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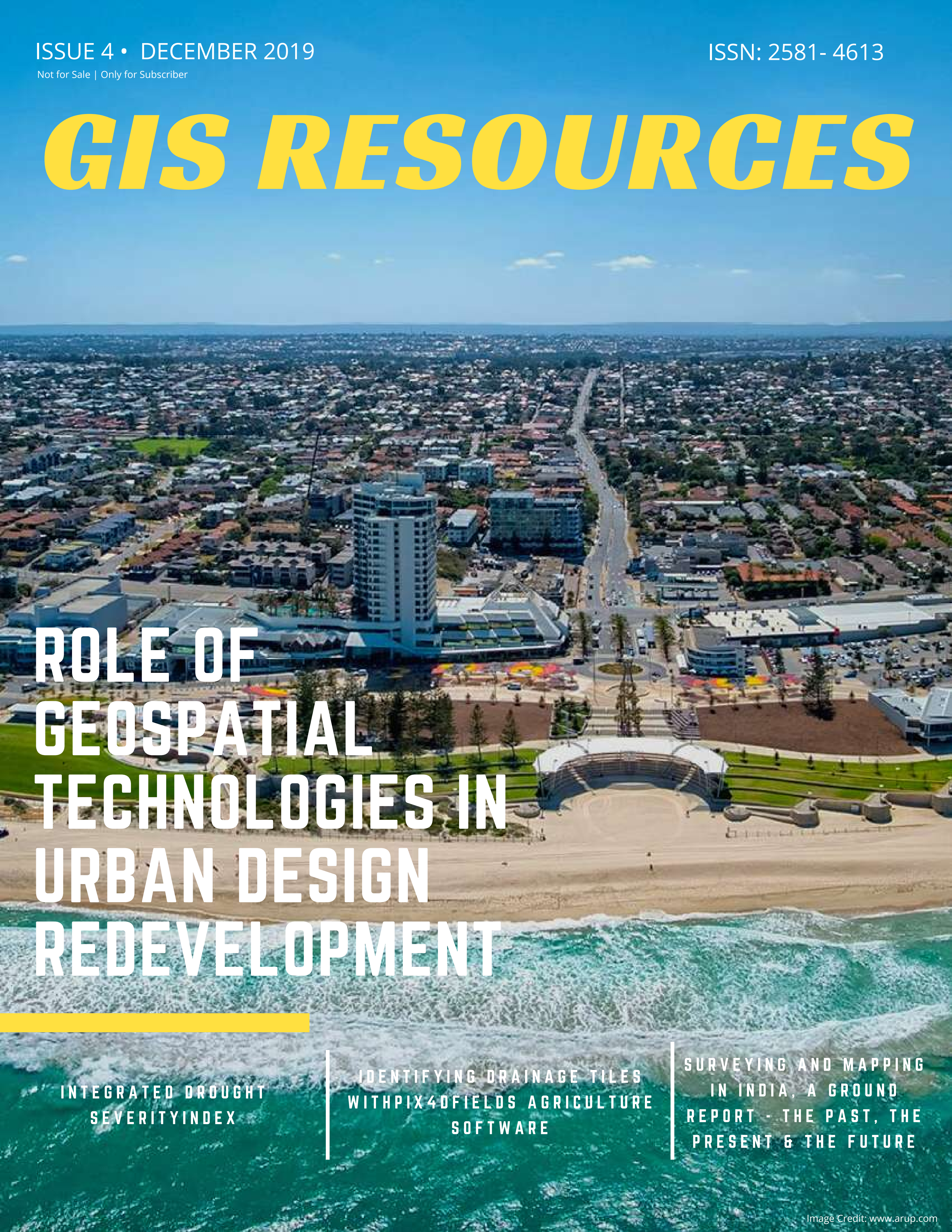
GIS RESOURCES



ROLE OF GEOSPATIAL TECHNOLOGIES IN URBAN DESIGN REDEVELOPMENT

INTEGRATED DROUGHT SEVERITYINDEX

IDENTIFYING DRAINAGE TILES WITHPIX4DFIELDS AGRICULTURE SOFTWARE

SURVEYING AND MAPPING IN INDIA, A GROUND REPORT - THE PAST, THE PRESENT & THE FUTURE

Image Credit: www.arup.com

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editor's note

In the last 2 decades, India's urban population has increased exponentially with 33% of the population living in cities in 2015. Experts estimate that urbanization will peak in 2050, with more than half of India's population living in cities. The growth rate of small and medium-sized towns in India is much higher than its metropolitan cities, which in recent years, have seen their population decline but grow on their peripheries.

Urban development is largely based on Master Plans of the Metro/City. Depending on priorities and funds the development activity is taken up. However, the pace of development undertaken by the town planning department is far behind the unplanned growth of settlements coming up in the periphery of metros and towns which are inhabited by economically mobile migrant settlers, seeking better economic prospects in urban areas. By the time the urban development local bodies reach these outer settlements with their development plans, more settlements have arisen further around the urban areas. This is a viscous cycle, with layer upon layer of unplanned growth being added where development is always far behind.

The view that cities are central to the country's economic growth and development is gaining wider acceptance, strengthened by the increasing contribution of the urban sector to India's GDP. According to several studies and reports, Indian cities are likely to account for nearly 70% of India's GDP by 2030. Hence, there is a need to make our urban areas more efficient.

Realizing the need for Urban Development and Renewal, the Government of India has undertaken several projects. Earlier the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005 brought the urban development agenda into focus through planned development, redevelopment and renewal of cities, city centres, urban areas, outgrowths, settlements and urban corridors; the recent Smart Cities Mission, started in 2016, has sought to undertake retrofit and redevelopment of urban areas of 100 cities and the Heritage City Development and Augmentation Yojana (HRIDAY) is being implemented with the overall objective of revitalizing heritage cities.

Geospatial Technologies play a vital role in the survey and data capture of existing urban areas that require redevelopment. Supplemented by extensive data collection and analysis, these technologies can be used to create scenarios and decision-making models that incorporate smart solutions, innovation, best practices and new technology that enable efficient & planned growth.

Geospatial Technologies can be used to generate futuristic projections about urban growth areas. With the help of these technologies urban local bodies can plan development to ensure planned growth that provide basic urban services such as water, electricity, opportunities for livelihood & recreation, provide for nature & natural spaces, sanitation, sewerage and transportation as well as implement green building concepts such as water harvesting, conservation and reuse, efficient energy generation and use and the use of efficient information and telecommunication technologies.

Ashok Prim
Editor

URBAN DEVELOPMENT GAINS NEW PERSPECTIVE WITH OBLIQUE AERIAL IMAGERY

Detailed 3D models based on survey-grade oblique aerial imagery advance planning, design and construction efforts in major metro areas.

by Alexander Wiechert

UltraCam Osprey from Vexcel Imaging

3D models and interactive maps contribute to the development of actionable information.

We live in a three-dimensional world, so understanding complex two-dimensional plans and models can be quite challenging. When objects are represented in a three-dimensional format, it is easier to visualize where features are in relation to each other, what impact a design has on the surrounding areas and structures, and how the final project will appear. This has led to the increased use of detailed digital 3D models in urban development work, with the associated benefits of improved visualization, timely updates, and better results. To obtain the measurements and other data needed to create accurate 3D models, oblique aerial imagery is an attractive alternative to vertical aerial imagery that only captures a top-down view, and ground surveys and terrestrial mapping, which present logistical problems in dense urban areas.

The Side View Advantage

Use of oblique imagery is growing in the architectural, engineering and construction (AEC) industry to meet

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demand for accurate models throughout the project lifecycle, from concept to completion. Effective urban planning requires seeing the "big picture" and communicating with all stakeholders, including the public and potential investors. With access to survey-grade oblique data, developers can model existing buildings and infrastructure to use as a foundation for future changes and improvements.

Traditional vertical imagery has long been used to produce various kinds of location-based information; however, oblique imagery provides additional perspective and valuable information. With an aerial system like the UltraCam Osprey from Vexcel Imaging, high-resolution imagery is captured simultaneously at nadir and oblique: 45-degree angle views in four directions—forward, backward, left and right. Together the 5-band nadir images (PAN, RGB and NIR) and the oblique images (80-megapixel RGB) form a wide footprint for efficient image collection. By applying photogrammetric processes, the comprehensive data enables the creation of photo-realistic digital 3D models that accurately depict buildings from the outside, including the facade, roof slope and dimensions.

To facilitate access to current oblique data of urban areas in the US, Canada, Australia and New Zealand, Vexcel Imaging launched the Vexcel Data Program in 2017. The cloud-based imagery service offers 7.5-centimeter GSD vertical and oblique aerial imagery that is updated annually. To ensure reliable image analysis, consistency is maintained by collecting data with the same type of sensor—the UltraCam Osprey—at the same resolution and using the same workflow every year. Additionally, using a second UltraCam system—the UltraCam Condor wide area mapping camera—nationwide contiguous coverage at 20-centimeter GSD vertical imagery for the US and Germany is collected and updated over a two-year period and offered through the same service. Other European cities and countries will follow in 2020.

