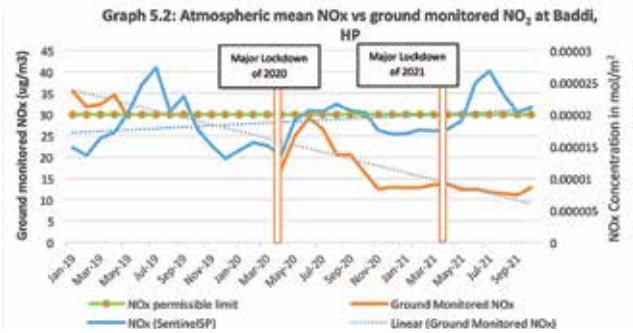
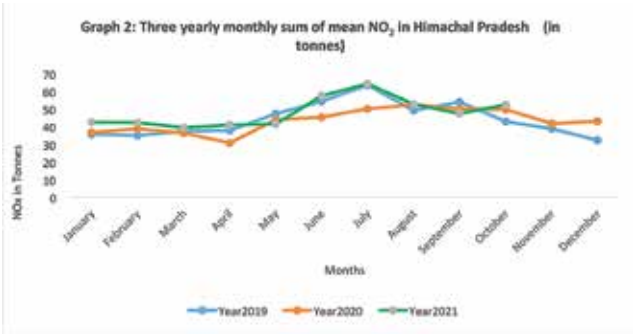


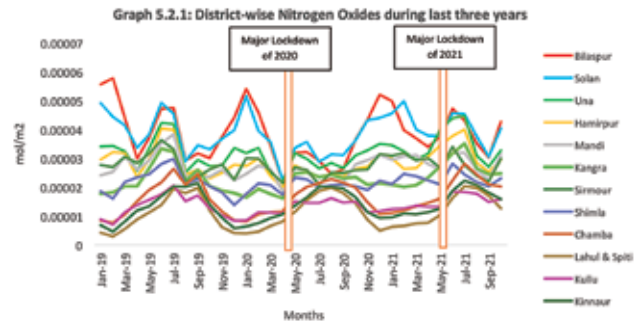
Figure – 08: Mean monthly concentration of NOX during 2019 to 2021



(Source: Calculated from ground monitored monthly average of NO2 of Himachal Pradesh Pollution Control Board Shimla & mean monthly NOx of Sentinel 5p)



(Source: Sentinel 5p)



(Source: Sentinel 5p)

the stratosphere. They enter the atmosphere as a result of anthropogenic activities (notably fossil fuel combustion and biomass burning) and natural processes (wildfires, lightning, and microbiological processes in soils). Here, NO_2 is used to represent concentrations of collective nitrogen oxides because during daytime, i.e. in the presence of sunlight, a photochemical cycle involving ozone (O_3) converts NO into NO_2 and vice versa on a timescale of minutes. (https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S5P_OFFL_L3_NO2).

5.2.3 Spatiotemporal pattern

Scientists say that the nitrogen dioxide (NO_2) has a short lifetime, which means it is detected near its source. NOx pollution is emitted by automobiles, trucks and various non-road vehicles (e.g., construction equipment, boats, etc.) as well as industrial sources such as power plants, industrial boilers, cement kilns, and turbines (Source: https://www3.epa.gov/region1/airquality/nox.html). Spatial pattern of NO_2 in the State is in agreement with the distribution of population density and physiographic pattern. However, there are three major cement plants in the State, where due to kilns, they generate heat, thus demonstrating thon patches of NOx concentration over and around these three plants however these concentration are insignificant compared to the normal concentrations of neighbouring states.

Reductions in tropospheric NO_2 concentrations were observed during lockdown due to Covid-19 pandemic compared to pre-lockdown concentrations. Consequently a gradual decline in state-level tropospheric NO_2 is evident in most districts from 2019 to 2020.

Following satellite-derived average NO_2 concentration maps indicate the presence of red and yellow patches in the western parts of Kangra, Una and consistent concentration over and around cement plants of M/s Ambuja Cement, M/s Jaypee Cement Baga and M/s ACC Barmana. Areas over cement plants record relatively high concentration of NO_2 owing to heat generation from their kilns. However as per the

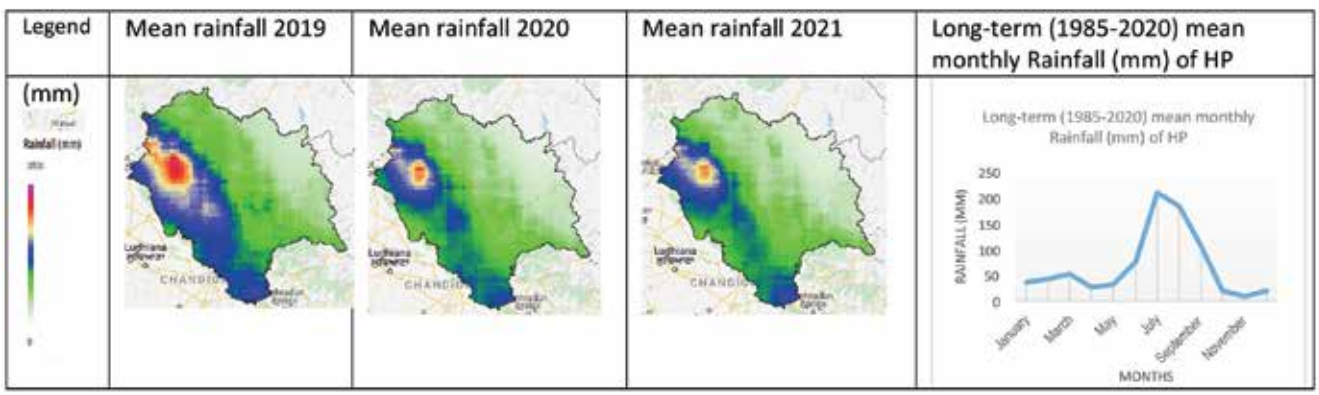


Figure – 09: Mean monthly concentration of NOX during 2019 to 2021

(Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) obtained/analysed through GEE)

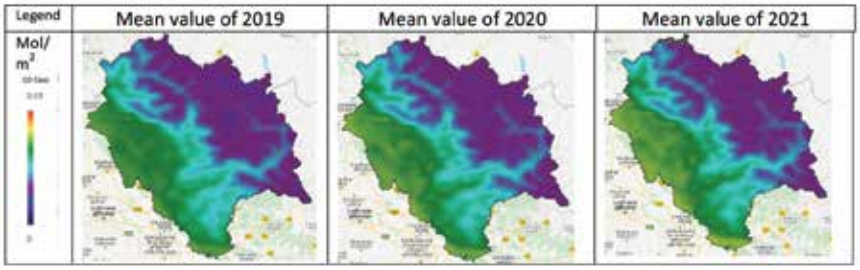
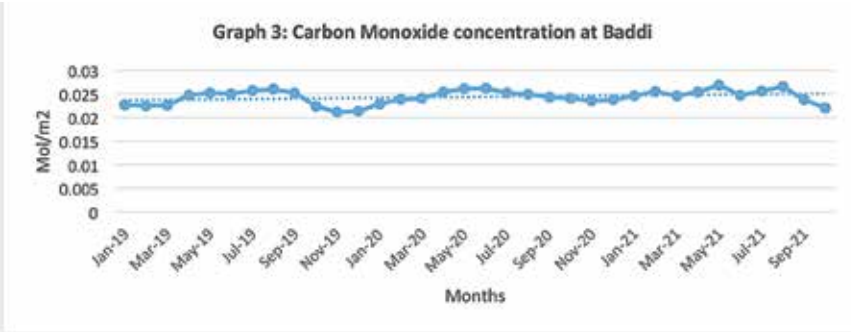


Figure – 10: Mean monthly concentration of NOX during 2019 to 2021



(Source: Sentinel 5p)

monitoring conducted by the State Board, concentration of oxides of nitrogen are insignificant and below the permissible limit in comparison to other western neighbouring States (Refer Figures 6&7).

5.2.4 Comparison between satellite data vs ground monitored data of NOx

There are some gaps in ground monitoring data of NOx, however demonstrating declining trend at Baddi, while atmospheric data show a partial increase in trend-line. However this is worthwhile to note that lockdown periods recorded lower concentration of NOx during early 2020 and mid-2021.

