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TRANSPORTATION

SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | NOVEMBER 2021

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Dear Valued **watt**now Reader

This being the last issue for 2021, which features Transportation, we look at South Africa's transportation industry which gives you much food for thought.

Our first feature article looks at Transportation in South Africa - especially trains, buses and taxis. Not every commute is easy to make by public transportation in South Africa, but it's certainly possible in many urban areas. Whether you're taking the train in Gauteng or the bus in Cape Town, there are plenty of options to get where you're going safely and efficiently. We discuss a few key topics. Read it on page 32.

On page 36, we look at the "State of affairs of South African Railways". Rail freight transportation is a method of transporting goods and commodities from one place to another through wheeled vehicles (rolling stock) along directionally guided railway tracks. It is crucial to the South African economy.

Page 44 brings you an article on "Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg, South Africa". There have been growing concerns about the state public transportation systems, particularly in the cities of developing countries. Chief among these concerns has been the lack of well-coordinated, efficient, and reliable transportation systems.

The January 2022 issue features Energy Storage, and the deadline for article submission is 6 December 2021. Please email your articles/white papers to minx@saiee.org.za.

I want to take this opportunity to thank all my contributors for your support in 2021. Without you, there won't be **watt**now.

I am wishing you all a serene festive season. If you are travelling, please do so safely and keep your following distance.

Herewith your November issue, enjoy the read!

Minx

CHARGE REWARD PROGRAMME





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www.saiee.org.za

Alternatively, call Connie on 011 487 3003.

SAIEE
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ROSATOM GREEN HYDROGEN COCKTAIL EVENING

From left: Ms Irina Simonova, Business Development Manager, Rosatom SA, Prof Dmitri Bessarabov, Director, HySA and Mr Dex Machida, Manager, Mobility 2030 South Africa, KPMG

The SAIEE hosted its 2021 Corporate Partner Rosatom Central & Southern Africa at a cocktail evening at its head office on the 4th of November 2021.

Decarbonisation of the industry is becoming an essential topic for various governments and key industrial players. Hydrogen is considered a "clean" energy carrier to reduce the carbon footprint of many industrial processes. The talk was about "clean" electrolytic hydrogen production, storage and transportation options, and the international "clean" hydrogen landscape, including South African strategies.

Minx Avrabos, Executive: Corporate Partnership welcomed the guest and introduced Ms Irina Simonova, Business Development Manager, Rosatom SA, who introduced the guest to Rosatom's Green Hydrogen offerings. "Currently, for Rosatom, hydrogen energy is a priority area of scientific and technological development. Last year Rosatom started implementing a large-scale R&D program in hydrogen technologies and developed solutions along the entire hydrogen supply chain. One of the priority technological tasks is to ensure the minimisation of carbon dioxide emissions from hydrogen production," she said. "Introduction of environmentally friendly hydrogen production technologies and international cooperation in the area will contribute to the diversification of the global energy portfolio, which is an important step towards a carbon-free future," she added.

The keynote speaker, Prof Dmitri Bessarabov, Director of HySA Infrastructure Center of Competence, discussed the vital importance of Green Hydrogen and its applications in South Africa and its continent.

In support of Prof Bessarabov's presentation, Mr Dex Machida from KPMG shared the financial implications on how Green Hydrogen can save the South African Economy.

Rosatom is open to cooperation with international companies in a joint analysis of the prospects for export supplies to European, Asian and African countries. Interaction in this direction will solve the issues of storage and transportation of hydrogen over long distances while maintaining the commercial attractiveness of the projects. wn

From left: Minx Avrabos, Executive Corporate Partnership, with Lee Muller, Provectus Engeering.

From left: Guest with Liya Botha, Marketing Manager, Rosatom SA.

SAIEE WIE donates sanitary towels to the Teto Secondary School learners in Welkom township, Free State Province

The South African Institute of Electrical Engineering (SAIEE) Women in Engineering (WIE) chapter launched the sanitary towels drive in August 2021 to keep a girl child at school. Three hundred eighty-four packs of sanitary towels were donated to the Teto secondary school on the 22nd of October 2021.

Mpai Letebele (SAIEE WIE treasurer) introduced the SAIEE WIE members and explained the day's purpose. Maite Sako (SAIEE vice-chairperson) encouraged the girls to embrace themselves in their own unique way.

She explained that a woman's body is unique and sacred and need to be treated with high dignity and ensure that it is always clean. She further explained that life is not a competition but a journey. Each learner needs to embrace their journey with all its difficulties and that it will all be worth it in the end. She said they must not let the noise of others' opinions distract their journey and ensure that they get rid of anything that would distract them from following their dreams.

The principal shared a heartwarming message and highlighted that there are many days when some girls end up leaving school early because of menstrual emergencies—seeing SAIEE WIE donating sanitary towels to restore the dignity of Teto girls meant a lot for them. Lastly, he concluded that we are empowering and building our nation by taking care of our communities.

SAIEE WIE chapter prides itself on ensuring that a girl child remains in school even though their menstrual period promotes education. There is always a great need for sanitary towels, and lack thereof can negatively impact a girl child because sometimes they have to stay away from school during their monthly cycle.

This was SAIEE WIE's second project since its establishment in 2019.

SAIEE WIE team would like to say a big "Thank You" to everyone who contributed to this initiative. Your support is greatly appreciated. wn

If you want to get involved in this life-changing project, email: wie@saiee.org.za

Girls from the Teto Secondary School celebrating the SAIEE WiE Sanitary Towel Drive with members of the Women in Engineering Chapter.