Utilizing Oblique Imagery in Urban Development

As population centers continue to grow, geospatial technology is being integrated into every aspect of urban development to address major issues, such as inadequate infrastructure, lack of green space, pollution and crowding.

The development or redevelopment of any large community benefits from using technology to improve performance and quality of services. Geographic information systems provide a wealth of information to form a basis for decision making and prioritizing resources. 3D models and interactive maps contribute to the development of actionable information.

The current emphasis on building sustainable, energy efficient, safer and healthier "smart cities" is creating opportunities to incorporate diverse types of technology. With the addition of oblique imagery, highly accurate 3D models are being used to visualize everything from transportation and telecommunication networks to solar panels on individual buildings. By collecting information through the Internet of Things (IoT) and applying advanced analytics to the data, many communities are working to improve quality of life while protecting the environment and conserving natural resources.

Rebuilding After a Disaster

The insurance industry recognizes the value of having up-to-date aerial

Figure 1: High-Resolution Imagery Allows for Detailed Inspections After Catastrophic Events.

imagery to gain a comprehensive understanding of structure and property features, which allows the company to fairly assess risk and calculate premiums.

In addition, the ability to make comparisons against post-disaster imagery aids in assessing damage and expediting payments to customers. As floods, hurricanes, tornadoes and wildfires increasingly threaten existing homes and businesses, the importance of pre- and post-event views becomes even more apparent.

The Geospatial Intelligence Center (GIC) is a National Insurance Crime Bureau (NICB) initiative in partnership with Vexcel Imaging that is focused on building a database of vertical imagery for every address in the US and both vertical and oblique imagery of top US metro areas. The long-term mission of the GIC is to provide all subscribers with street-level imagery and 3D data products, along with derivative products that include high-density point clouds, digital surface models and ortho mosaics.

The GIC web map portal, built on Esri's ArcGIS cloud-based mapping platform, provides GIC's member insurers access to "blue sky" imagery as well as post-disaster "gray sky" imagery. Real-time access to oblique aerial images helps insurers assign the appropriate coverage and manage claims from their desktop without physically being onsite. Oblique imagery also provides vital information for emergency responders during a disaster and supports planning and rebuilding efforts afterward.

Better Than Ever

Whether retrofitting existing structures, designing new and improved "green" buildings, or planning safe and efficient citywide infrastructure, architects, engineers and contractors have an abundance of geospatial tools and information at their fingertips. With greater access to more detailed and accurate data, everyone involved in urban development projects has an opportunity to explore new ways of solving existing problems.

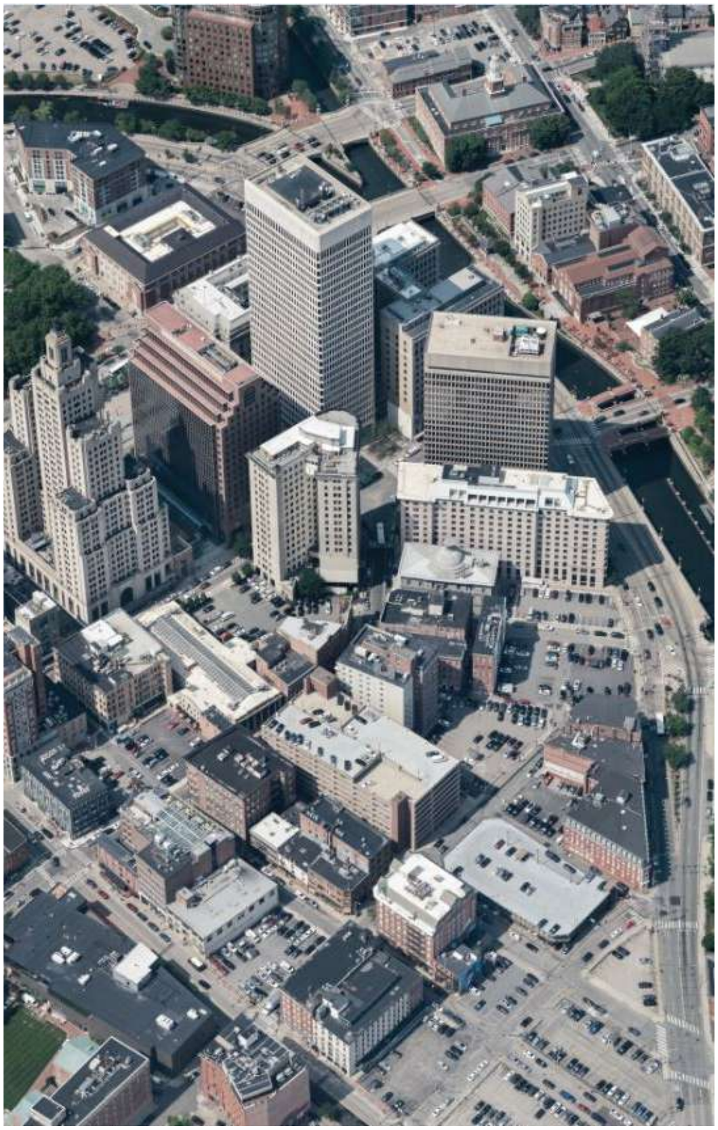

Figure 2: Providence, Rhode Island (US) Captured with An Ultracam Osprey Mark 3 Premium.

Figure 3: Philadelphia, Pennsylvania (US) Captured with An Ultracam Osprey Mark 3 Premium.

ENHANCING URBAN CROSS BORE PREVENTION PROGRAMS WITH CLOUD-BASED GIS

Unearth delivers on the abandoned promises of legacy desktop GIS with a cloud-based GIS platform that's mobile-friendly and easy-to-use.

by Morgan Sullivan

Unearth provides a simpler, more profitable way to manage location-based data: one that's optimized for monitoring and maintaining physical structures.

The Cross-Bore Problem in the US

On March 13, 2006 in Middletown, Ohio, Mechelle Eldridge's family home was leveled by a massive gas explosion. Eldridge was at work when the explosion occurred, but her mother, Vikki Gibson, as well as her three children were in the house when the gas line was ruptured.

According to Gibson, the plumber they had hired to unclog a sewer line ran upstairs and told her she had three minutes to get the kids out of the home: saying, "the house could explode anytime." [1]

Gibson got the kids out of the house and, looking back, saw the structure engulfed in flames.

This near-tragedy is just one of a surprisingly long line of cross-bore related incidents in the United States.

As there were no injuries or atalities, the Middletown explosion - though by no means a positive occurrence - is one of the least calamitous cross bore gas explosions. Past incidents, such as the home explosion in Kenosha, Wisconsin in 1976 - the incident that first brought national attention to the lethal threat of cross

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bores - resulted in the deaths of two people: a father and son. [2]

What are Cross Bores?

Cross bores are the unintentional intersection of underground utilities. Though cross bores can occur between any type of utility, the most dangerous ones involve gas lines.

With the Middletown explosion, a gas line had unintentionally been bored through the sewer line. In a case like that, when a plumber attempts to clear a clogged sewer line, they often use a rotating root cutter - as is standard practice. [3]

The problem arises when that same root cutter meets the cross bored gas line, rupturing the pipe.

Gas from the ruptured line flows in the most natural direction: the structure above. From there, all it takes is a pilot light, or even the flick of a light switch to trigger an explosion.

What Causes Cross Bores?

Trenchless technology is at the heart of the cross bore problem in the United States. With minimal disruption to ground surface, traffic, and everyday activities, trenchless drilling is faster and more efficient than other methods of laying pipeline.

The problem is that trenchless technology, also referred to as horizontal drilling, doesn't allow the contractor or utility to see where the new line has been laid, or if it has intersected with anything along the way. There are an estimated 1 million cross-bores in the United States. [4] The more gas and sewer lines that exist in an area, the higher the likelihood of cross-bores. Within urban areas, some estimates for cross bores are as high as 2-3 per mile. [5]

Responsibility for legacy cross-bore detection and mitigation, as well as new cross bore prevention, falls to regional utilities. As significant as these programs are, they are also quite challenging to execute.