5.2.5 Total yearly emission of NO_2 in tonnes

Total yearly emission of NO_2 for Himachal Pradesh was calculated using Sentinel-5p Offline NO_2 stored in Google Earth Engine. First of all, yearly sum of mean NO_2 (tropospheric_NO2_column_number_density) was calculated by converting mol/m^2 to ton/m^2 and by employing *GEE reduceRegion* function for Himachal Pradesh during three years namely 2019, 2020, 2021. Summary of three yearly data were tabulated in Graph – 2. As indicated below, the year 2000 recorded the lowest of three years except few outliers in the months of May and September 2020. This may be attributed to the frequent lockdowns imposed during the year due to Covid 19 pandemic.

5.2.6 Inter-district variation in NOx observance

Inter-district mean concentration of nitrogen oxides for 34 months retrieved through Sentinel 5P is analysed below. Districts of Solan and Bilaspur top the list of concentration. Three cement plants namely M/s Ambuja Cement, M/s Jaypee Cement Baga and M/s ACC Barmana are located in eastern parts of these two districts. Districts recording patches of concentrations are industrialized and relatively more populated, which are known major NO_2 emission contributors. Nevertheless these patterns depict the tropospheric concentration not the ground level concentration.

The graph as included in Figure-09 also indicates the monsoon phenomena during July to September where districts in plains show declined concentration (troughs) of NOx, while some of mountainous districts such as Kinnaur, Kullu, Chamba and Lahul & Spiti have shown peaks during rainy seasons indicating no-monsoon related rainfall in high hills compared to plains, which reduces pollution concentration. The spatial pattern and temporal trend of rainfall in Himachal Pradesh is also analysed through GEE as indicated in Figure-09.

5.3 Carbon Monoxide

Carbon monoxide (CO) is an important atmospheric trace gas for our understanding of tropospheric chemistry. In certain urban areas, it is a major atmospheric pollutant. Main sources of CO are combustion of fossil fuels, biomass burning, and atmospheric oxidation of methane and other hydrocarbons **(**http://www.tropomi.eu/data-products/carbon-monoxide**).** As indicated below, total atmospheric column density of CO is highly correlated to the anthropogenic activities. The concentration of CO can be related to high vehicular activities in plains and valleys. Though the concentrations are less but displays the similar spatiotemporal trend and pattern in all three years. Partial increase may, however, be observed in 2021 indicating CO concentration is highly correlated with increase in day to day economic activities of the State (Refer Figure-10).

5.3.1 Mean monthly concentration of CO

Mean monthly concentration of Carbon Monoxide (CO) at Baddi is more or less stagnant and display a partial increase as per the *CO_column_number_density* of Sentinel 5p. However, impact of Covid-19 lockdown is not quite visible through the Graph-3.

6.0 Concluding remarks

The spatial distribution, direction, and magnitude of PM changes near the surface are substantially different from those of the tropospheric aerosols

assessed via satellite data, indicating the significance of monitoring ground-level changes in air pollution compared to satellite-retrieved spatial patterns and trends. Hence, data monitored by the Pollution Control Boards are more relevant and concerned to human health.

Further permissible limit of tropospheric column concentrations for aerosol, NOx, CO are not available as yet as in the case of ground level monitoring of pollutants enforced by the Pollution Control Boards/Committees. Therefore, only high and low levels of concentration are explained spatially for understanding purposes. The fact remains that the ground monitoring being conducted by relevant agencies observe a very low level of NO_2 concentration across the State and they are below detectable limit at several locations as well. Nevertheless, the spatial pattern are clearly visible across the districts, which can either be linked to economic activities or trans-boundary movement of pollutants particularly along bordering areas towards west. Further Covid-19 lockdowns also caused two dips in pollution concentration as evident in the months of April 2020 and May 2021. Urban settlements of mountainous state are of small sizes, hence in order to monitor pollution pattern at micro level, researchers require more high spatial resolution satellite sensors, which are currently not available. Nonetheless Sentinel 5p has opened a new vistas of monitoring atmospheric constituents on daily basis.

Abbreviations:

AAI - absorbing aerosol index, NOx - Nitrogen oxides, NO_2 - Nitrogen dioxide, CO - Carbon monoxide, PM_{10} - particulate matter 10 microns or less in diameter, $PM_{2.5}$ - particulate matter 2.5 microns or less in diameter, NAAQS - National Ambient Air Quality Standards, FY - Financial Year, GEE - Google Earth Engine, AER - Aerosol, NAC - Non-attainment Cities, SRTM - Surface Radar Terrain Model, NAMP – National Air Monitoring Programme, NOAA/DMSP-OLS - Operational Linescan System (OLS) flown on the Defense Meteorological Satellite Program (DMSP) satellite.

Disclaimer

The analysis and conclusion drawn in the study is independent of institutional affiliation of the author.

Endnotes

[1] Non-attainment Cities (NAC) are those, which do not meet the National Ambient Air Quality Standards (NAAQS) consistently for PM_{10} (Particulate matter that is 10 microns or less in diameter) or NO_2 (Nitrogen Dioxide) or SO_2 (Sulphur Dioxide) over a 5-year period. In Himachal Pradesh, there are seven such non-attainment cities (NACs) namely Baddi, Parwanoo, Kala-Amb, Paonta Sahib, Nalagarh, Sundernagar and Damtal, which violated NAAQS.

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UN Mongolia workshop report on the applications of GNSS

Understanding the private sector and commercial feasibility[1] to successfully operationalize PPPs in land administration, it is critical to examine and assess the commercial feasibility of each proposed transaction inclusion

Introduction

1. Global navigation satellite system (GNSS) is a general term describing any satellite constellation that provides positioning, navigation and timing services on a global and regional basis and whose data are used for a broad range of applications. Current GNSS include the following global and regional constellations: the Global Positioning System (GPS) of the United States of America, the Global Navigation Satellite System (GLONASS) of the Russian Federation, the BeiDou Navigation Satellite System (BDS) of China, the European satellite navigation system, Galileo, of the European Union, the Navigation with Indian Constellation (NavIC) system of India and the Quasi-Zenith Satellite System (QZSS) of Japan. The performance of GNSS can be improved through satellite-based augmentation systems to provide greater accuracy, integrity and availability for professional use and applications in critical sectors involving safety of life, for example, the aviation sector, which requires high-performance integrity verification.

2. The International Committee on Global Navigation Satellite Systems (ICG) is an important platform for communication and cooperation in the field of GNSS. The United Nations Office for Outer Space Affairs, in its capacity as the executive secretariat of ICG, supports progress in achieving compatibility and interoperability between all satellite navigation systems. As new systems emerge, signal compatibility and interoperability among GNSS systems and transparency in the provision of open civil services are key factors for ensuring that civil users around the world receive the maximum benefit from GNSS and its applications.

3. The Office for Outer Space Affairs and ICG work together to raise awareness of the important role of GNSS in our societies and to promote international collaboration in this field. Specific areas of interest to ICG and its working groups include systems, signals and services (Working Group S); the enhancement of GNSS performance, new services and capabilities (Working Group B); information dissemination and capacity-building (Working Group C); and timing and geodetic reference frames (Working Group D). More detailed information is available at www.unoosa.org/oosa/en/ourwork/icg/icg.html.

4. The United Nations/Mongolia workshop on the applications of GNSS was organized by the Office for Outer Space Affairs in cooperation with the Mongolian Geospatial Association and the Agency for Land Administration and Management, Geodesy and Cartography of Mongolia. The workshop was held online from 25 to 29 October 2021. It was supported by ICG.

5. The present report contains a description of the background, objectives and programme of the workshop, as well as an overview of the highlights of each technical session and observations made at the workshop. It has been prepared for submission to the Committee on

the Peaceful Uses of Outer Space at its sixty-fifth session, to be held in 2022, and to its subcommittees.

A. Background and objectives

6. The main objectives of the workshop were to reinforce the exchange of information between countries and scale up capacities in the region for pursuing the application of GNSS solutions; share information on national, regional and global projects and initiatives, which could benefit regions; and enhance cross-fertilization among those projects and initiatives.

7. The specific objectives of the workshop were to introduce GNSS-based technology and its applications; promote the greater exchange of actual experiences with specific applications; and focus on appropriate GNSS applications projects at the national and/or regional levels.

B. Programme

8. At the opening of the workshop, introductory and welcoming statements were made by the State Secretary of the Foreign Affairs Ministry of the Government of Mongolia, the General Deputy of the Agency of the Land Management, Geodesy and Cartography and the representative of MonMap LLC. The first Mongolian cosmonaut also addressed the workshop. The representative of the United Nations Office for Outer Space Affairs made opening remarks.