NEED FOR SPEED?
New High-Speed Pyrometer CT 4M From Optris

With very fast processes, requirements for the pyrometers used for temperature measurement are especially onerous. Typical examples are plastics processing machinery, such as those used for blow-molding PET bottles, which work on very short cycle times. Another application is the monitoring of rail vehicles, where the temperature of the wheelset bearings is measured as the train wheels pass the pyrometer, in order to detect components running hot, in good time.

INSTROTECH, local supplier of Optris products now offers the new high-speed pyrometer CT 4M for these types of challenging tasks. With a detection time of just 90 µs, it is the fastest pyrometer within the Optris product range.

OPTIMUM FOR METAL SURFACES AND LOW TEMPERATURES

The CT 4M measures within the spectral range of 2.2 µm to 6.0 µm, making it ideal for low-temperature measurements on metals, metal oxides, ceramics or for materials with an unknown or changing emissivity. Here, low temperature means the measurement range which spans 0 °C to 500 °C. The sensor head of the new pyrometer is very compact; with a diameter of 14 mm and a length of 28 mm, it can easily be installed even where space is at a premium, for example directly within a machine. The remote electronics unit is connected to the sensor head via a cable which can be up to 15 m long. Important parameters can be entered here directly via three keys and an illuminated display.

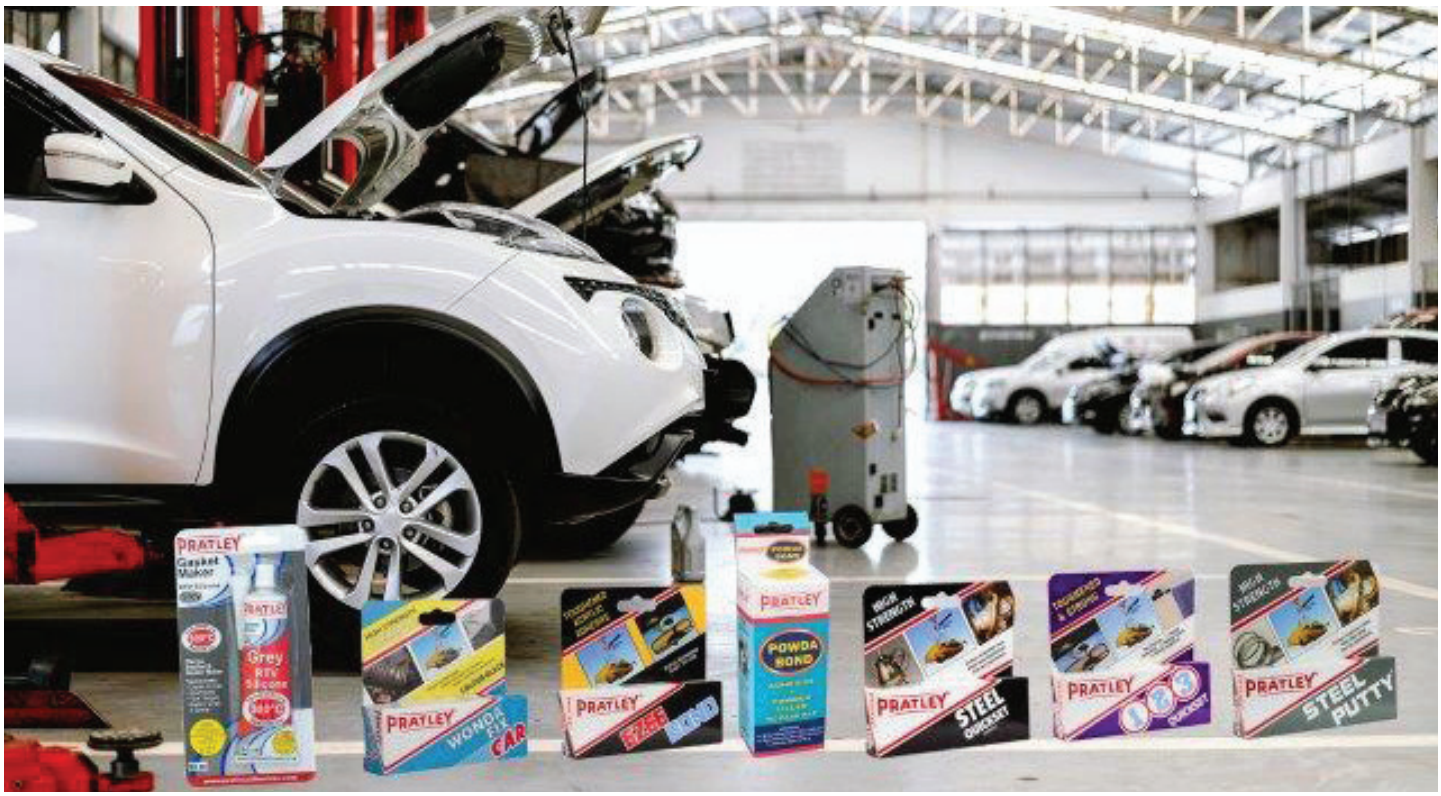
The integrated interface allows the CT 4M to be connected directly to a PC, where all settings can be fine-tuned in the CompactPlus Connect software. Date capture and recording are also possible using the software. Other serial interfaces or an Ethernet interface are also available as options. Instead of a PC, the pyrometer can also be connected to an Android mobile device which has the free IRmobile app installed. This allows the settings of the pyrometer to be adjusted very conveniently during commissioning or maintenance work directly on site.

To connect the CT 4M to the process, two scalable analog outputs and three I/O pins (programmable inputs/outputs) are available.