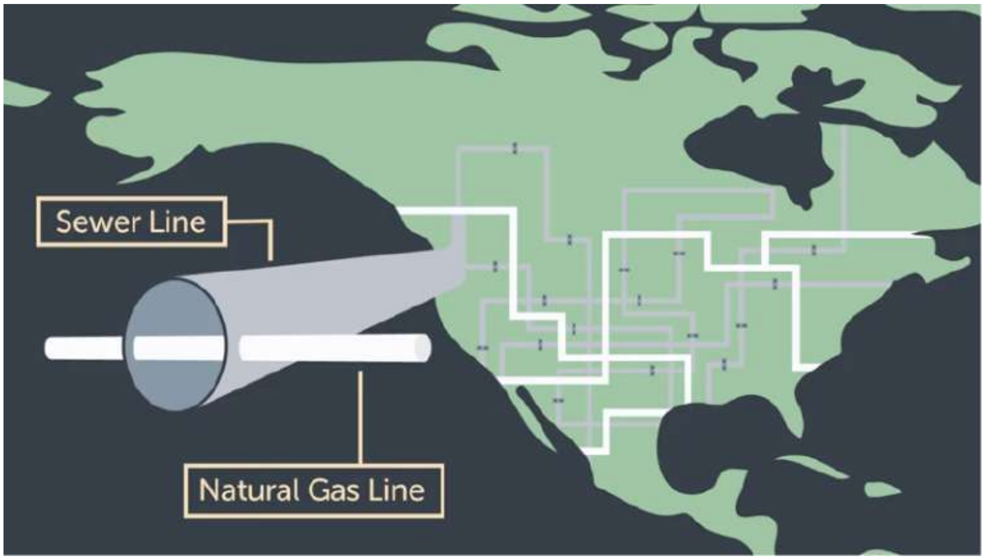

Figure 1: Illustration of Cross Bores in the United States.

The only way to avoid deaths from existing cross bores is to manually inspect every length of sewer pipe in the United States. Prevention programs often follow the same protocols as legacy, but with a narrower focus. [6] The line is drilled and then, with utmost precision, every sewer lateral within the path of the drill is inspected for cross-bore occurrence.

The challenge of collecting, managing, and storing this quantity of dispersed location-based data is immense. This is where cloud-based GIS comes into play.

Simply put, cloud-based GIS enables utilities and their inspectors to create permanent, easily accessible records of all cross-bore detection, mitigation, and prevention activity. More than that, it enables field teams to collect data using a mobile device and upload it directly into the GIS mapping system.

These capabilities stand in direct contrast to desktop GIS: solving a multitude of issues and inefficiencies.

What Causes Cross Bores?

Cross bore prevention programs are focused on preventing the occurrence of new cross bores.

These programs progress in three general phases: pre-inspection, inspection, and post-inspection review and recording. [7] Cloud-based GIS increases the efficiency and speed throughout all three phases.

Increased efficiency is important for several reasons. Primarily, it allows utilities and contractors to complete inspections faster with the same, or even lower budget. This means that more lines can be inspected in a shorter amount of time, decreasing the risk of ruptured cross bores and increasing safety overall.

Part 1: Pre-inspection

Objective:

1. Check records to identify existing gas and sewer lines
2. Create maps with gas facilities, wastewater, and planned construction.

Challenges: The system of record for cross bore detection and mitigation is often varied in methods and difficult to maintain. Most utilities rely on a combination of desktop GIS, paper maps, handwritten documentation, and inspection videos - often stored on external hard drives and DVD's.

As each utility is responsible for hundreds, if not thousands of miles of pipeline, the data is often convoluted and incomplete.

Role of cloud-based GIS: Cloud-based GIS bridges the gap between data collection and data management, which in turn simplifies the process of record keeping and map making. With cloud-based GIS, inspection crews can upload photos, videos, and map annotation while they're still in the field - creating a record in real-time.

Real-time record keeping eliminates the need for manual transcription, allows for immediate data review, and ensures that the data is organized and readily available for future reference.

Part 2: Inspection

Objective:

1. Clear sewer main lines with cameras and sonde locators
2. Clear lateral lines with cameras and sonde locators
3. Gather GPS coordinates of relevant structures in both main and lateral lines
4. If cross bores are found, repair immediately.

There are two schools of thought when it comes to prevention inspection. One posits that all lines should be mapped and accounted for in order to help drilling crews avoid cross bore creation completely.

These inspections rely on cameras attached to sonde locators, which use radio frequency to report horizontal position and approximate depth of sewer lines. The lines are then marked on the surface above using paint.

The other approach is to drill without pre-inspection, and then inspect immediately after to see if any cross bores were created. This approach may seem counter intuitive at first, but it is actually favored by some because it eliminates the duplicative work inherent to the pre-inspection option. With pre-inspection, even if all lines are mapped ahead of time, they must still be inspected after drilling to ensure that no cross bores were created accidentally. [8]

Challenges: No matter the approach, this part of the process creates an incredible amount of location-based data. This information must be collected onsite, transmitted to the office, integrated into the larger inspection program, and recorded for future use.

Figure 2: Illustration of Inspection.

Inspection data is often recorded using paper maps. This method presents a multitude of issues, ranging from the physical limitations of paper (getting wet or torn), to lack of organization, to something as seemingly mundane as poor handwriting.

Not only that, but even if all the data is collected and recorded successfully on paper maps, it must then be transferred by hand into a digital database: wasting time and increasing opportunities for error.

Pipeline inspection also involves terabytes of video recording. These videos must be saved, associated to a specific location on the map, and stored for future reference. As you might imagine, associating digital videos to paper maps at scale is a considerable organizational challenge.

Role of cloud-based GIS: Cloud-based GIS enables effective data capture in the field by allowing GIS access via web browser or mobile app. Maps can be created and updated from anywhere, and videos can be associated with a specific location on the map.

Data collection is one area where traditional desktop GIS falls particularly short. Though many desktop GIS providers also have mobile applications, they are historically underdeveloped and often don't work without internet connection - rendering them useless in many field situations.

Most cloud-based GIS systems are inherently mobile friendly, and many include an offline mode. These features open the connection between field and office: saving time, ensuring greater accuracy of field data, and speeding up the next step in the process-review.

Part 3: Post-Inspection: Review and Documentation

Objective:

1. Ensure inspection accuracy
2. Collate data and integrate into program documentation.

Challenges: This step is incredibly time consuming. With no standardized method for data collection and reporting, inspections can often return incomplete. If an inspection is found to be incomplete during QA/QC review, the inspection team must return to the field to obtain the missing information. This results in significant delays, as reports must be sent back and forth multiple times until they contain all necessary information.

Once the inspections are complete, a packet is sent back to the utility who then needs to integrate the inspection data into their larger cross bore prevention program.

This step is particularly complex because most prevention programs cover massive territories with thousands of miles of pipeline. Maintaining an organized, easily accessible system of program record is challenging and, using traditional methods, often falls short.

Role of cloud-based GIS: With cloud-based GIS, project managers in the office can review data uploaded from the field in real-time. This eliminates the waiting period between data capture and review.

Any issues or incomplete information can be caught and addressed immediately, while inspection crews are still in the field. This reduces the margin for error overall and eliminates the need for rework or re-inspection.

For utilities, the post-inspection benefit is largely the same as the pre-inspection benefit: a real -time record. A single system of digital record, shared by both the contractor and the utility, increases overall accuracy, saves time from start to finish, and ensures that data is organized effectively.

Benefits of Cloud-based GIS

In laying out the steps and challenges of a cross bore prevention program, a clear theme emerges. In order to ensure the safety of populated urban cores, the utility industry needs a single system of record: one that simplifies pre-inspection research, enables data capture in the field, and streamlines data review and storage.

Cloud-based GIS is the only software category that comes even remotely close to addressing these needs.

If cross bore prevention is ever to reach maximum efficiency and effectiveness, the industry must focus on two overarching problems: speed and cost.

Cloud-based GIS offers the most opportunity to advance these goals from both a short- and longer-term perspective.

Short term benefits: Cloud-based GIS simplifies time-consuming tasks and eliminates redundant processes: increasing inspection speeds from start to finish. As overall efficiency increases, per unit inspection costs will decrease. This means teams will be able to inspect more pipeline on the same budget.

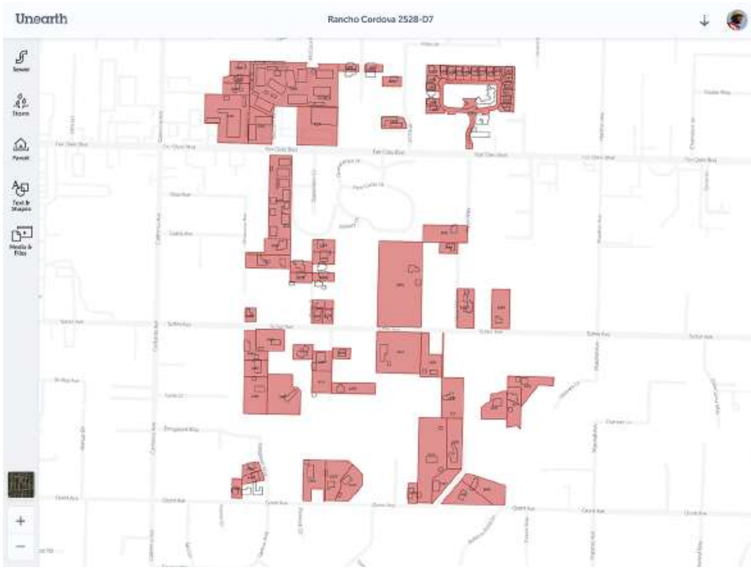

Figure 3: Unearth Cloud-based GIS Platform.

Moreover, moving to a single system from various point solutions decreases the budget spent on both hardware and software. These savings can then be redirected towards expanding the size and scope of prevention programs.