9. The workshop included the following technical sessions covering a wide range of topics related to GNSS-based technology and its applications: (a) an update on GNSS and GNSS-based applications; (b) space weather; (c) high-precision GNSS positioning; (d) timing, frequency and applications; (e) Geodetic reference networks; (f) national GNSS programmes and projects; (g) case studies; and (h) reports from the ICG Working Group B Application Subgroup. In total, 48 presentations were made during the five-day workshop. Speakers were selected on the basis of their scientific or engineering background, the quality of the abstracts of their proposed presentations and their experience in programmes and projects using GNSS-based technology and its applications.

10. In accordance with its workplan, on 26 and 27 October 2021, the experts of the Task Force on Interference Detection and Mitigation of ICG Working Group S conducted a seminar on GNSS spectrum protection and interference detection and mitigation. The purpose of the seminar was to describe the importance of GNSS spectrum protection at the national level and to explain how to reap the benefits of GNSS. The seminar lecture notes are available at www.unoosa.org/oosa/en/ourwork/psa/schedule/2021/2021-seminar_IDM_-presentations.html.

11. The programme of the workshop was developed by the Office for Outer Space Affairs and the Mongolian Geospatial Association in cooperation with ICG working groups.

12. The presentations made at the workshop, abstracts of the papers presented and the programme of the workshop are available on the website of the Office for Outer Space Affairs (www.unoosa.org).

C. Attendance

13. A total of 324 specialists representing national space agencies, academia, research institutions, international organizations and industry from developing and developed countries concerned with the development and use of GNSS for practical applications and scientific exploration were invited to participate in the workshop.

14. The following 61 Member States were represented at the workshop: Algeria, Australia, Azerbaijan, Bahrain, Bangladesh, Brazil, Burkina Faso, Cambodia, Canada, Chile, China, Côte d'Ivoire, Croatia, Cuba, Ecuador, El Salvador, Ethiopia, Fiji, Finland, France, Gabon, Germany, India, Indonesia, Iran (Islamic Republic of), Japan, Kenya, Kiribati, Lao People's Democratic Republic, Lesotho, Malaysia, Maldives, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Nigeria, Oman, Pakistan, Peru, Philippines, Portugal, Russian Federation, Rwanda, Saudi Arabia, Sri Lanka, Tajikistan, Thailand, Togo, Tonga, Tunisia, Turkey, Uganda, United Arab Emirates, United States of America, Uzbekistan, Venezuela (Bolivarian Republic of), Zambia and Zimbabwe. The European Commission was also represented. Representatives of the Office for Outer Space Affairs and the International Telecommunication Union also participated.

Summary of discussions and observations

15. Through the presentations and the exchange of views that took place during the workshop, participants raised awareness of issues and opportunities in the use of GNSS for various applications that could provide sustainable social and economic benefits, for developing nations in particular. Each of the technical sessions included a discussion of the key challenges and issues presented.

16. The workshop noted that the field of GNSS was developing in a way that enabled satellite operators responsible for current and planned systems and their augmentation systems to cooperate at the international level with each other and the user community. It was noted that ICG had become an important platform for communication and cooperation in the field of GNSS and that the Office for Outer Space Affairs continued to support progress towards achieving compatibility and interoperability among global and regional space-based navigation systems. It was also noted that ICG, as a multilateral coordination mechanism, had allowed GNSS technology to evolve over time while still providing the structure necessary to achieve efficient interaction in one of the most important fields of space applications.

17. The workshop noted that space weather was a major factor limiting the precision and reliability of positioning, navigation and timing services provided by GNSS. It was noted that geomagnetic storms and substorms, solar flares and ionospheric irregularities could result in the deterioration of those services. Case studies of the impacts of space weather on GNSS highlighted the different approaches to mitigating the influences of space weather on single-frequency, dual-frequency, real-time kinematic and precise point positioning. Another focus of presentations delivered at the workshop was the evaluation of the characteristics of the different ionospheric models used in single-frequency operations during space weather events.

18. The workshop noted that a number of training activities focusing on ionospheric physics and space weather science had been planned by the Office for Outer Space Affairs in cooperation with the Abdus Salam International Centre for Theoretical Physics, Italy, Boston College of the United States and ICG, to be held in 2022.

19. A seminar conducted by the Task Force on Interference Detection and Mitigation of ICG Working Group S introduced spectrum management for radio-navigation satellite services (RNSS) and the mitigation of radio frequency interference, collectively referred to as "spectrum protection". Experts with experience in the development, operation and use of RNSS discussed regulatory, technical, operational and policy aspects of RNSS spectrum protection. It was noted that there were an almost limitless number of GNSS applications and that GNSS was of crucial importance for national and global economies.

20. With respect to GNSS vulnerability and threats, it was noted that the satellite signals received by GNSS receivers were much weaker than the radio signals typically used by ground-based systems such as television stations or mobile phone networks, and consequently, it was essential to keep the frequencies used by terrestrial services well separated from those used in GNSS. There were many potential interference sources that could degrade GNSS performance and prevent the use of GNSS.

21. Participants in the workshop were therefore encouraged to engage with spectrum regulators and decision makers in their respective countries to ensure that there was a solid understanding of the processes and the organizations involved in the regulation of the GNSS spectrum and that the GNSS spectrum was adequately protected. Only by ensuring that the GNSS spectrum was kept clean and free of interference could GNSS be used to maximum benefit.

22. It was noted that GNSS systems, using a standard GNSS receiver, could provide positioning accuracy of about 10 metres. However, that level of accuracy could be improved using error correction techniques. GNSS measurements were affected by satellite clock errors, orbit errors (ephemeris errors), ionospheric effects, tropospheric effects, receiver circuit errors and multipath distortion. All those effects, with the exception of multipath distortion which remained a major source of error, could be removed or reduced by using special signal observation methods and signal-processing techniques. One such method was differential observation, in which a reference station, installed at a known position location, enabled exact measurement errors to be computed, thus providing accuracy to a few centimetres – a process known as real-time kinematic processing. Another method took into account satellite-related error data (clock and orbit data) from the satellite itself using a separate signal or link. At the workshop, a presentation was made on a simple methodology to design and implement a low-cost GNSS software-defined radio receiver. It was noted that the availability of reliable and flexible receivers was a priority for many applications, including research.

23. Participants noted that access to high-accuracy positioning services provided by GNSS and regional navigation satellite systems would serve as an enabler for emerging mass-market high-accuracy positioning applications, such as in autonomous systems in transportation, construction, mining, agriculture and location-based service applications. It was also noted that the ability to measure and monitor GNSS signal quality was critical to assess GNSS usability and performance.

24. The workshop noted that ICG Working Group C, led by the Office for Outer Space Affairs, and the Centre for Spatial Information Science at the University of Tokyo, Japan, organized a series of training courses from 2018 through 2020 focusing on a low-cost receiver for high-accuracy positioning and GNSS data processing using the post-processing real-time kinematic technique. The training course lecture notes were available at the ICG information portal (www.unoosa.org/oosa/en/ourwork/icg/activities.html). A new series of training programmes focusing on GNSS data processing would begin in 2022. That series would include a session for policy - and decision makers on GNSS principles and applications.

25. It was noted that GNSS satellites were equipped with atomic clocks that were accurate to within nanoseconds. While that was incredibly accurate, time measurements were necessary for the calculation of GNSS positioning. GNSS receivers could also use time measurements to provide timing accuracies of within 20 nanoseconds. The participants were shown an example of GNSS time transfer methods for remote clocks of common-view and all-in-view observations based on code measurements and the reference timescale of GNSS.

26. Participants took note of recent developments in the use of both the Integrated Geospatial Information Framework Overarching Strategic Framework and Implementation Guide for the purpose of geodetic capacity-building, including examples from countries currently using the Framework to develop country-level action plans. There was

a need for standards and procedures that were fit for purpose, including consolidated checklists that would serve to ensure consistent and sustainable use of GNSS, and related activities in the regions.

27. The workshop noted that technical seminars on reference frames in practice were being organized by the International Federation of Surveyors (FIG) Commission 5 on positioning and measurement, in cooperation with the International Association of Geodesy, the International GNSS Service and ICG Working Groups C and D. The seminars were held in conjunction with the FIG Working Week for the benefit of operational geodesists or surveyors who dealt with reference frame issues in both governmental and commercial environments.

28. Participants learned about education and training programmes on GNSS. It was noted that social and economic development in the countries of the region could be enhanced by improving the skills and knowledge of university educators and scientists through the conduct of rigorous theory, research, field exercises and pilot projects in GNSS technologies. Information on short- and long-term training courses on various aspects of GNSS, conducted at the regional centres for space science and technology education, affiliated to the United Nations, was also provided.

29. The session on case studies gave participants an additional opportunity to share their experiences in the use and applications of GNSS. Participants learned about high-accuracy positioning products that increase efficiencies and save time and input costs for the agriculture industry. A wide selection of innovative GNSS positioning products that could assist with construction and mining applications were also demonstrated.