For more info, contact INSTROTECH: sales@instrotech.co.za

INDUSTRY AFFAIRS

DIY auto repair products for Transport



Pratley is showcasing its range of versatile and cost-effective DIY adhesive products for the automotive sector. These products are ideal for various quick, on-the-spot automotive repairs, especially in situations where well-equipped mechanical workshops are often unavailable.

Most automotive repairs require a type of adhesive that can handle the same conditions your vehicle might encounter. When deciding on the best adhesive for automotive repairs, Pratley has a wide range available to save you time and money.

Pratley Steel Quickset® is a quick-setting adhesive metal filler and mender that sets very hard and matches the colour of most ferrous metals. This means it can be subjected to filing, sawing, machining and sanding. Typical applications include filling blow-holes in metal castings, repairing cracked castings, making fillets or filling seams in metal parts, bonding ceramics, slate and tiles where the colour matches, bonding metal parts and repairing holes in car sumps.

Pratley Steel Putty is ideal for applications such as sealing metal water tanks and repairing cracked sumps, metal castings, metal radiators, and metal petrol tanks, among others. It can also be used to fill blowholes and be used on engine castings. A major advantage of the putty is that it can be extensively machined after curing, meaning it can be easily cut, drilled and sanded down as required.

Another significant benefit is that the product will not corrode, which makes it ideal for humid environments where corrosion is an issue. There is also no additional strengthening requirement once the putty has hardened, which can be spray-painted for aesthetic purposes.

Pratley Grey RTV Silicone is a new flange sealant and gasket maker in the form of a tough and elastic silicone rubber for superior sealing. It can tolerate extreme temperatures of -50°C to +300°C for short periods and is resistant to diesel, paraffin, water, oil and anti-freeze. What is more, the product has no negative effect on electrical components such as vehicle sensors. In addition, it is non-corrosive, making it ideal for engine sumps, gearboxes, pipe flanges and water pumps, to name but a few. wn

For more info, visit:
www.pratleyadhesives.com

Heavy lifting equipment runs on polymer bearings

Up and coming dock-levelling manufacturer, REV Designs, recently completed the design and construction of three of the country's largest scissor lifts ever produced with a capacity of up to 40 tons per lift.

The Springs-based manufacturer incorporated a host of clever designs to facilitate the heavy-lifting ability of the scissor lifts, which will be used in the saw milling industry. It also included the latest polymer bearings to enable heavy lifting with minimal wear and damage for and considerably longer service life and maintenance intervals.

According to REV Designs chief designer and founder, Ricardo Viljoen, the use of igus high performance polymer bearings ensures that the pivot points work smoothly with vastly reduced wear compared to traditional bearings and the added advantage of not requiring either lubrication nor daily maintenance.

TOUGH ENVIRONMENT

"The bearings needed to be very strong to withstand the kind of forces that are placed on it in this hard-pushed timber processing environment. The bearings also have a distinct advantage in this kind of "dirty environment" with potential for the ingress of sawdust, woodchips and other debris that could snag lesser bearings.

"With this in mind, we chose to work closely with igus' polymer bearing specialist, Juan-Eric Davidtz, who was able to match the right bearings for our requirements. Our design uses 33 bushes per lift and each one has specific operational requirements," says Ricardo.

He adds that polymer bearings supplied by igus have become integral to nearly all new designs due to the bearings rugged and long-lasting abilities. That means that the bearings are able to last as long as the best materials used on the company's lifting equipment, dock-levellers and other equipment. See more about the lifts here.

GROWING DEMAND

The success of the bearings in the massive scissor lifts has also buoyed Juan-Eric, who says the company's polymer products are increasingly being used in all kinds of industries and the timber industry is the latest one.

"We are an international supplier of motion plastics such as bearings, energy chains to protect cables and hydraulics, as well as speciality cables for different applications. Our motion plastics take things to a different level and usually result in machines and equipment using our products being more effective and long-lasting than those using traditional materials." wn

Juan-Eric Davidtz of igus

REV Designs heavy duty scissor lifts use speciality polymers from igus

Mini-Substations for Motor Plant Boasts Dry-Type Transformer

Dry-type transformer specialist Trafo Power Solutions will supply two custom-engineered mini-substations to a significant motor plant expansion near Pretoria.

The two units will be located outdoors, serving to power the lighting system and security requirements of the facility, as well as other loads. While most mini-substations are equipped with conventional oil-cooled transformers, these units have dry-type transformers – delivering a number of benefits to the customer.

David Claassen, managing director of Trafo Power Solutions, says these include security and environmental factors.

"Used by both the private and public sector, mini-substations must often be located in unprotected areas, making them vulnerable to vandalism and theft," Claassen says. "The oil-cooled transformers are often targeted for the copper in their windings, as well as the oil for the cooling system."

The dry-type transformer's windings, by contrast, are cast in resin so the copper or aluminium cannot be readily accessed. There is also no oil to harvest, further reducing the incentive for criminals to destroy the structure.

"In terms of environmental considerations, the dry-type transformer does not require any additional protective structure like walls or bunds to contain leaking oil or fire," he says. "These units also require very little maintenance, easing the managerial and technical burden on the owner."