Long term benefits: Long term benefits are where cloud-based GIS gets really exciting. As inspection data accumulates in a single system, it increases the potential for predictive analysis. With enough easily accessible inspection data, everyone - from contractors to homeowners to utilities - can empower themselves to lower cross bore risk during construction and maintenance.

Though predictive analysis is more exciting from a legacy cross bore explosions and increased safety for all.

Cloud-based GIS Built for Utilities: A note on Unearth

Unearth is a modern GIS system for built-world organizations. We provide a simpler, more profitable way to manage location-based data: one that's optimized for monitoring and maintaining physical structures.

When managed correctly, data enhances your operations and saves millions of dollars. Without proper management, you become buried beneath the data: slowing down operations and costing millions. Unfortunately, most built-world industries are in the latter situation.

Unearth delivers on the abandoned promises of legacy desktop GIS with a cloud-based GIS platform that's mobile-friendly and easy-to-use. Our platform saves time and money by streamlining your digital workflow and connecting field with office.

We strongly believe in the importance of detecting, mitigating, and preventing cross bores, and are excited to be helping the utility industry move swiftly towards a solution.

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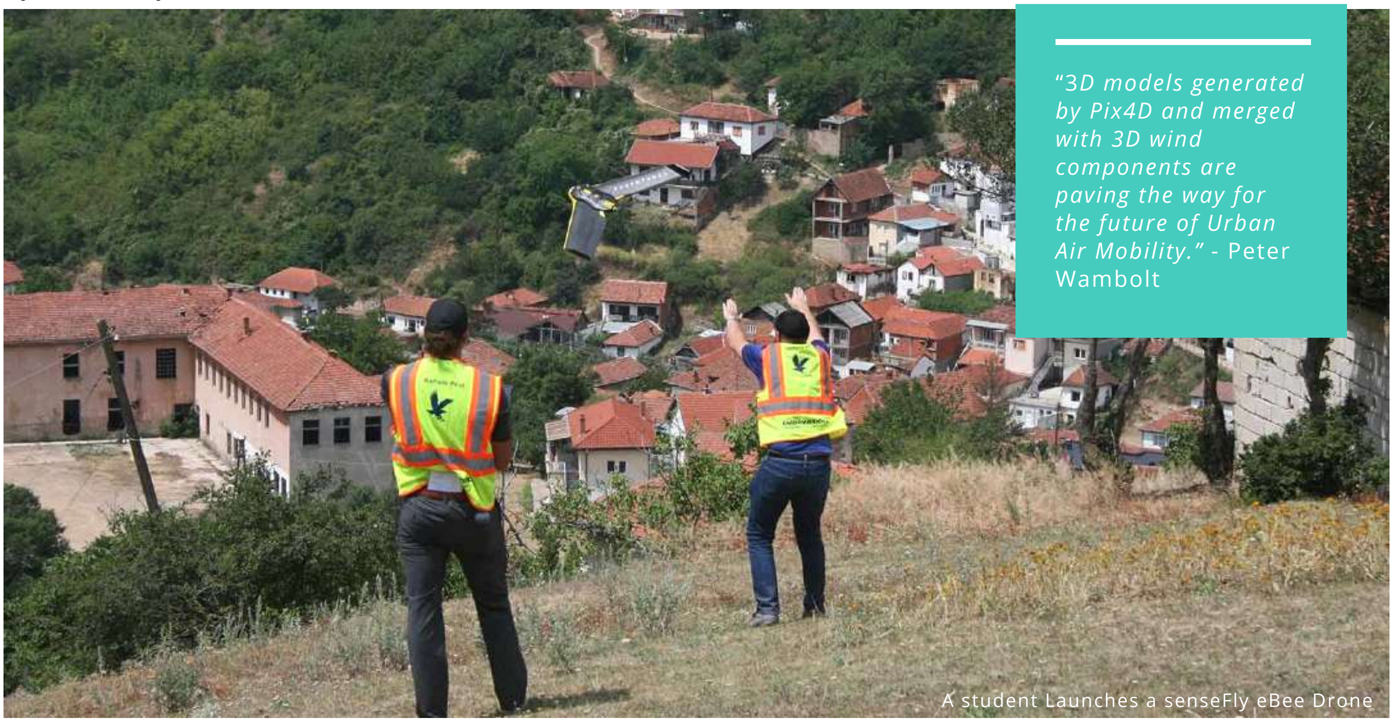
IS DRONE MAPPING THE KEY TO UNLOCKING URBAN AIR MOBILITY?

Air mobility has the potential to release the gridlock strangling the streets - but before we can take to the skies above the city, there are some problems which need to be solved.

by Rachel Rayner



A student Launches a senseFly eBee Drone

> "3D models generated by Pix4D and merged with 3D wind components are paving the way for the future of Urban Air Mobility." - Peter Wambolt

The 20th century dream of flying cars has never seemed closer. Drones are being used on farms and construction sites around the world for mapping and monitoring; they deliver essential medicines in remote areas, and in leafy suburbs pilot programs are delivering groceries by drone.

But this is just the first step. Scientists envision autonomous air-taxis ferrying people and goods high above city streets. These redesigned helicopters with six or more rotors and electric engines will be quieter, safer and faster than either cars or the helicopters we see today.

But before urban air mobility can unlock gridlock, urban air flow needs to be better understood.

As terrain, cities are different than the suburbs, mountains, fields or construction sites where drones fly today. Consequently, before we see drones being flown in big cities, some real challenges need to be overcome.

Urban wind tunnels (or 'street canyons') increase wind speed and turbulence. At the city street level, residents may notice higher

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Figure 1: The Large Group Meant That There Was Plenty of Eyes on The Drones at All Times.

Figure 2: Urban Canyons Cutting Through a City Block.

temperatures from the urban heat island effect. Drone pilots may feel the Venturi effect, as the breeze is funneled into the relatively narrow gap between buildings, increasing wind speed dramatically, or thermals from increased surface temperatures.

Because of the sheer density of population, there is little room for error in urban operations. Any drone program in a city needs to be absolutely safe.

A team from Embry-Riddle Aeronautical University and Gaetz Aerospace Institute is studying the effects of urban landscapes on drones by using Pix4D software. The project is one of the first of its kind, and will pave the way for the future of urban air mobility.

The study is taking place in Kosovo, as many of the country's urban environments are relatively sparsely populated following the war in the late 1990s, and it would be extremely difficult to get permission to fly in a similar built-up area in the United States. Still, getting the equipment to Kosovo from the US was one of the trickier challenges of the project!

Taking specialized measurements calls for specialized equipment. To measure wind velocity and turbulence, the team relied on sonic anemometers mounted on the DJI S1000. The octocopter drone is particularly stable, so it provided a solid foundation for hosting the sensors.

The team flew the S1000 and its sonic anemometer payload to measure the fluctuating wind within the atmospheric boundary layer. The atmospheric boundary layer is the atmosphere adjacent to the earth's surface and can extend up to about a kilometer above the ground. Surface conditions affect what happens above - heat from the sun hitting the earth and radiating back out, temperature differences creating pressure differences and creating wind, or buildings disturbing the flow. As well as the octocopter, the team flew a senseFly eBee and a DJI Phantom 4 with the free flight planning app, Pix4Dcapture.

The datasets were wildly different in size. The group mapped some individual buildings, collecting less than a hundred photos. In contrast, the largest area covered was 400 acres (1.6 square km), which was captured in 1,500 images.

Once all the images were captured, they were processed in Pix4Dmapper photogrammetry software. In addition to the RGB and multispectral images, the team worked with a CSV file from the sonic anemometer.

Processing the data took as little as one hour for the smallest dataset - and 15 hours for the largest. Most of the projects were smaller, and Peter Wambolt, UAS Project Manager at Embry-Riddle Aeronautical University and team were happy with the "Quick processing time."