30. Participants expressed appreciation for the various reports from the ICG Working Group B Application Subgroup on topics such as intelligent transport system applications and services, a GNSS-based emergency warning system responding to all types of hazards ranging from earthquakes to forest fires, GNSS user technology, high-precision products and services, and GNSS signal authentication applications, all of which illustrated that GNSS technology was undergoing a rapid evolution responding to the need for ubiquitous access, automation and secure positioning and showed how new developments would bring continuous accuracy, integrity and robustness to the main application domains.

31. The workshop was informed that the second edition of the publication The Interoperable Global Navigation Satellite Systems Space Service Volume (ST/SPACE/75/Rev.1), which had undergone a thorough review and update of all content, including the latest constellation data from all GNSS providers and adding GNSS space user flight experiences. The workshop took note of the release of the companion video. Both had been made available at www.unoosa.org/oosa/en/ourwork/icg/documents.html.

Concluding remarks

32. The discussion session provided guidance on how institutions could work together through regional partnerships to share and transfer knowledge and develop joint activities and project proposals. The feedback on the workshop received from participants was very positive, with participants saying that the topics address ed met their professional needs and expectations.

33. It was also emphasized that the Office would continue its work on capacity-building through the regional centres for space science and technology education, affiliated to the United Nations, and the centres of excellence, and would work further to ensure that end users benefited from the GNSS multi-constellation.

34. Participants expressed their appreciation to the United Nations, the Government of Mongolia and the ICG working groups for both the excellent organization and the substance of the workshop.

Bell and Esri Canada deliver Integrated Smart City Ecosystem

Bell and Esri will create the Bell Integrated Smart City Ecosystem. This integrated solution will combine Bell's award-winning 5G network and Internet of Things (IoT) solutions with Esri's real-time analytics and location intelligence capabilities to help cities of all sizes across Canada become connected communities.

The Bell Integrated Smart City Ecosystem enables Canadian communities to accelerate their digital transformations, enhancing decision-making and streamlining collaboration across municipal or regional departments. The platform collects, integrates and displays data in one seamless end-to-end experience, enabling multiple stakeholders to make decisions from a shared view that provides broader and clearer context for all involved. Cities can customize the solution, building on top of their existing location intelligence investments, or access multiple pre-integrated IoT solutions with customized reporting and automation of processes. www.bell.ca

IRIS wins Global Infrastructure Hub competition

IRIS R&D Group Inc. becomes the first Canadian start-up that provides privacy-centric smart cities data using best in class Machine Learning (ML) and Artificial Intelligence (AI) to win the Global Infrastructure Hub (GI Hub) 'InfraChallenge' supported by the Italian G20 Presidency. This challenge was focused on technological solutions for building and maintaining better and more resilient infrastructure and asset management. The Company was declared successful following a live pitch at the InfraChallenge final in September 2021 against nine other finalists from different parts of the world.

Maintenance is critical to the safety and resilience of IRIS infrastructure, yet most technology that gathers asset condition data is expensive or impractical at scale. IRIS' winning solution enables

cities to monitor road infrastructure at a substantially lower cost by using dash cameras with Artificial Intelligence (AI) to detect road hazards and defects in real-time. *www.irisradgroup.com*

ESA and NASA launch revolutionary open-source platform

ESA and NASA have publicly released the first globally-harmonized assessment of above ground biomass – information that is vital for managing global climate change. The Multi-Mission Algorithm and Analysis Platform (MAAP) provides seamless access to above ground biomass information from both NASA and ESA Earth observation data.

MAAP is the culmination of a two-year NASA and ESA effort and reflects the cooperation between the two agencies under the NASA and ESA JPPG (Joint Program and Planning Group) Joint Working Group (WG) on Ground Segment and Operations.

The MAAP platform enables international scientists and researchers to collaboratively develop algorithms and code as well as analyse and visualise large datasets acquired from sources including satellite instruments, the International Space Station, and airborne and ground campaigns. The large data and high-performance computing required for MAAP, along with a shared code repository and catalog, are stored and managed in the cloud. MAAP capabilities are supported and shared between NASA and ESA.

The initial application of MAAP focuses on above-ground biomass to help determine the size and carbon content of Earth's forests. These data are vital for informing our understanding and forecasting of climate change, including regular updates to the Intergovernmental Panel on Climate Change (IPCC).

While biomass is the first application of MAAP, it easily can be adapted for collaborative exploration across the breadth of science data and scientific disciplines available through NASA, ESA, and similar research agencies.

MAAP currently includes data from missions such as NASA's Global Ecosystem Dynamics Investigation (GEDI) and the joint NASA/ESA AfriSAR campaign, and will eventually support data from upcoming NASA and ESA missions such as the joint NASA/Indian Space Research Organization SAR (NISAR) and ESA's Biomass mission. *www.esa.int*

Esri India's ArcGIS Platform to give thrust to 'Make in India'

Esri India have launched ArcGIS Platform as-a-service (PaaS) that includes maps and location services. With a full range of SDKs, APIs, and low-code options, the platform will reduce time to market and promote creative design, enabling an open location-focused PaaS for software developers, businesses, and organizations that need to bring maps and location services into their products, solutions, and systems. With this launch, developers in India will now be able to get seamless access to Esri India's leading geospatial technology and capabilities. *www.esri.in*

UKHO becomes Strategic Member of Open Geospatial Consortium

The UK Hydrographic Office (UKHO) has strengthened its long-standing relationship with Open Geospatial Consortium(OGC) by enhancing its membership level from Technical to Strategic to provide greater leadership, boost innovation, and advance geospatial data for the marine industry. As a Strategic Member, UKHO will augment its expertise and leadership offering to OGC, while providing greater access to and usage of its marine geospatial data. *www.ogc.org*

Collaboration of NHTSA and Mission Critical Partners

The National Highway Traffic Safety Administration (NHTSA) and Mission Critical Partners (MCP) will collaborate to assess the current status of GIS within the 911 community. The goal of the initiative is to define what is required to achieve interoperable GIS data sharing nationwide. The National 911 Program, housed within NHTSA, will lead this important effort.

In 2019, the "National NG911 Roadmap," a report published by the National 911 Program, and supported by MCP, highlighted GIS as a significant barrier to achieving a nationwide "system of systems." The report emphasized the need to develop standards, requirements, and best practices for sharing GIS data. *www.911.gov*

Haryana, India launches GIS Labs in 11 districts

The Chief Minister of the Indian state of Haryana announced that GIS Labs are in the process of being established in all districts of the state to facilitate data collection pertaining to various departments through satellites.

The monitoring of the projects run by various departments can be done through satellite and the data related to all the departments will be available in these labs, the Chief Minister said after inaugurating GIS Labs set up by Haryana Space Application Centre (HARSAC) in 11 districts of the state through a virtual meeting. *www.dailypioneer.com*

IHO and Singapore launch Hydrographic Innovation Laboratory

Singapore and the International Hydrographic Organization (IHO) launched the Joint IHO-Singapore Innovation and Technology Laboratory on 26 October 2021. The laboratory seeks to optimize the resources of IHO Member States to harness and develop emerging technologies in the hydrographic domain that support safe maritime navigation and the protection of the marine environment.

In accelerating innovation in the field of hydrography, the laboratory aims to (i) conduct research and testing of projects proposed by IHO Member States, IHO organs and other stakeholders; (ii) grow knowledge and foster

collaboration on global standard-setting for the development and application of technologies enhancing safety at sea; and (iii) promote a multidisciplinary and collaborative environment to drive innovative solutions and develop pioneering technologies through active partnerships. *https://iho.int*

Seabed mapping survey in Cayman islands

The UK Hydrographic Office (UKHO) will support maritime trade and economic growth in the Cayman Islands as it embarks on a new programme of seabed mapping.

The surveys will unlock vital new information about the waters around the Cayman Islands and will enable safe navigation and the continued development of the islands' sustainable blue economy.

Under the UK government's Overseas Territories Seabed Mapping Programme (OTSMP), UKHO will collect a range of geospatial data in waters around the islands to a depth of 40 metres. The survey will also have its estimated carbon impact offset by Fugro, who have been awarded the contract to conduct the data gathering.

The survey will be conducted by a small aircraft using Lidar data gathering techniques. The aircraft will fly twice daily for periods of up to four hours at a time over the islands, operating at a height of around 300m. While it is airborne, the aircraft's onboard survey equipment will gather information on water depth and land heights, as well as high-resolution images of both land and sea.