While these two transformers are manufactured in TMC Transformers' world-class facility in Italy, the design and manufacture of the balance of the mini-substation is carried out in South Africa. This gives Trafo Power Solutions a high level of control over the quality of the final product, says Claassen. "This also allows us to fully test the equipment locally before it is delivered, installed and commissioned on site," he says. "We embrace the opportunity to manufacture locally as much as we can, to support local industries and enhance job creation."
Visit Trafo Power Solutions here wn

Market entry into South Africa: novomind, with new local presence in Cape Town, ensures customer proximity

German software developer offers intelligent omni-channel commerce and customer service solutions for the South African market / novomind iAGENT customer service platform as a cen-tral all-in-one solution for contact centres with several digital channels including messaging and collaboration

The Hamburg-headquartered German software developer - novomind AG - has started to intensify its activity in the South African market. With a local presence in Cape Town, and the cooperation of local partners, novomind ensures customer proximity.

According to the novomind claim "Customer focused. Technology driven", proximity to customers and a consistent focus on their unique needs, has always been key to novomind's success. Being a German and European technology leader in its specific field of expertise, no-vomind develops efficient software solutions for fast, modern and high-performing online opera-tions in commerce and customer service. Among novomind's customers are institutions and associations, as well as government agencies of all sizes, financial services providers, mid-sized companies and international conglomerates. While novomind's software is partly cloud-based and on-premise, the company's SaaS (software as a service approach) means that it can be integrated flexibly in almost any environment.

"With our software technology, we are enabling our customers to continuously increase their number of digital customer relationships across all channels and to strengthen the value of these relationships", says Michelle Greeff, novomind Business Development Manager in Cape Town. "We are passionate about South Africa and would like our software solutions to create an impressive digital footprint all across the country."

NOVOMIND IAGENT CUSTOMER SERVICE PLATFORM AS AN ALL-IN-ONE SOLUTION FOR CONTACT CENTRES

With novomind iAGENT, the German software specialist offers the South African contact centre and business process outsourcing (BPO) call centre sector, an AI (Artificial Intel-ligence)-based central all-in-one customer service platform for optimal multichannel management. From chat or video chat to e-mail, call, social media and messaging platforms such as WhatsApp business solution, Facebook messenger and others. All contact channels are mapped in a single system with a single user interface. This eliminates the need for time-consuming switching between different surfaces and devices.

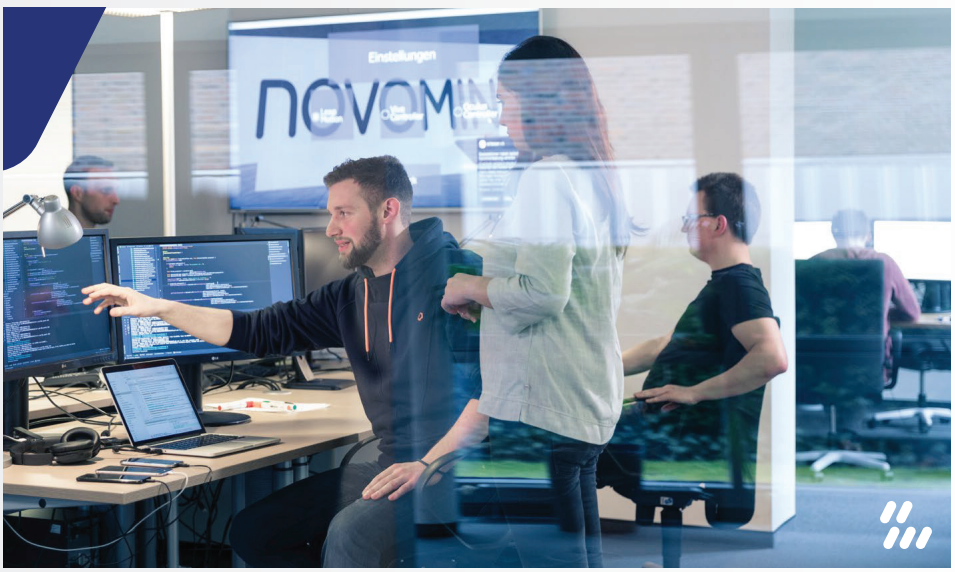
Additionally, the intelligent contact centre functions of novomind iAGENT such as skill-based routing and queue management can be combined with the various collaboration functions of Microsoft Teams. This can optimise and simplify the communication path from the contact cen-tre to the back office. Thanks to the uncomplicated exchange of information, customer re-quests are resolved much more efficiently, giving the customer a very streamlined experience.

MARKET ENTRY INTO SOUTH AFRICA

By entering the South African market, novomind continues its growth strategy and the interna-tionalisation of its business which was started several years ago. Being present in Europe as well as in the Asia-Pacific region, and after setting up the subsidiary novomind MEA located in Dubai for Middle Eastern and North African regions in April 2018, expansion into South Africa was the next logical step.

novomind is a member of the Contact Centre Management Group (CCMG), a body of like-minded professionals and organisations that are committed to developing contact centre services in South Africa. wn

Further information click here.



Zest WEG Customers can now Buy Online – Anytime

First phase of roll-out includes standard products like low voltage electric motors, variable speed drives, soft starters and switchgear.

Zest WEG has become one of only a few industrial companies to pioneer an E-Commerce facility linked to its new website, allowing its customers to make purchases online. Incorporated into the online purchasing facility on the new website are functionalities which include features such as technical tools and other capabilities including access to stock availability levels and more.

"The E-Commerce facility is part of Zest WEG's continuous drive to serve customers better, making it easier and quicker for them to deal with us," says Johan van Niekerk, Zest WEG national sales executive. "This is just another way to make our products more readily available to customers."

Around South Africa, customers can now conveniently place orders on this new Zest WEG E-Commerce site, which in its first phase of roll-out includes standard products like low voltage electric motors, variable speed drives, soft starters and switchgear.