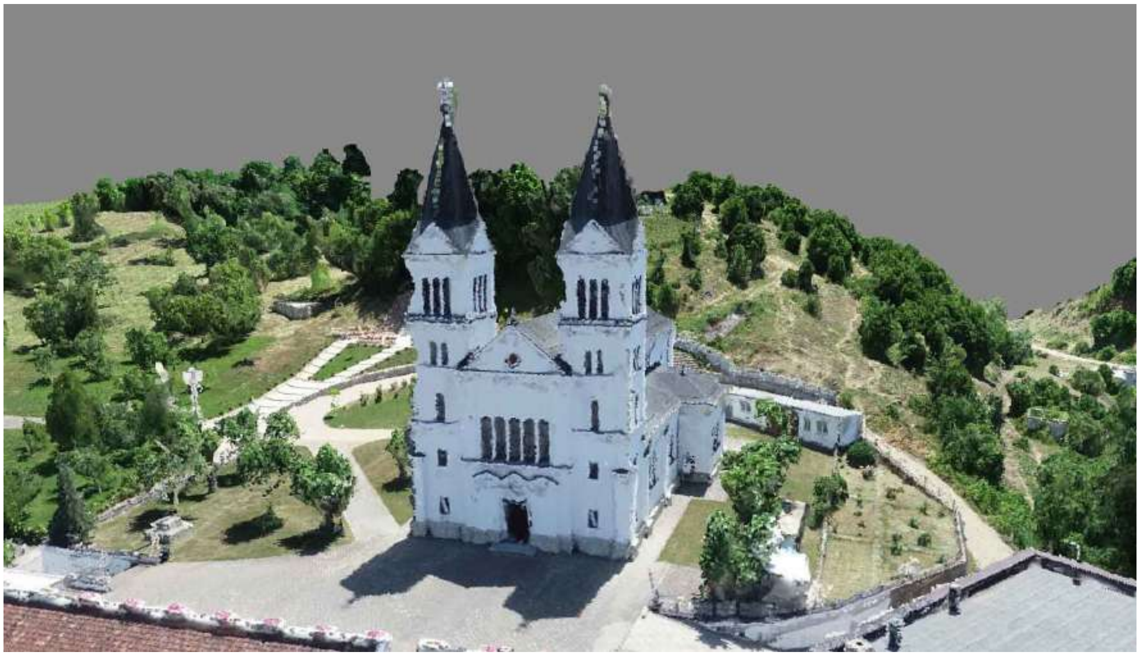

Figure 3: The Church of The Black Madonna In Vitina-Letnica, Where It Is Said That Mother Teresa Found Her Calling.

They also liked that the results were "Easily exportable to others, and able to operate with or without the internet."

We use road maps to navigate the city streets. But aerial maps won't be sufficient to map the skies. Roads remain static for years but the terrain that is the sky changes from moment to moment.

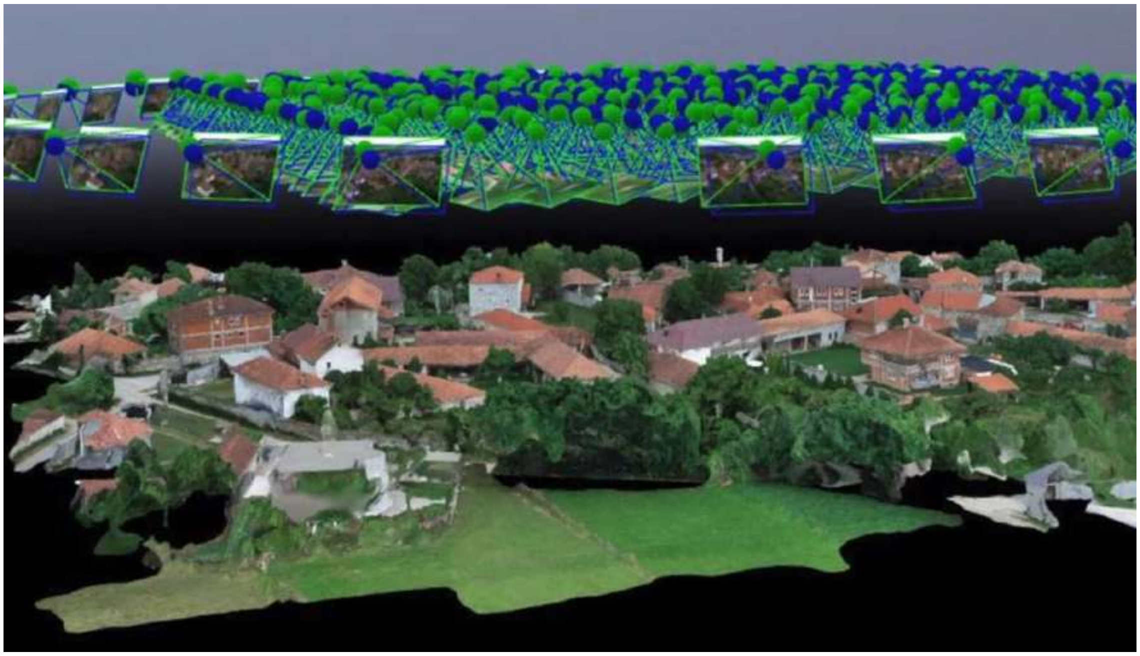

Figure 4: Recreating the Model in Pix4Dmapper.

Dr. Kevin Adkins explains: "One of the challenges with urban areas is that each city is so different, so it's hard to make generalisations. But if we can identify problematic areas, then we can investigate those more and identify areas of concern."

Rather than create a map of every single city around the world, teams like that from Embry-Riddle Aeronautical University hope to create fluid dynamic models of air flow in one specific area. By creating a model of a limited and relatively static area, the formula can be checked and rechecked against various real world conditions before being extrapolated into other cities around the globe. "That will tell us two things," says Dr. Adkins. "It will tell us how well the model is working and it will help us create better modeling schemes."

Dr. Adkins continues: "We can take models of different types of cities with different footprints - because of course you can't observe every single city and its intricacies, but we can make better models."

"This was the first field campaign of what we hope will be many to come," says Dr. Adkins. "Now we're more confident with Pix4Dmapper and the workflow, we want to get up higher, get into more challenging spaces, and see where the science leads."

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WATER SECURITY: SATELLITE-BASED REMOTE LAKE HEALTH MONITORING WITH SLIMS

The Seequent Lake Indicator Monitoring System (SLIMS) prototype, winner of the recent 2019 New Zealand Aerospace Challenge, measures indicative lake water quality using a combination of satellite vision, algorithms, and cloud technology - delivered over the web.

by Daniel Wallace

Seequent's SLIMS solution remotely senses 'Indicative Trophic Level Index', based on hlorophyll-A and Secchi depth, captured via spectral analysis from space.

Landsat 8 Satellite. Image Credit: NASA

Water security is a topic that has increasingly concerned academia, government and NGOs in recent years – with good cause. Climate change, burgeoning populations and shifting lifestyles have all placed pressure on this critical resource. For sustainable development of an urban city much also depends on the water bodies in and around the city.

Water is the one resource for which no substitute exists says Daniel Wallace, General Manager, Civil and Environmental Industries, Seequent. "Water governs our ability to produce food and drives many aspects of industry. However, it is also seeing increasing demand and pressure due to factors such as growing population, rising incomes and accelerating consumerism.

"Couple this with increasing stress on water resources due to changes in climate and it is clear that the water scarcity is a looming issue. Water security is more than just water availability and quality, it also includes water related risks such as flooding, subsidence and slope failures," he says.

Seequent is increasingly seeing clients working to address issues

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around water availability (quantity) and water suitability (quality). Wallace says, "Helping them understand and manage this vital resource is an important part of the contribution we can make to ensuring water security for all."

Over the past 18 years, much of Seequent's innovation has been focused below ground, for understanding subsurface geoscience and engineering design solutions. Its geoscience analysis, modelling and collaborative technologies are used on a range of earth, environment and energy challenges to uncover valuable insights from data, ultimately leading to better decisions in areas dependent on geoscience.

Today, Seequent is extending its reach above ground to help people better understand complex infrastructure and environmental issues, including water security.

Wallace says, "We jumped at the opportunity to participate in the 2019 New Zealand Aerospace Challenge to apply our innovative technology in an exciting new space that has huge potential. Water quality and the health of our lakes sustains our way of life - so we identified it as an area with huge potential for impact."

The company's winning prototype, the Seequent Lake Indicator Monitoring System (SLIMS), measures indicative lake water quality using a combination of satellite vision, algorithms, and cloud technology - delivered over the web. The solution has the potential to virtually monitor the water quality of every lake globally.

Satellite-based Remote Lake Health Monitoring

As part of the New Zealand Aerospace Challenge, Seequent was tasked with developing a solution to identify, monitor or measure water or soil pollution using satellite data and unmanned aircraft technology.

Seequent's goal was to develop a satellite-based remote sensing solution that has the potential to virtually monitor the water quality of every lake globally.

Figure 1: The Seequent Team Accept the NZ Aerospace Challenge Award from Hon Dr Megan Woods, Minister of Research, Science and Innovation (Third from Right) and Valentin Merino Villeneuve from Airbus (Far Right).

Seequent's Lake Indicator Modelling System (SLIMS) can capture water quality data across many hundreds of lakes at once and model and visualise it through time, to help freshwater scientists identify lake health changes. An indicative lake water quality measure is derived using a combination of satellite vision, algorithms, and cloud technology - delivered over the web.

Seequent created its prototype SLIMS solution, which is globally scalable, to demonstrate how it could effectively and economically monitor the health of all New Zealand's 3,820 lakes. With only 2% of lakes currently monitored via established methods of lake water sampling and analysis, SLIMS enables organisations to monitor changes in lake conditions with the ability to use historical satellite data to identify seasonal trends. This allows users to identify lakes exhibiting any unexpected change for closer monitoring and management.

Wallace says, "It's not economical to visit all lakes to monitor adverse environmental impacts, but with satellite remote sensing every lake can be monitored virtually. Alga blooms sediments events and other adverse changes in lake health, which could otherwise be unseen and unknown suddenly emerge with our new monitoring solution. Subsequently these lakes could be visited to further investigate health degradation."