Seabed 2030 project announces partnership with TCarta

As the effort in pursuit of the complete map of the ocean floor accelerates, The Nippon Foundation-GEBCO Seabed 2030 Project has signed a new Memorandum of Understanding (MOU) with TCarta Marine – a US-based company dedicated to marine remote sensing and hydrospatial data services.

Seabed 2030 is a collaborative project between The Nippon Foundation and GEBCO to inspire the complete mapping of the world's ocean by 2030, and to compile all bathymetric data into the freely available GEBCO Ocean Map. GEBCO is a joint project of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) and is the only organization with a mandate to map the entire ocean floor. Seabed 2030 is formally endorsed as a Decade Action of the UN Decade of Ocean Science for Sustainable Development. *https://seabed2030.org*

Bentley Systems to Acquire Power Line Systems

Bentley Systems, Incorporated has entered into a definitive agreement to acquire Power Line Systems—a leader in software for the design of overhead electric power transmission lines and their structures—from private equity firm TA Associates for approximately $700 million. *www.bentley.com*

Fugro wins two Energinet site investigation contracts

Fugro has secured two geotechnical site investigation contracts with Energinet for Denmark's proposed Energy Island project. This purpose-built artificial island will be situated 80 km offshore in the North Sea and act as a hub connecting hundreds of surrounding wind turbines. Fugro will perform the preliminary geotechnical site investigation for the Energy Island and the adjacent offshore wind farm zone. The resulting Geo-data will be used to prepare an integrated geological and geotechnical soil model on which wind farm developers will base future tenders. *www.fugro.com*

Pix4D launches the viDoc RTK in the USA and Canada

Pix4D has just made the viDoc RTK rover available for purchase in the USA and Canada. The rover attaches to the latest iOS devices to bring RTK accuracy to terrestrial scanning on iPhones and iPads. *pix4d.com*

GIOVE-A, Galileo Pathfinder satellite, de-commissioned

Surrey Satellite Technology Ltd (SSTL) has successfully de-commissioned GIOVE-A, the pathfinder satellite for Europe's Galileo constellation, after 16 years of operations in Medium Earth Orbit (MEO). The decision to de-commission the satellite was made due to the obsolescence in computing systems required for the operation of GIOVE-A, and de-commissioning of the spacecraft took place on 24 November 2021.

GIOVE-A was designed, built and tested by SSTL in only 30 months for the European Space Agency (ESA) and was launched on 28 December 2005 with a mission to secure vital frequency filings, generate the first Galileo navigation signals in space, characterize a prototype rubidium atomic clock, and model the radiation environment of MEO for future Galileo spacecraft. It was the first European satellite launched into the demanding MEO radiation environment, where it greatly out-performed its 27-month design lifetime. *www.sstl.co.uk*

Sandia's Atomic 'Avocado' could allow GPS-free navigation

Sandia National Laboratories has developed the core technology needed to create small enough quantum sensors to potentially free the US military (and civilians around the world) from reliance on GPS satellites for way-finding, according to lab officials.

The first-of-its-kind device, a passively pumped vacuum chamber for containing clouds of atomic particles that drive quantum sensors, is about the size of an avocado, according to an Oct. 26 news release from the Albuquerque-based US nuclear research lab. According to Sandia scientist Peter Schwindt, while lab researchers hadn't weighed the device, "If I had to guess, it is less than one pound."

That is small enough to enable highly accurate quantum positioning, timing and navigation (PNT) systems that in the future could be carried on vehicles,

aircraft, satellites or even soldiers' backpacks — providing an alternate, or even a replacement, for GPS satellites, which use highly accurate atomic clocks for PNT measurements. Quantum sensors, based on lasers, already are being tested in laboratories around the world, but Schwindt cautioned that there is still development work — not just on vacuum chambers — to be done to be able to use them as replacements for GPS. *www.sandia.gov*

Terry Moore wins international navigation award from IAIN

Terry Moore, a positioning and navigation expert at the University of Nottingham has become the first British academic to win a prestigious international award in the field. He is an Emeritus Professor and former director of the Nottingham Geospatial Institute at the University's Faculty of Engineering.

The International Association of Institutes of Navigation (IAIN) awarded Moore with its John Harrison Award for outstanding contributions to navigation. The award ceremony took place during a special session of the Navigation 2021 Conference in Edinburgh, which took place Nov. 16-18.

ASI completes the New National GNSS Frame Network

Construction of the New National GNSS (Global Navigation Satellite System) Frame Network of the Italian Space Agency (ASI) has been completed. This infrastructure is of vital importance in providing up-to-date, accurate geodetic information for the scientific community and professional and entrepreneurial operators. The new network was built by e-GEOS.

Through the use of latest-generation technologies, 46 stations distributed evenly across the Italian peninsula will enable the acquisition of signals generated by all the global satellite navigation systems, such as the US GPS, the Russian GLONASS, the Chinese Beidou and Europe's Galileo. ASI's GNSS network, which was designed and developed to provide indispensable support for the global geodetic networks (such as the International GNSS Service IGS and the EUropean REference Frame EUREF), will produce data for the management of the International Terrestrial Reference Frame (ITRF). What's more, it will make a variety of products and services possible: from determining the orbits of GNSS satellites (with an accuracy to the nearest centimetre) to time synchronizing them (better than one nanosecond), useful both for applications on-site as well as to support satellites equipped with GNSS receivers.

The new network will enable ASI and e-GEOS to intensify and fine-tune the joint scientific and operational development under way for the last 25 years at the ASI Space Centre in Matera in the field of meteorology, as well as the study of climate change and space weather. Specifically, the network will enable the provision to the national supply chain – from research centres to SMEs, universities and major corporations – of products and services that are useful for developing innovative, high-precision positioning applications, which can be implemented in a wide variety of sectors: from professional applications to those in the field of precision farming.

In order to contribute to scientific activities, some stations in the new GNSS network have been installed in particularly significant locations where purpose-designed structures are already present. These include, for instance: the ASI Space Centre in Matera, home to the Matera Laser Ranging Observatory MLRO and a VLBI (Very Long Baseline Interferometry) antenna whose data are used for accurate space geodesy measurements; ASI's new SDSA (Sardinia Deep Space Antenna) operations base in San Basilio (Cagliari), where the Sardinia Radio Telescope SRT built by INAF can be found – a versatile instrument for radio astronomy, geodynamic studies and space science; the European Gravitational Observatory EGO in Cascina (Pisa), which plays host to the large VIRGO interferometer built to detect gravitational waves; as well as several Italian Air Force bases, home to weather stations. *www.asi.it*

Planet to acquire VanderSat

Planet is set to acquire VanderSat, a leading provider of advanced earth data and analytics. Vandersat's products help customers better measure and understand water management and crop health in major markets. Planet intends to leverage VanderSat's technologies and products in further pursuit of bringing to market next-generation solutions that combine the best of commercial and public satellite data to provide clear and actionable information. *www.planet.com*

UP42 unveils very high-resolution imagery

UP42 unveils very high-resolution optical imagery from the Airbus Pléiades Neoconstellation on the UP42 geospatial marketplace and developer platform. Pléiades Neo's unique combination of 30cm native spatial resolution, daily revisit, and faster tasking/data delivery will benefit end users in all sectors. *https://up42.com*

Hexagon announces partnership with Airbus

Hexagon's Geosystems division announced partnership with Airbus to integrate two Leica Chiroptera 4X bathymetric LiDAR sensors for maritime surveillance into the C295 MSA, Airbus' Maritime Surveillance Aircraft. The new technology enables detection of underwater objects in near real-time, a significant innovation in the airborne bathymetry industry. The unique object detection feature enables real-time LiDAR data visualisation and analysis during the flight. *https://hexagon.com*

Valeo introduces its third generation LiDAR

Valeo has introduced its third generation scanning LiDAR system set for market debut in 2024. The new technology offers significantly enhanced performance, makes autonomous mobility a reality and provides previously unseen levels of road safety. *www.valeo.com*

China successfully launches new remote-sensing satellites

China has successfully launched two new remote-sensing satellites from the Jiuquan Satellite Launch Center in northwest China at 3:43 p.m on Nov 3, 2021. The satellites, members of the Yaogan-32 family, will be used for electromagnetic environment surveys and other technology tests. The launch was the third mission of Expedition-1S. Its first flight with a Long March-2C carrier rocket was in October 2018, when the pair sent the first group of satellites of the Yaogan-32 family into orbit. *https://news.cgtn.com*

DAT/EM releases guide on Summit Evolution

DAT/EM Systems International released a new guide on its Summit Evolution photogrammetric workstation. This software is an innovative photogrammetric tool that is available in several licensing levels and allows organizations to better discover and capture 3D information. It works with other photogrammetric software that businesses use to interpret 3D-mapping software. This software works by taking stereo imagery, which can be from several imagery types, and capturing 3D information. Examples of accepted formats include orthophotos, satellite imagery, aerial photos, close-range imagery, digital sensor photos, LiDAR, and synthetic aperture radar. *www.datem.com*

Tianwen-1 Mars probe enters final mission of global remote sensing

China's first interplanetary probe mission has come to its final stage of global remote-sensing exploration of the Red Planet after the Tianwen-1 orbiter successfully completed its fifth brake recently and entered a new mission orbit automatically.