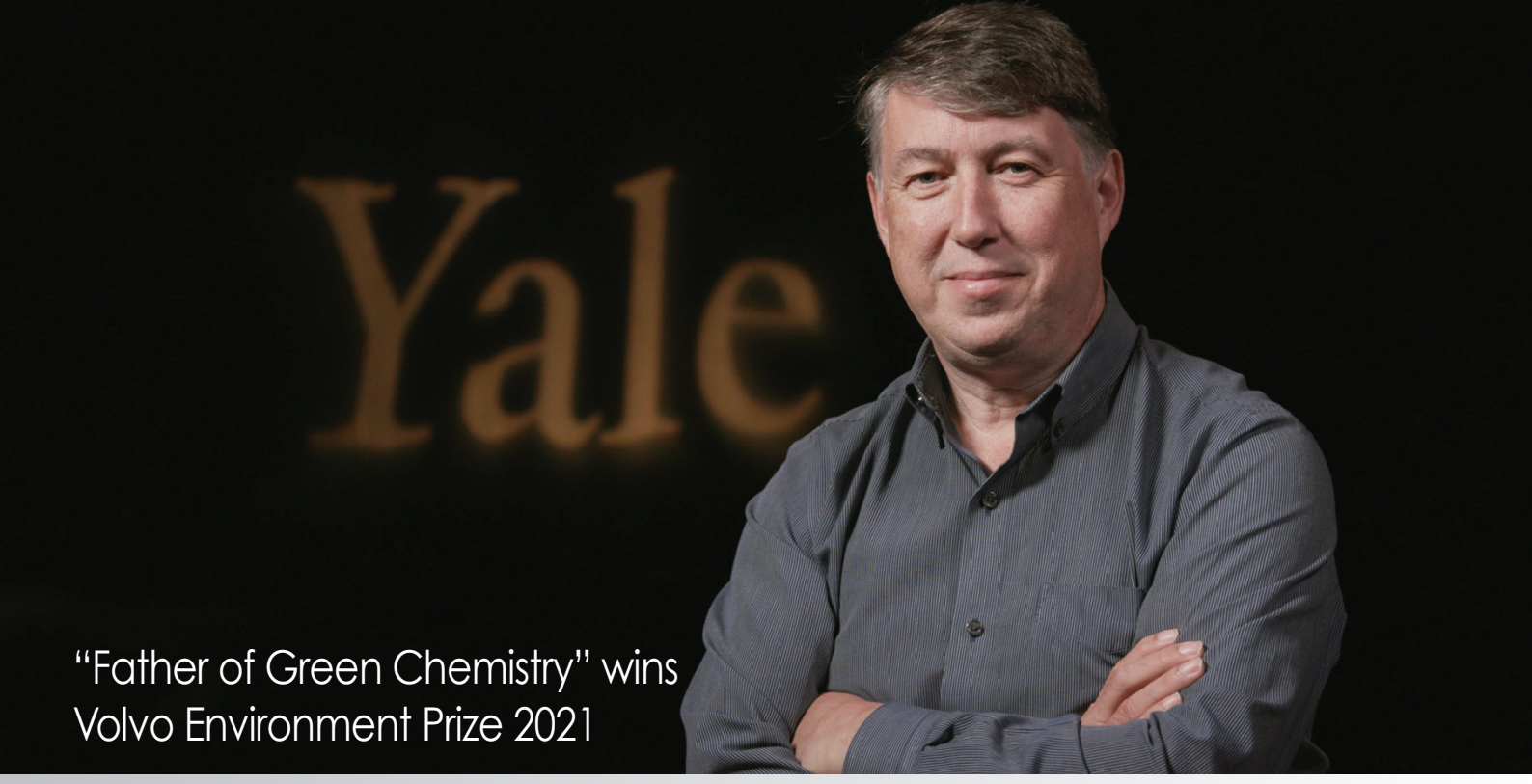
Van Niekerk highlights that the design and programming for this kind of site – which includes a wide range of technical products – has been quite demanding. The company began the thought process long before the Covid-19 lockdowns were implemented, and prioritised the roll-out since then.

"The digital world around us, and especially electronic or internet trading, is developing very rapidly," he says. "It was therefore important for us to develop our E-Commerce capability as part of our philosophy of ongoing improvement and customer service."

He emphasises that customers requiring assistance will still have access to the staff that currently provide them with service support.

"The E-Commerce site is an important value addition to our new corporate website, which has been redesigned partly to facilitate easy integration with the E-Commerce element," he says. "The website is now easier to navigate and offers an even greater depth of technical information and brochures, as well as more tools that customers will find useful. We are confident that customers will find the added flexibility of Zest WEG E-Commerce valuable, giving them access to an ordering system at all hours of the day or night," he says. wn

For more info, click here.



"Father of Green Chemistry" wins Volvo Environment Prize 2021

Paul Anastas, a Yale professor and pioneer in developing non-hazardous chemicals, wins the 2021 Volvo Environment Award, one of the world's most respected scientific and environmental awards. The research of Paul Anastas "is revolutionizing the chemical industry, a key contribution to meeting the sustainability challenge," says the Prize Jury.

Everything we touch, see and feel is chemical, whether it's furniture, clothes we wear, medicines we take, or electronics. For the past two centuries, chemistry has been creating technological miracles, increasing the human quality of life. But its performance has also led to unintended consequences of pollution, waste, and toxicity.

Paul Anastas, widely known as the "father of green chemistry", set about to change this early in his career as a staff chemist in the US Environmental Protection Agency. He co-founded the Green Chemistry Institute and later served as an advisor in the White House and chief scientist at EPA. Professor Anastas is currently Director of Yale University's Center for Green Chemistry and Green Engineering.