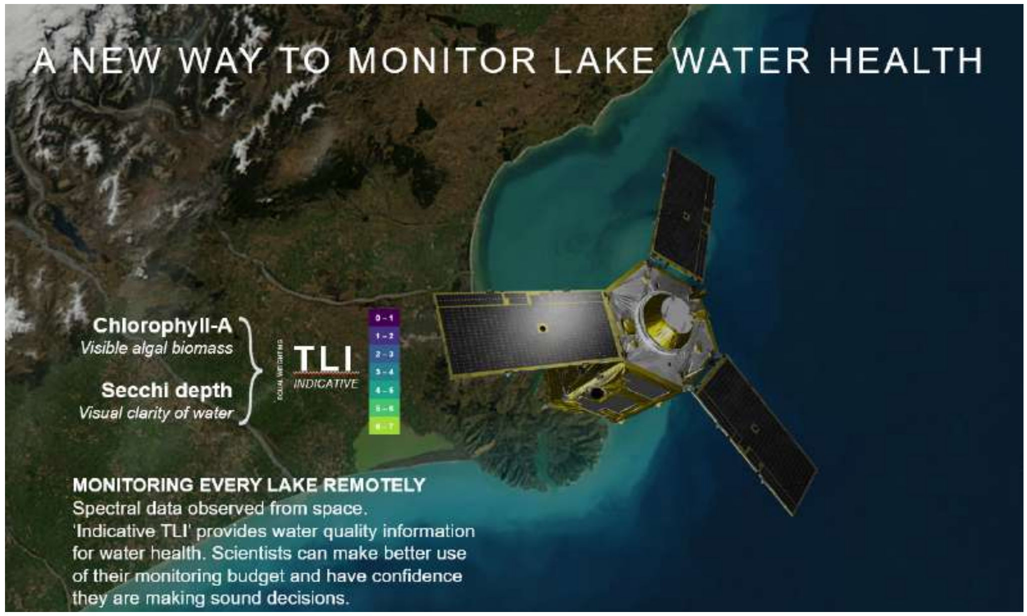
Seequent had a multi-disciplinary team working on its new SLIMS solution, including local collaborators from Lincoln Agritech and the Waterways Centre for Freshwater Management. The team was also supported by Environment Canterbury, a regional environmental authority responsible for water sampling, and the University of Waikato, who have developed a global reputation for research into regression algorithms.

Andrew Mathewson, Managing Director Airbus Australia Pacific, said the Challenge, powered by Airbus and delivered by ChristchurchNZ and SpaceBase, demonstrated that space technology and sustainability are converging in new and exciting ways.

"There is so much opportunity to use satellite data to better manage agricultural activities, but also to combat global environmental challenges like climate change. Seequent's solution is a great example of this type of innovative and practical technology to enable better management of our environment," he said.

Entries were judged by Valentin Merino Villeneuve, Head of Airbus Defence & Space Australasia, alongside New Zealand's top space and agritech industry leaders. Merino Villeneuve announced the winners with Hon Dr Megan Woods, New Zealand's Minister of Research, Science and Innovation.

"Seequent's grand-prize winning solution demonstrated the potential of commercialising existing satellite data to monitor environmental challenges on the ground. It is these tangible solutions that will drive innovation and change in how we research and respond to our changing world," Merino Villeneuve.



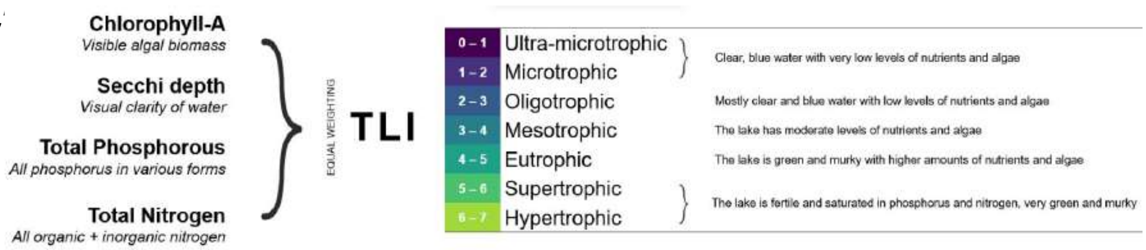


Figure 2: Seequent's Lake Indicator Modelling System (SLIMS) offers a new way to monitor lake health. The water quality in each lake is assigned a number between 1 and 7, the lower the number representing the better the water quality.

How Does Seequent's Lake Indicator Modelling System (SLIMS) Work?

Trophic Level Index (TLI)

In New Zealand an overall picture of the health of lakes is based on the Trophic Level Index (TLI), which broadly categorizes the health of a lake water. TLI is calculated through equal weighting of separate water quality components:

- Chlorophyll-A Visible algal biomass
- Secchi depth Visual Clarity of water Total Phosphorous All phosphorus in various forms
- Total Nitrogen All organic + inorganic nitrogen

Chlorophyll-a is the green colour in plants. Knowing how much chlorophyll there is in a lake gives us a good idea of how much algae the lake has. Algae can be present in a lake, but just not too much. The more algae present, the poorer the water quality.

Water clarity is a measurement of how clear the water in the lake is known as secchi depth. In general, the clearer the water, the better the water quality.

Total nitrogen and total phosphorous are nutrients that plants thrive on. Large amounts of these nutrients in the lakes encourage the growth of algae which can lead to poor water quality.

By combining these measurements, the water quality in each lake is assigned a number between 1 and 7, the lower the number representing the better the water quality.

Waterbodies in mesotrophic and higher states deteriorate through stages of murkiness through to being entirely consumed by algae. Waterbodies in these states quickly become smothered by biomass, reducing dissolved oxygen, light transmission and preventing life from functioning in the water body's 'dead-zones'.

What Impacts the TLI in a Lake?

Changes in a lake's water quality will impact the overall TLI. Regulators and landowners can play a role in reducing the TLI score of a lake over time, for example, by reducing the amount of phosphorus and nitrogen entering the lake.

Indicative TLI from Space

Only laboratory analysis can measure TLI, but we can indicate TLI trends and changes, based on cost-effective spectral data observed from space.

Seequent's SLIMS solution remotely senses 'Indicative TLI', based on Chlorophyll-A (visible algal biomass) and Secchi depth (visual clarity of water), captured via spectral analysis from space. It models the two components to provide base-level water quality information for many thousands of water bodies with each satellite flyover. Regression algorithms researched by the University of Waikato help make it possible to model the Chlorophyll-A and Secchi depth components.

Indicative TLI results can be packaged and deployed alongside lake monitoring data collected by traditional lake sampling.

Monitoring Every Lake with Remote-Sensed 'Indicative TLI'

Remote-sensed Indicative TLI allows all lakes in a region to be modelled through time, revealing changes in conditions and trends from historical satellite data. Algal blooms and sediment events which would otherwise be unseen and unknown suddenly emerge. Scientists can make better use of their monitoring budget and have confidence they see the whole picture.

How Does It Work?

- FLY-OVER: Satellite observes and collects top-of-atmosphere observation data.
- SURFACE REFLECTANCE PROCESSING: Processing for geographic registration, atmospheric processing, cloud masking and classification.
- PRE-PROCESSING: Preparation of bands 2 – 4 for bio-optical modelling, including temporal compositing and water confidence clipping for lake edges.
- MODELLING: Application of lake water regression models to derive raster outputs; Chlorophyll-A, Secchi Disk, total suspended solids, and lake surface colour.

Rapid Prototyping

A rapid cloud-based web app was developed by Seequent engineers to conduct customer interviews to derive feedback.

The lean prototype was built using Google's EarthEngine Platform, traversing the full history of the USGS's Landsat-8 Surface Reflectance Tier-1 data to calculate the Chlorophyll-A component of TLI for a small selection of lakes in Canterbury, New Zealand.

Results were packaged and deployed alongside monitoring data collected by physical sample for each lake.

Seequent is continuing to develop its prototype Seequent's Lake Indicator Modelling System (SLIMS) for the global market. For more on Seequent see: www.seequent.com

Urbanisation: Four Emerging Trends for Water Security

Water security has traditionally been challenged by factors such as degradation in quality and decline in availability. But it is in areas of growing urbanisation that concerns are now advancing, leading to four emerging trends.

1) Better Governance: Factors such as urbanisation and climate change are increasingly challenging the way water is governed. A case in point would be California's Sustainable Groundwater Management Act that aims to prevent excessive groundwater extraction causing "overdraft, failed wells, deteriorated water quality, environmental damage, and irreversible land subsidence that damages infrastructure and diminishes the capacity of aquifers to store water for the future."

2) Reuse and Recycle: Zero Liquid Discharge is becoming common in industry and society. At the industry level, it means water in a factory is kept in the factory and re-used via cleaning and treatment. In potable water situations it means once you have used the water, you use it again. Currently, sewage (used potable water) is recycled for another use such as irrigation and infiltration ponds. But that will likely change.