The Tianwen-1 probe has so far completed all preset mission stages including being captured by Mars' gravity, the orbiter-lander separation, the landing of the Zhurong rover, and the roving and exploration of the rover. It has come to the final stage of global remote sensing. *www.globaltimes.cn*

PLI of Rs. 120 crore is provided for Indian manufacturers of drone and drone components

The Production-Linked Incentive (PLI) Scheme for drones and drone components has been notified on Sept. 30, 2021 to push the production of drones.

The details of this scheme are as follows:

i. An incentive of INR 120 crore (approximately $16 million) has been provided for Indian manufacturers of drone and drone components on the basis of their value addition in India. The value addition by a manufacturer will be calculated as the annual sales revenue from drones and drone components (net of GST) minus the purchase cost (net of GST) of drone and drone components. The incentive shall be provided over three financial years commencing from 2021-22.
ii. The PLI that can be claimed by a manufacturer is 20% of the value addition by such manufacturer. The PLI rate is constant at 20% for all three years.
iii. Minimum value addition is specified as 40% of net sales
iv. Eligibility norm for Micro, Small and Medium Enterprises (MSME) and startups is specified as INR 2 crore (approximately $ 266,000) of annual sales revenue for drone manufacturers and INR 50 lakhs (approximately $67,000) of annual sales revenue for drone component manufacturers.
v. PLI for a beneficiary is capped at 25% of the total annual outlay to allow widening of the number of beneficiaries.
vi. In case a manufacturer fails to meet the threshold for the eligible value addition for a particular financial year, the manufacturer will be allowed to claim the lost incentive in the subsequent year if the manufacturer makes up the shortfall in the subsequent year.

The liberalized Drones Rules, 2021 notified on 25 August 2021 provide the regulatory framework for owning and operation of drones. These rules cover various aspects like type certification, registration and operation of drones, airspace restrictions, research, development and testing of drones, training and licensing, offences and penalties etc.

https://pib.gov.in

ModalAI releases new seeker micro-development drone

ModalAI have recently released two new products that help developers create smaller, smarter and safer robots and drones quickly and easily – the VOXL CAM perception engine and the Seeker micro-development drone. The VOXL CAM is an all-in-one compute and perception engine that makes it easier to develop smaller, smarter and safer drones, robots and Internet of Things devices with GPS-denied navigation, depth mapping, unmanned aircraft systems flight control and cellular connectivity. *www.modalai.com*

Autonomous drones with evidence management

Axon in partnership with Fotokite have announced the autonomous Fotokite Sigma UAS complete with wireless live streaming and evidence management is now commercially. Through Axon's real-time operations platform, Axon Respond, ground operators will have access to real-time streaming video to support effective decision making and improved outcomes. The Fotokite Sigma can launch, fly, and land with the push of a button—no setup time, calibration, or active piloting required. *www.axon.com*

senseFly named to Blue sUAS 2.0 list

AgEagle Aerial Systems Inc., has announced that its wholly-owned subsidiary, senseFly, has been named to the Blue sUAS 2.0 list, published by the US Department of Defense's Defense Innovation Unit (DIU).

The Blue sUAS 2.0 project follows the successful partnership between the U.S. Army and DIU on the Short Range

Reconnaissance (SRR) program for small unmanned aircraft systems (sUAS), which started in 2019. The project, now referred to as '1.0,' followed the SRR program in August 2020 and made minor modifications to five final SRR candidate air vehicles and built integrated commercially-based ground control stations to create a standalone commercial/enterprise configuration available to the Department of Defense (DoD), as well as other US government entities.

The 2.0 project was subsequently created to increase the diversity, capability and affordability of UAS on DIU's "Blue UAS Cleared List," bringing a greater variety of UAS with a wide range of modalities, capabilities and price points. *www.sensefly.com*

Mavic 2 drone to autonomously take off

Firefighters and police drone teams have been using the V-Line tethered system for the Mavic 2 drone in a variety of situations on land. Volarious has now launched a new product called the V-Line boat mode. A drone can take off, follow, and land on small vessels autonomously while providing a real-time elevated view of high resolution thermal & RGB images and video streams at the comfort of the cabin. *www.volarious.com*

XAG launches Agricultural Drone

XAG has geared up to launch its V40 and P40 Agricultural Drone globally. Both are fully autonomous drones that can conduct mapping, spraying, and broadcast on farm. The V40 is the first tilting twin-rotor unmanned flying platform of its kind in agriculture to find the right balance between precision, performance, and efficiency. The P40 is more compact, flexible, and easy to transport. *www.xa.com*

Walmart and DroneUp drone delivery operations

DroneUp, LLC and Walmart have announced the first multi-site commercial drone delivery operations. The three locations, which will be located at Walmart stores in Northwest Arkansas, will operate from 8:00 a.m. – 8:00 p.m., seven days per week, to deliver items to eligible Walmart customers by air in as little as 30 minutes.

Enjoying the benefits of drone delivery is as easy as:

- **Verify:** Customer enters their address to verify eligibility.
- **Shop:** Customer selects from thousands of items for delivery.
- **Secure:** Operators pack the order and secure the box to the drone using a patented delivery release mechanism.
- **Deliver:** The flight engineer manages a controlled and guided delivery, placing the order gently at the customer's home.

https://corporate.walmart.com

New drone and advanced AI-powered analytics

Percepto launched its upgraded 2022 Autonomous Inspection & Monitoring (AIM) platform and its new Air Mobile drone. Recently listed in TIME magazine's 100 Best Inventions of 2021, it offers the only end-to-end solution powered by AI to collate and streamline all visual data for accurate actionable insights.

Percepto's AI change detection framework offers unified visual data and critical business insights for each of the sector-specific solutions. AIM 2022 can be integrated with autonomous drones and robots as well as other visual data collectors, now including DJI drones, and fixed cameras. Reports and insights are automatically generated based on the combined visual data. Disseminated to relevant stakeholders on any mobile device, issues and faults are geotagged and displayed on a map, enabling effective action before escalating into more serious problems. *www.percepto.co*

Tata Steel shortlists AUS to provide drone-based solutions

AUS (Aarav Unmanned Systems has been awarded multiple long-term contracts from various business verticals of Tata Steel to provide advanced drone-based enterprise solutions. AUS's drones are expected to help Tata Steel operate their mines more effectively and enhance productivity, besides ensuring higher regulatory fulfillment and safety. Its drone solution is helping the Projects team of Tata Steel to map the progress of the upcoming Kalinganagar Expansion Plant in Odisha. In another contract from the Tata Steel Corporate Audit team, AUS has signed a Two-year rate contract to carry out drone-based physical verification of bulk inventory at all the 23 locations across multiple Tata Steel entities. For the Natural Resources Division of Tata Steel, AUS will carry out monthly drone surveys of the mining leases of Tata Steel Ltd. and deliver advanced Mine Analysis. Tata Steel Ltd. also signed a contract with AUS to procure three survey-grade Drones for serving internal survey requirements and RnD applications. *https://aus.co.in*

Drone delivery in Yeongwol with 3D UAM/UTM system

CLROBUR's DROW, an AI-integrated automatic flight ground control platform (GCP) that uses urban air traffic management (UATM) technology, has opened a new chapter in the field of logistics by delivering a product using an autonomous drone.

During a presentation on the establishment of "drone cities," which was held recently in Yeongwol, CLROBUR showcased DROW to the audience. By delivering a box of seasoned fried chicken from a drone hub in Saekyung University to a hub located in front of a drone test site in Yeongwol, the company successfully demonstrated a beyond visual line of sight (BVLOS) flight by an autonomous drone. The company was also able to complete its urban traffic management (UTM) technology, which is necessary to enable autonomous flights with the technological convergence of drone manufacturers, 3D map providers, and telecom companies. *http://clrobur.com*

ASPAARO established

Northrop Grumman Corporation and Airbus Defence and Space, together with seven industrial players, have established ASPAARO, the Atlantic Strategic Partnership for Advanced All-domain Resilient Operations. ASPAARO will bid to undertake the Risk Reduction and Feasibility Studies (RRFS) for the NATO Support and Procurement Agency as part of the Alliance Future Surveillance and Control (AFSC) programme.