"Green chemistry is not about sacrifice," says Paul Anastas. "The new products of green chemistry not only perform as well, they almost always perform better than the incumbent technologies. It's because, historically, our way of converting one chemical into another has been rather brutish and ugly. We heat, beat and treat these substances, often making them more toxic, and that increases the risk of them reacting with our bodies and the biosphere".

Instead, Paul Anastas' research has focused on how nature does it, and he and his students have developed methods for generic molecular design for reduced toxicity and waste reduction. In addition, Paul Anastas has developed The Twelve Principles of Green Chemistry, a framework widely used by industry and universities. He has also championed the development of green chemistry networks operating in more than 30 countries, resulting in numerous actions, such as creating new bio-based plastics. Or the redesign of manufacturing to reduce waste, which could have substantial environmental benefits since 90 per cent of all materials that go into manufacturing wind up as waste immediately.

But the ultimate challenge is CO2, the primary driver of climate change. Paul Anastas is optimistic: "What's going on now is brilliant green chemistry that converts CO2 to useful materials, such as buildings or bridges. Large quantities of CO2 going into materials is part of shifting the equation. It's one of the great challenges that green chemistry is meeting, and this award honours all the green engineering practitioners around the world."

Says the jury of the Volvo Environment Prize Foundation: "Paul Anastas' research is revolutionizing the chemical industry, from fundamental reaction methods to applications as diverse as processing foods and producing green hydrogen."

The Prize will be celebrated on the 1st of December with a live streaming prize ceremony and seminar. wn

High-voltage ToT keeps the content current

GREEN Solar Academy's Training of Trainers kicked off yesterday (28 October 2021) in Auckland Park, Johannesburg. Trainers from GREEN academies all across Africa gathered to become familiar with new courses and modules and training methods and welcome new trainers into the fold. And this was no small undertaking! GREEN had to coordinate the schedules of trainers from partner academies such as Logos in Mozambique, Young Africa in Namibia, Sunergy in Zimbabwe, ANH Technologies in Pretoria, Life Choices in Cape Town, Solarvest in Ballito, KZN, and the GREEN Solar Academy in Ghana.

To effectively train solar installers, GREEN Solar Academy must first effectively train its trainers! And this needs to happen regularly. GREEN calls it the ToT (Training of Trainers), and the 2021 session kicked off at the end of October in Auckland Park, Johannesburg.

What makes a good training course? Besides relevant content, the second major factor is the mode of presentation. Our goal is to deliver excellent training, so we pay great attention to what's on the slide and how it is presented.

Once a year, trainers from GREEN Solar Academies all over Africa are invited to the Training of Trainers event, a 3-day workshop where we top up on skills, work on new training courses and content and integrate new trainers into the existing GREEN trainer community.

Consistency is vital in delivering a training curriculum. GREEN trainers receive the same materials they were trained on, and therefore they disseminate the same learning in every SuperSolarSchool course. The standardized format allows us to measure and compare the performance of each training group.

Trainers are primarily experienced solar installers who also enjoy sharing their knowledge of PV technology. At GREEN, you will never encounter dry academic theory with no relevance to today's marketplace. Our lecturers are men and women who run their successful businesses and offer valuable insights into the soft skills required alongside a sound foundation in solar design and installation.

Regularly updating course content and training facilitators to properly transfer that information is vital to staying relevant in a rapidly evolving modern world, particularly renewable energy. We frequently review all our training and their implementation and our trainers to ensure a consistently high standard in all our academies.

The first day of the ToT also marked the return of GREEN's exclusive in-person networking meetings for GREEN alumni. Day 1 ended off with a well-attended live panel discussion on the ins and outs of the SSEG (Small Scale Embedded Generation) Application. wn

SAIEE CGC CSI Invited to the Farewell Celebration at Olievenhoutbosch Secondary School

By Neo Mapapanyane and Maite Sako

SAIEE Central Gauteng Centre (CGC) was invited to the Olievenhoutbosch Secondary school farewell celebration on the 23rd of October 2021. Since last year, the SAIEE CGC Corporate and Social Investment (CSI) team has been working closely with the school, when the CSI team donated sanitary towels and face masks. The event was attended by learners, educators, parents and other esteemed guests. The CSI team used the platform to encourage the class of 2021, who started their examinations on the 28th of October. The message shared with the learners was preparing for the exam and life after matric.

Neo used the analogy of a battle that they (learners) are faced with and have to prepare for it to conquer. No one goes to a fight without a proper plan and training. To triumph, you need to plan appropriately before attacking, and this is the same with exams. There are a couple of things they need to put in place before they can begin studying, including preparing a study timetable, committing to the study times, and understanding study methods that work for them. Once the plan is in place, one can start training in preparation for the big fight, which is now studying for the exams. Furthermore, she emphasised that the most important thing is knowing what to do on the day of the battle. Everything they have learnt and practised will be tested, and they need to show strength, commitment and determination.

The second part of the presentation was the aftermath of the battle. Maite Sako shared this message and thanked the Olievenhoutbosch school leadership and the present parents at the event. She also congratulated the Grade 12 learners for having reached the milestone of being in Grade 12. In her message, there are four key points she emphasised:

FAMILY BACKGROUND. Wangari Maathai says, "A tree has roots in the soil yet reaches high above the ground". It tells us that to aspire, we need to be grounded and that no matter how high we go, it is from our roots that we draw sustenance". Maite encouraged the learners never to forget their families where they are from. They always need to remember that those are the first people they know love from, are their true roots, and must always be kind to them.