3) Conservation: Certainly, one of the best ways to improve water security is to make sure that water is used efficiently and not lost. This has been a focus in many parts of the world for a long time, but there are still places it has not been

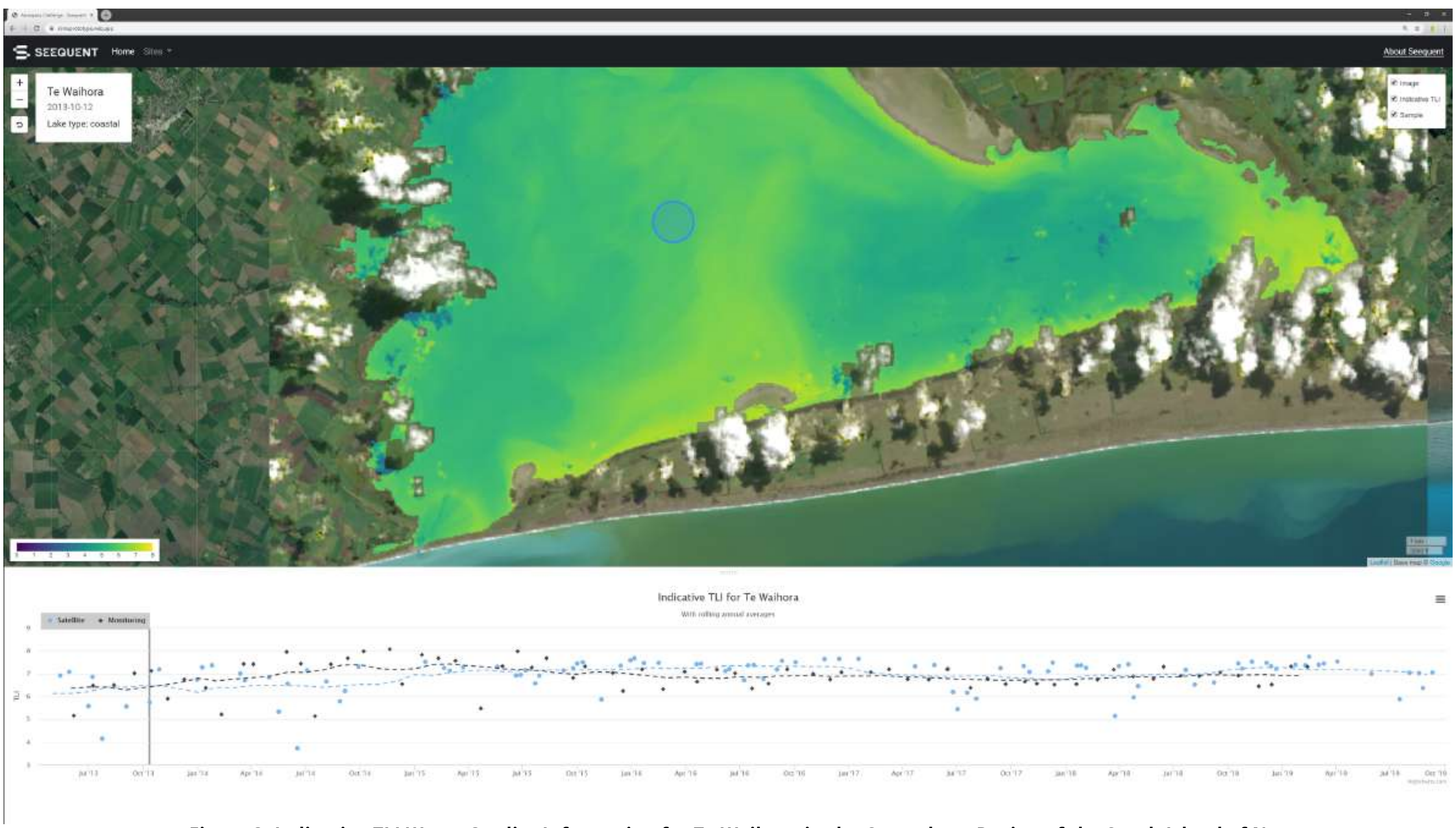


Figure 3: Indicative TLI Water Quality Information for Te Waihora in the Canterbury Region of the South Island of New Zealand Shown In SLIMS.

implemented well. On top of that, there are constantly new technological advances that improve water efficiencies such as waterless toilets and urinals.

4) Water Harvesting: Urbanisation means grassland, lawns or fields are now an urban landscape. Hard roofs, roads and sidewalks impede the recharge of aquifers whereas the previous surfaces allowed rainfall to percolate down. There are practices to ensure all water falling on those roofs, etc, is recharged as close as possible to where it fell. In addition, open landscapes could be used to capture runoff to serve as temporary storage or increase aquifer recharge. Constructing infiltration systems to capture roof water can also mitigate the flooding seen in modern urban landscapes.

More on Seequent

Seequent is a world leader in the development of powerful geoscience analysis, modelling and collaborative technologies for understanding subsurface geoscience and engineering design solutions.

Seequent's solutions enable people to analyse complex data, manage risk and ultimately make better decisions about earth, environment and energy challenges. Seequent software is used on large-scale projects globally, including road and rail tunnel construction, groundwater detection and management, geothermal exploration, subsea infrastructure mapping, resource evaluation and subterranean storage of spent nuclear fuel.

Seequent's global footprint includes its Christchurch-based HQ and R&D centre, and a network of offices across Asia/Pacific, Africa, South America, North America and Europe servicing blue chip companies and customers with leading subsurface solutions in over 100 countries.

For more on Seequent see: www.seequent.com

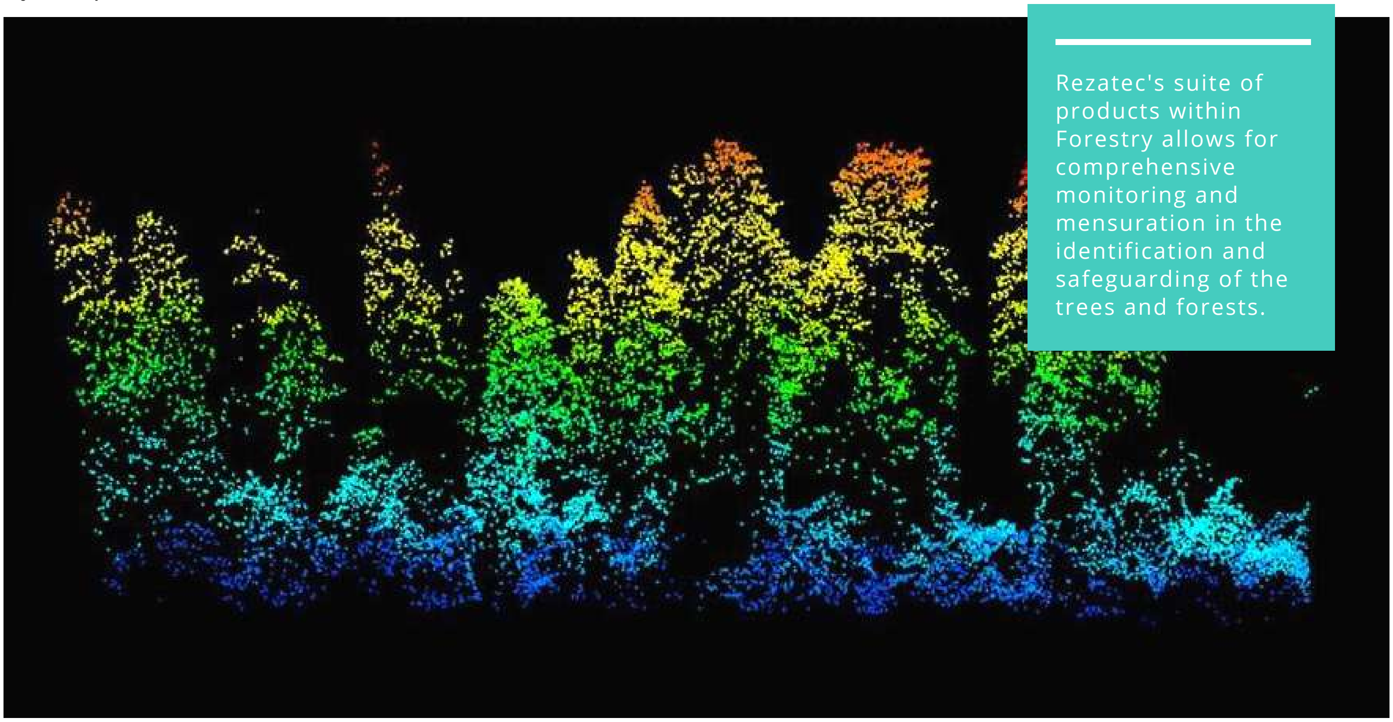
Water Security - Facts & Figures

- **2.7 billion** people are affected by water scarcity at least one month each year.
- **$114 billion** the degree of investment required per year to hit the world's sustainable development goals on water supply, sanitation and hygiene. This figure is three times what's actually being spent.
- **By 2025** half the world's people will live in countries with high water stress.
- **117 million** lakes in the world totalling 20.4 million km2 with a mean size of 0.2 km2 / lake.
- **3/4 of all Americans** live within 16km (10 miles) of polluted water.
- **20%** increase in salinization of the world's irrigated land area due to inefficient use of water for crop.
- **40%** The gap expected between water demand and water availability by 2030.
- **1/2 of the world's hospital beds** are estimated to be occupied, at any one time, by patients with waterborne illnesses.
- **30% of the Earth's freshwater** is in the ground

SATELLITES vs. LIDAR FOR FORESTRY MANAGEMENT?