The feasibility studies are a key milestone in the AFSC programme which aims to support NATO and NATO nations as they consider the Alliance's future tactical surveillance, command and control capabilities after the current Airborne Warning and Control System (AWACS) fleet reaches the end of its service life in 2035. *www.airbus.com*

Spytec GPS partners with Google Maps

Spytec GPS has launched Time Machine, a feature providing small businesses a first-of-its-kind historical record of GPS data for their vehicles and mobile assets. This release comes less than a month after the company announced its integration with Google Maps, the leading solution in digital mapping technology.

ESA to improve road traffic efficiency

HORIBA MIRA in collaboration with GMV NSL will develop new and improved passenger car platooning solutions on behalf of the European Space Agency (ESA), which will move into a live trials phase in Q1 2022, encompassing both simulated and physical testing during 2022.

The project aims to advance platooning – the process of optimizing the co-ordination of traffic streams – by embracing a number of advanced technologies. The first of these is cooperation between all the cars in the platoon to share information about their respective positions on the roadway. Cooperative positioning is enabled with a variety of range-finding sensors, such as radar, with data being shared between cars via low latency wireless communications. Finally, for this data to be 'trusted' to inform the management of the positions of the cars in the platoon, it is evaluated by an integrity algorithm.

A platoon automatically optimizes the flow of vehicles along highways and prevents the characteristic phenomenon of waves of braking and acceleration events, known as perturbations, transmitting through streams of traffic when vehicles are manually driven at high levels of density, such as during rush hours.

Topcon announce new machine control solutions

Topcon Positioning Group has announced its MC-Max machine control solution. Based on its MC-X machine control platform, and backed by Sitelink3D — the company's real-time, cloud-based data management ecosystem — MC-Max is a scalable solution for mixed-fleet heavy equipment environments. It is designed to adapt to owners' machine control and data integration needs as their fleets and workflows expand. *www.topconpositioning.com*

SoftBank Corp. and u-blox collaboration

SoftBank Corp. and Swiss-based u-blox AG have signed a Memorandum of Understanding (MoU) to cooperate in GNSS augmentation services for global markets. SoftBank provides the "ichimill" GNSS augmentation service in Japan, its subsidiary ALES operates a business that generates and delivers positioning correction data, and u-blox is a leading global provider of positioning services for the automotive, industrial and consumer markets. *www.u-blox.com*

Rohde & Schwarz joins Car Connectivity Consortium

Rohde & Schwarz has joined the Car Connectivity Consortium (CCC) to support the organization's mission to foster industry wide standards for communications between vehicles and smartphones. The company will contribute its broad expertise in mobile device and automotive technology testing. In particular, the company will provide its solutions for the development and production of UWB devices and modules for automotive applications such as keyless vehicle access. *www.rohde-schwarz.com*

RadioWaves introduces new GPS / GNSS timing antennas

RadioWaves' new series of GPS/GNSS timing antennas provide top-of-the-line axial ratio and higher accuracy for the reception of satellite timing signals and reference frequencies for enhanced phase synchronization in precision network deployments. The high gain, low noise figure of 2 dB plus high, out-of-band rejection provided by these antennas allow for the use of longer and cost-effective cables for easy and flexible installs. They also feature a VSWR less than 1.8:1 and are compatible with several existing mounting brackets. *www.radiowaves.com*

Ultra-rugged PDA – NAUTIZ X9

Handheld Group has announced a new version of its NAUTIZ X9 PDA: an ultra-rugged enterprise handheld built for fieldwork in the most challenging outdoor and industrial environments. With an upgraded platform, the Nautiz X9 Android rugged handheld runs Android 11 and is Android Enterprise Recommended (AER). Designed to handle the toughest conditions, the Nautiz X9 is built with a sturdy magnesium casing. It is targeted for mobile computing and data collection in industrial and field applications. *www.handheldgroup.com*

Lockheed Martin contracted for three more GPS IIIF satellites

The U.S. Space Force exercised its second contract option valued at approximately $737 million for the procurement of three additional GPS III Follow On (GPS IIIF) space vehicles (SVs) from

Lockheed Martin on October 22, 2021. This contract option is for GPS IIIF space vehicles 15, 16 and 17 (SV15-17).

Spirent Federal launches new flex power capability

Spirent Federal has announced a new positioning, navigation, and timing (PNT) test capability commonly referred to as programmable power—or flex power—available at no additional cost to qualified customers under support. Flex power is the reallocation of transmit power among individual signals in GPS satellites, providing a countermeasure against GPS jamming. Spirent simulators fully support programmable power for M-code, Y-code, and C/A (coarse acquisition) code. *www.spirentfederal.com*

Harxon offers two new GNSS antennas

Harxon is offering two new GNSS antennas for intelligent connected vehicles (ICV). ICVs are equipped with advanced sensors, controllers, actuators and other devices. They are enabled for intelligent information exchanges between the vehicle and everything (car, road, people, cloud), technology known as V2X.

The ICV antennas connect autos with GNSS, 5G, Wi-Fi, ultra-wideband and more.

The integrated antennas support dedicated short-range (DSRC) and cellar vehicle-to-everything (C-V2X) communication. The antennas embed a premium GNSS antenna with high gain for consistent and reliable precise positioning service. They also allow for multiple input and output of data to achieve swift internet download speed in 5G networks. *https://en.harxon.com*

Tallysman offers automotive-grade GNSS signal splitter

Tallysman Wireless Inc. has added the TW162A automotive-grade smart power GNSS signal splitter to its line of GNSS accessories. The splitter supports the full GNSS spectrum: GPS/QZSS-L1/L2/L5, QZSS-L6, GLONASS-G1/G2/G3, Galileo-E1/E5a/E5b/E6, BeiDou-B1/B2/B2a/B3, and L-band correction service frequency band. *http://tallysman.com*

Honeywell launches new navigation systems

Honeywell has launched two new resilient navigation systems: the Honeywell Compact Inertial Navigation System and Honeywell Radar Velocity System. These systems, along with Honeywell partner InfiniDome's Anti-Jamming system, GPSdome, are designed for commercial and military customers needing reliable navigation solutions with low size, weight and power. The systems will provide multiple layers of protection that allow continued operations even in GNSS challenged or denied environments.

NovAtel's PwrPak7-E1 supports Nvidia AV platform

The PwrPak7-E1 from NovAtel is now supported on the Nvidia Drive Hyperion autonomous vehicle (AV) development platform. Selected for its robustness and precise position output, the PwrPak7-E1 will be offered with Nvidia's autonomous driving test fleets worldwide.

The GNSS and inertial measurement unit (IMU) output of the PwrPak7-E1, along with data from other onboard sensors, are recorded and fed into Nvidia's sophisticated autonomous-driving development infrastructure and processing pipeline. There, data is synchronized, used for training AI models, and used in testing of various software components and autonomous driving behavior. *https://novatel.com*

MicroSurvey releases FieldGenius

MicroSurvey has released FieldGenius for Android™ 2.0! This release adds instrument support for conventional total stations for users to continue to work where GNSS observations are limited or if higher accuracy measurements are required. Updates to LandXML import routine to support importing

Trimble establishes Dr. Gladys West scholarship program

Trimble has announced a scholarship program to honor Dr. Gladys West, a pioneer in mathematics, minority advancement and the advent of the GPS-one of our most widely used innovations throughout the world. Known today as the hidden figure who helped invent GPS, Dr. West is one of the reasons why consumers can receive driving directions from a phone or tag a photo location on social media. And why professionals in industrial markets such as construction, transportation and agriculture can leverage geospatial technology to realize significant improvements in productivity, quality, safety, transparency and sustainability to transform the way they work with precision.

Dr. West knew from a young age that education would be the key to moving forward from her family farm in rural Virginia. A scholarship recipient herself, Dr. West earned a Bachelor's and Master's degree in Mathematics and was offered a position in 1956 with Virginia's Naval Proving Ground—now called the Naval Surface Warfare Center. Hired as a mathematician, she was one of only four African American employees at the time and only the second woman of color.

With her intelligence and computational skills recognized, she quickly climbed the ranks and became project manager for the Seasat radar altimetry project in the 1960s. Knowledge gained through that work enabled her to program an IBM computer to calculate an accurate geodetic Earth model—the detailed mathematical model of the shape of the Earth that is the essential building block for GPS.

That tenacity, talent and enterprising fortitude encapsulates the spirit of Trimble's scholarship program designed to honor Dr. West's contributions to science and the geospatial industry. *www.trimble.com*

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of alignments for users to perform station/offset staking constrained to the alignments and any project line figures. A new temporary height function along with some performance improvements to the application to help increase efficiency have also been added.