UNIQUENESS. Each one of you is unique and special in your own way, and you need to make that unique contribution to this community, the South African economy, and the entire world. In furthering your studies next year, you will all go to different faculties in different educational establishments to get the skill you need to build the South African economy. The better way to find out how to contribute is to find your abilities and strengths and make sure that you invest time and energy in enhancing and mastering that area. The other important aspect is to read; empower yourself with the correct information to make informed decisions about what career path you want to follow.

LIFE AT UNIVERSITY. University life is different altogether because of the teaching style and independence you get. You will need to adapt to a new environment. Ensure you don't miss classes, ask questions, and attend the tutoring classes. As an adult, you will be required to take responsibility for yourself and focus on why you are there in the first place.

DELAY STARTING A FAMILY. Maite mentioned that there is no need to rush into starting a family while still at the university level. She shared her own story when she had a baby during her 3rd year of study, and it became challenging for her to juggle university studies and pregnancy simultaneously. She further encouraged girls not to be deterred from achieving their dreams no matter the circumstances.

As SAIEE CGC, we wish the class of 2021 all the best in their exams and future endeavours. It is not easy, but we know that it is possible. wn

World Cities Day

This year's World Cities Day, a commemorative day designated on 31 October by the United Nations General Assembly, once again focuses on the general theme of 'Better City, Better Life', but with the sub-theme of 'Adapting Cities for Climate Resilience' for 2021.

"The topic of sustainable urban development is close to our hearts at Danfoss," explains Ziad Al Bawaliz, Danfoss Regional President: Turkey, Middle East, Africa. "In particular urban efficiency is a priority for us, as we believe that this is the most effective way to turn the challenges of our cities into opportunities."

The UN's Department of Economic and Social Affairs estimates that the world's population will reach about 9.8 billion by 2050, with almost 70 per cent of people living in cities. "Since 2010, more people have been living in urban settings than in rural areas - 56.2 per cent of the population globally to be specific, according to figures released by the UN's Population Division in 2020. And currently, this figure is growing by a staggering 200,000 per day.

"This means that while cities are the main driving force behind the world's economies, they're also our biggest consumers, accounting for between 60 and 80 per cent of global energy consumption and 75 per cent of carbon emissions," Al Bawaliz adds. "Furthermore, buildings are responsible for 40 per cent of total energy consumption."

"It's within cities that our focus must lie to reach the objectives of the Paris Agreement, which sets out a framework to avoid dangerous climate change by limiting global warming to well below 2°C, pursuing efforts to reduce it to 1.5°C."

A report published last year by Navigant Energy sets out a technology pathway to achieve the Paris Agreement's less than 2°C targets by 2050, based on the significant potential of:

- Energy-efficient heating and cooling of buildings;
- The electrification of transport - cars, buses, trucks, and examples of vessels, ferries, and boats, plus required charging infrastructure; and
- Sector integration - as an enabler of energy-efficient buildings and electrification of transport. Sector coupling covers optimising the use of renewable energy, stabilising the grid, and cost-effectively using energy through the interconnection of urban energy systems' elements like industry, buildings, and transport.

The good news, says Al Bawaliz, is that the technologies to help reap the benefits of urbanisation are already available.

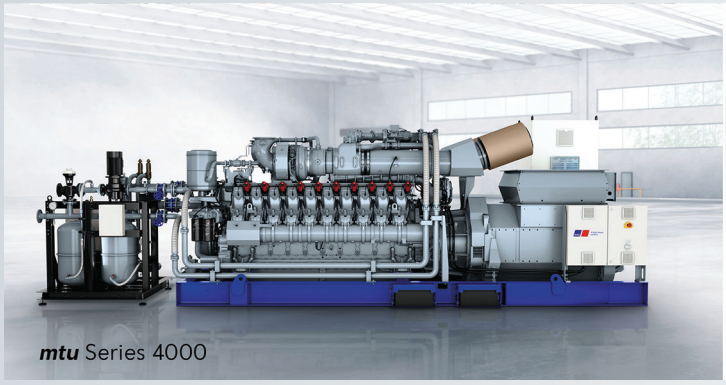
The Navigant study shows that implementing existing technology solutions for the three focus areas can bridge half of the gap in greenhouse gas (GHG) emissions reductions to reach the 1.5°C targets in urban areas. The remainder will come from other sectors, mainly industry, electricity for appliances, and construction.

The paper also states that the most cost-effective way to reach this objective is to invest in energy efficiency first. It says that energy efficiency in buildings is a precondition for an affordable, fully renewable, and secure integrated urban energy system. "More energy-efficient heating and cooling in buildings also provide a significant step in the right direction to curb air pollution, a severe issue within many urban areas, particularly places like Southeast Asia, China, and India. At the same time, Middle Eastern countries, including Saudi Arabia, the United Arab Emirates (UAE) and Qatar, have taken major steps to reach carbon neutrality following the Paris Agreement. By actively working to decrease emissions, we can then improve liveability within cities, providing a better indoor climate as well as a healthier outside environment.