Rezatec utilises EO optical and radar data in proprietary machine learning algorithms to output data products that are scalable and easier to update on a more frequent basis than traditional field surveys.

by Philip Briscoe



Rezatec's suite of products within Forestry allows for comprehensive monitoring and mensuration in the identification and safeguarding of the trees and forests.

Traditionally, monitoring and managing large forests has been a very costly and labour-intensive activity; involving ground teams to walk and observe a representative sample of forest.

In recent years however, two new forms of forest analysis have emerged: LiDAR and Satellites. Each offers new levels of data and insight not previously available to forest owners, but each with different characteristics.

Understanding the features of each method is crucial to identifying how and when to apply them to best effect.

In this article we look to unravel the two technologies to help foresters to gain a deeper understanding of both.

LiDAR DATA

LiDAR (light detection and ranging) is an optical remote-sensing technique that uses laser light to examine the surface of the earth. Benefits of LiDAR data include having high accuracy and good detail, however there are several drawbacks. Firstly, due to the labour-intensive process of collecting the data the costs are very high, this would typically include aircraft, employment costs and equipment.

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Then the price of obtaining the LiDAR data isn't the only thing you'll have to pay for, the data will have to be processed by a highly skilled analyst and presented in a way that's understandable showing the commercially important insights that were gathered.

Another disadvantage of LiDAR is the gap between data updates, which can often be 5 - 10 years. By the time you've got your set of data, paid for someone to analyse it and are ready to use it, it could be out of date and your forest could look completely different. There could have been an infestation of beetles, or even fire damage! Then you'll have to wait up to 10 years to go through the whole process again and recapture a new set of data. Realistically LiDAR is only used to look at a portion of the forest, rather than a tool to manage the entire forest.

Satellite Data

Satellites can provide both optical and adar data across your entire forest. The refresh rates are also much higher with satellites typically passing overhead every week (cloud cover permitting).

This frequency of monitoring allows for a much faster response to events, as well as temporal analysis – monitoring change over time.

The combination of both optical and radar data also affords a much wider range of applications. For example, you can determine tree species, mensuration and health analysis. The continuous management of forests using such up-to-date information means there are fewer chances to miss environmental and health changes. This can play an important factor in ensuring insurance claims are valid, by detecting things like fire and storm damage much quicker.

Satellite data has other advantages over LiDAR; it is much less weather dependant as synthetic-aperture radar (a form of radar that is used to create two-dimensional images) can penetrate cloud cover, whatever the weather.

How to Use This Data?

Whichever method of gathering data you use, you'll soon realise the biggest percentage of forest management costs arise from ground truthing, to make the data you've captured useful. With satellite data the need for ground-based manual data collection can now be minimised with the use of machine learning algorithms. This can reduce the amount of validation required and improve ground-based efficiency and targeting, so you only visit the relevant areas, hugely reducing costs.

Summary

Both LiDAR and satellite data provide useful insights and can be used to complement each other. Rezatec's GIS platform can incorporate LiDAR as well as several other data sources, but satellite data is unique in its versatility, frequency of updates and ability to monitor very large areas.

By using earth observation satellite data, you get a continuous large-scale view of your forest. You can pair this with existing LiDAR data you already have to enrich your view or use the satellite data as your stand-alone forestry management analytics.

Want to find out more? Download our guide: 'Satellite-derived forestry intelligence.'

Or request a demo.

Figure 1: Rezatec Portal Showing Tree Species Distribution.

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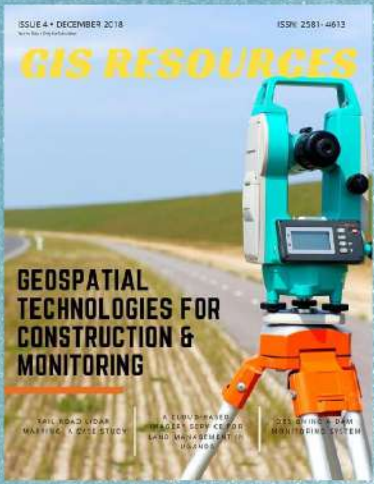

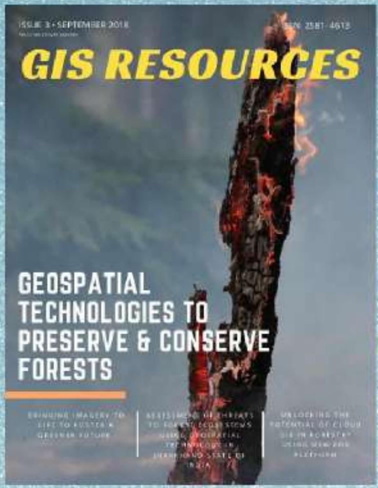

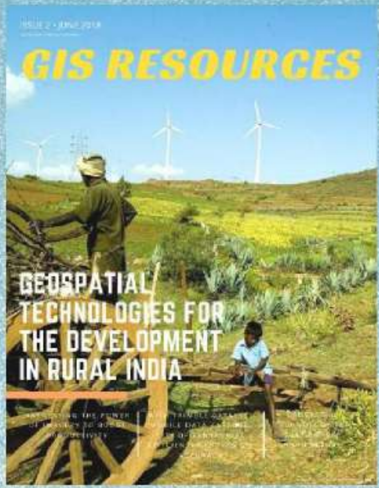

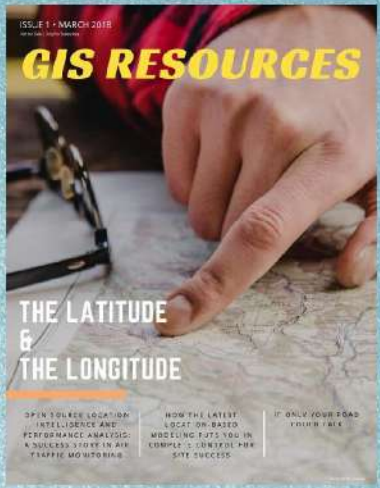

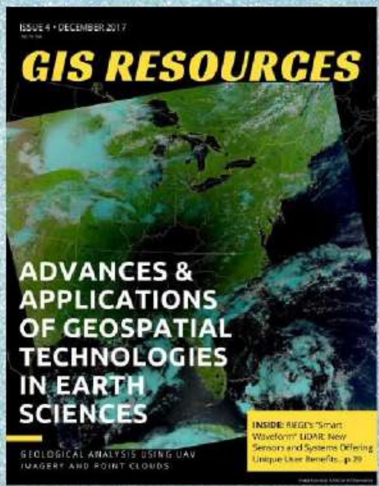

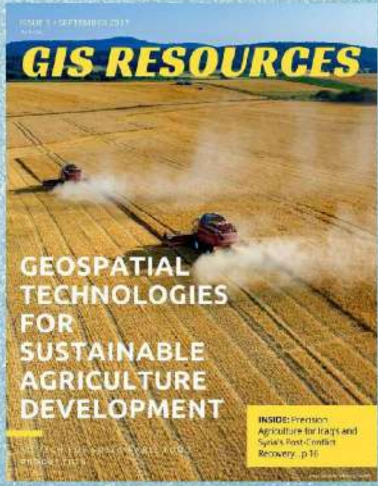

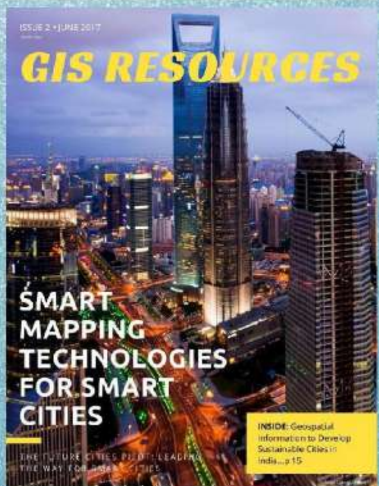

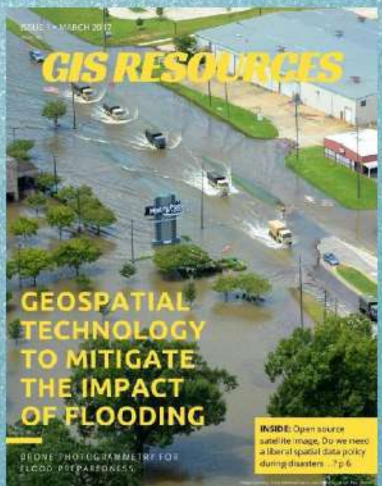

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