Galileo OSNMA position opens

The European Union Agency for the Space Programme (EUSPA) opened the Galileo Open Service Navigation Message Authentication (OSNMA) Public Observation test phase for the secured signal. The OSNMA is a freely accessible data-authentication function for the Galileo Open Service worldwide. OSNMA provides receivers a first-level of protection against spoofing the Galileo Open Service, assuming that the receiver meets requirements. This is realized by transmitting authentication-specific data in previously reserved fields of the E1 I/NAV message.

Galileo OSNMA improves confidence on the user side by enabling the user to verify the authenticity of the Galileo navigation parameters required for positioning, navigation and timing. *www.gsc-europa.eu*

Unicore Communications GNSS hardware available through Rx Networks

Unicore Communications is a sister-company to Rx Networks within the BDStar group of companies, and is headquartered in Beijing, China. Unicore will deliver affordable High Precision GNSS technology into the North American market through Rx Networks - a key supplier of high accuracy services and assistance data to a growing list of GNSS hardware manufacturers. As high precision GNSS becomes ubiquitous, those seeking precise positioning solutions can now have Unicore GNSS Hardware enlightened with Rx Networks data services.

Low-cost anti-jam GNSS antenna

Engineers from MBDA Missile Systems, working in conjunction with Swansea University research staff, have developed an innovative, compact, low-cost GNSS anti-jam antenna specifically suited to smaller calibre-guided weapons.

Prototyped and tested as part of the French/UK Materials and Components for Missiles Innovation Technology Partnership (MCM ITP) programme, the Novel Null Steering Antenna 2 (NNSA2) project has matured the antenna and associated electronics to a point where it is available for transition to a product. The design – featuring a 150 mm-diameter Slot Based Microstrip Patch Antenna and embedding a 'scan, monitor, and lock' algorithm that intelligently steers the null in the direction of arrival of interference – offers a capability in applications where traditional anti-jam devices would be unsuitable owing to their size, mass, and cost. *www.janes.com*

MARK YOUR CALENDAR

February 2022

Geo Week
6-8 February, 2022
Denver, CO, USA
www.geo-week.com

DGI Geospatial Intelligence for National Security 2022.
London on 08-09 February 2022.
https://dgi.wbresearch.com

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

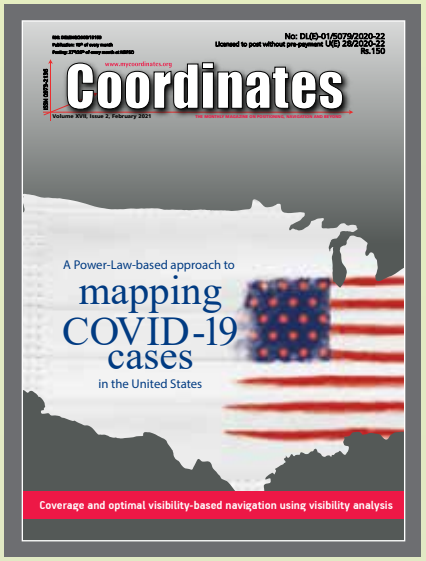
The 10th Land Administration Domain Model Workshop
31 March - 2 April 2022
Dubrovnik, Croatia
http://isoladm.org/LADM2022Workshop

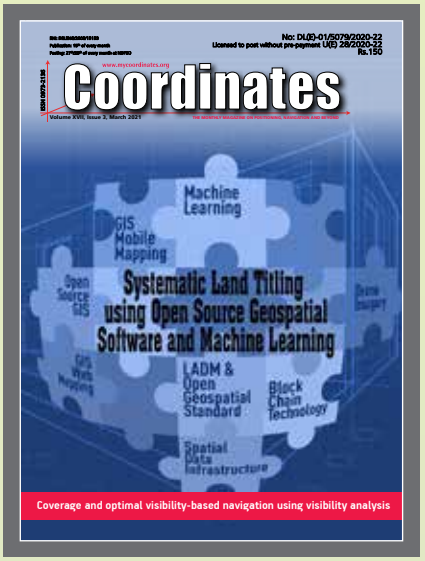
October 2022

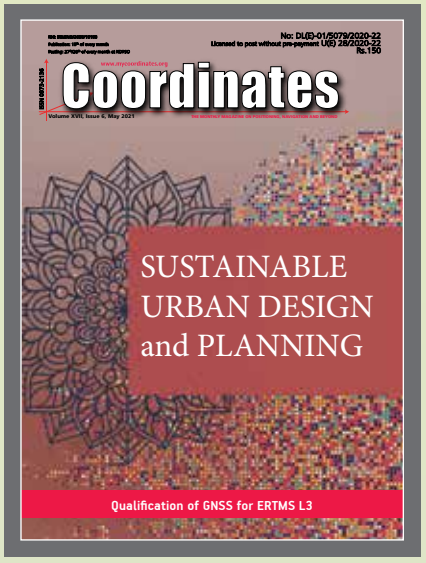
Intergeo Hybrid
18-20 October 2022
Essen, Germany
www.intergeo.de

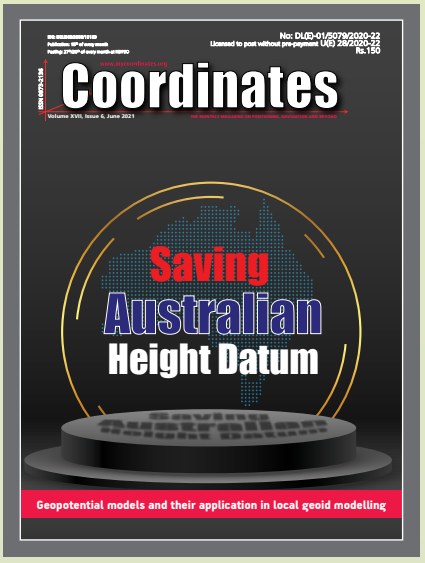
November 2022

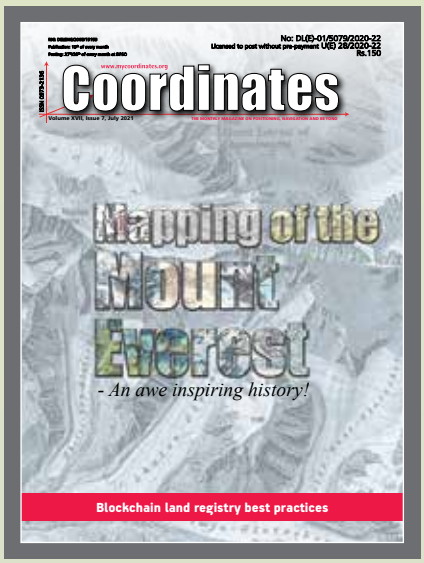
Trimble Dimensions+
7-9 November 2022
Las Vegas, USA
https://dimensions.trimble.com

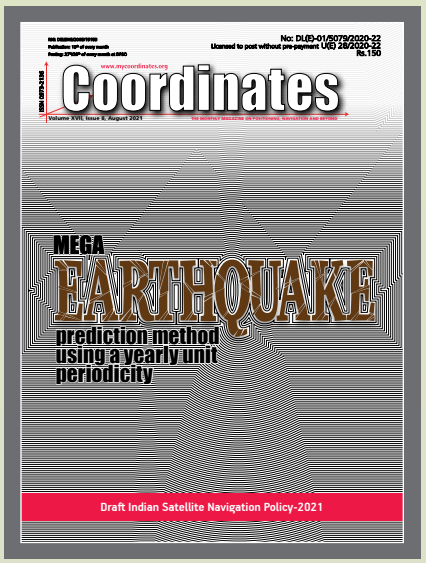


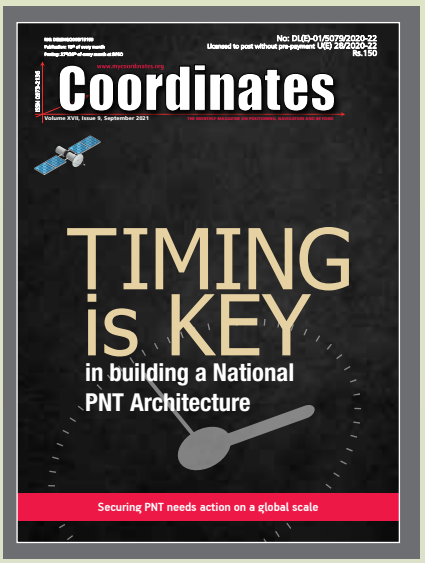












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