Ziad Al Bawaliz, Danfoss Regional President: Turkey, Middle East, Africa

"It is heartening to see more and more African countries also looking to build safer, resilient and more effective cities, with Luxor in Egypt being the official host of this year's World Cities Day celebrations, and countries further south, like Nigeria, Ethiopia and South Africa all pledging their support to raise awareness of urbanisation on this day," Al Bawaliz concludes. wn

Rolls-Royce launches *mtu* hydrogen solutions for power generation


mtu Series 4000


mtu Series 500

Rolls-Royce is further developing its mtu gas engine portfolio for power generation and cogeneration to run on hydrogen as a fuel. Already today, gensets powered by mtu Series 500 and Series 4000 gas engines can be operated with a gas blending of 10 percent hydrogen. Beginning in 2022, operation with a hydrogen content of 25 percent will be possible. Rolls-Royce will continuously market new mtu Series 500 and Series 4000 gas engines beginning in 2023 for use with up to 100 percent hydrogen, and on a design to order basis conversion kits to allow already installed gas engines in the field to run on 100% hydrogen.

- From 2022 *mtu* Series 500 and Series 4000 ready for 25% hydrogen
- From 2023 *mtu* engines and conversion kits available for 100% hydrogen

Rolls-Royce is developing its *mtu* gas engine portfolio for power generation and cogeneration to run on hydrogen as a fuel and thus enable a climate-neutral energy supply. Today, gensets powered by *mtu* Series 500 and Series 4000 gas engines can be operated with a gas blending of 10 per cent hydrogen.

Beginning in 2022, an operation with a hydrogen content of 25 per cent will be possible. "After intensive tests on test benches and pilot installations at customers in 2022, Rolls-Royce will continuously market new *mtu* Series 500 and Series 4000 gas engines beginning in 2023 for use with up to 100 per cent hydrogen. On design-to-order-basis conversion kits will allow already installed gas engines in the field to run on 100% hydrogen," said Perry Kuiper, President Sustainable Power Solutions at Rolls-Royce Power Systems.

POWER PLANTS WITH HYDROGEN ENGINES SUPPORT THE ENERGY TRANSITION

"The decarbonisation of power generation requires reliable, flexible, and climate-neutral power plants to supplement the fluctuating generation from wind and sun. We assume that natural gas will initially be the primary fuel in developing the hydrogen ecosystem, but we see hydrogen as technically and economically possible. That is why we continue to develop our gas engines for use with green hydrogen - whether as a 10 or 25 per cent admixture or for 100 per cent," explains Andreas Görtz, Vice President Power Generation at Rolls-Royce Power Systems.

ROLLS-ROYCE BUILDS EXPERTISE FOR THE H2 ECOSYSTEM

In addition, fuel cells powered by 100% green hydrogen can play an essential role in future energy supply in combination with renewable energies. At its Friedrichshafen headquarters, Rolls-Royce's Power Systems division has installed a 250-kilowatt fuel cell demonstrator, which will be used to test and present future CO_2-free energy systems to customers. The entire hydrogen ecosystem, including the infrastructure for supply, conversion, test benches and future production, is also being mapped in the company's plants, thus building up expertise.

ROLLS-ROYCE FOCUSES ITS CLIMATE PROTECTION PROGRAMME NET-ZERO AT POWER SYSTEMS ON NEW TECHNOLOGIES AND FUELS

With its climate protection programme "Net Zero at Power Systems", Rolls-Royce's Power Systems division has set itself the target of saving 35 per cent of greenhouse gas emissions by 2030 compared to 2019 using new technologies.

This near-term target plays an essential role in the Rolls-Royce Group's ambition to achieve carbon neutrality by 2050 at the latest.

In addition to new technologies, a key element in achieving these targets is the certification of crucial mtu engine products to run on sustainable EN 15940 fuels such as e-diesel and second-generation biofuels as early as 2023. wn

A historical milestone for the SAIEE Transactions, 1909 to date

The SAIEE Africa Research Journal (incorporating the SAIEE Transactions) has been publishing peer-reviewed articles in electrical engineering and associated disciplines since 1909. Over the years, the journal has developed from capturing meeting proceedings to advancing the body of knowledge.

BY | SAURABH SINHA | BEATRYS LACQUET | SUNIL MAHARAJ

Like many international journals, the journal moved to online access in 2005. At the same time, the journal's name also changed to SAIEE Africa Research Journal (incorporating the SAIEE Transactions).

The SAIEE website was the initial platform to access the journal and, with the name change, to also solicit further participation from the African continent. The journal is accredited by the South African Department of Higher Education and Training (DHET), which means that public universities in South Africa receive publication subsidies for affiliated papers presenting recognised and original research outputs.

In the world of journals, however, there are different online platforms. These online platforms carry large audiences of authors who take an interest in a given discipline. In electrical engineering, the largest platform is the IEEE Xplore database. The Xplore database was launched in May 2000. Given IEEE's membership of over 400 000, in the inaugural year, 2000, there were already over 11 million downloads. With IEEE's history and its origins in 1884, at inception the database benefited from 350 000 author records and 553 000 documents; in 2019, the database exceeded over 3,8m author records, 5m documents with over 1.5 bn downloads and views since inception.

Aside from their usage in academic settings, IEEE Xplore articles are also referenced in patents worldwide. Furthermore, to enhance the accessibility of articles, IEEE moved towards the model of hybrid and open-access (OA) journals. Because of these attributes, the SAIEE Africa Research Journal developed a collaborative partnership with IEEE Xplore.

Journal "performance" is often measured by the impact factor (IF). IF is a function of the number of citations over a period of time. Global reach, combined with the backing of a large audience, is helpful in extending reach; such reach often translates to a higher number of citations.

The collaborative discussions between the SAIEE and IEEE started in January 2012. Because quality assurance is of utmost importance, the IEEE carefully validates journals on the IEEE Xplore database; the SAIEE Africa Research Journal was considered over seven years to assess whether the peer-review process and quality were synonymous with the approach of the IEEE. To this end, the SAIEE Africa Research Journal diversified its editorial board, adopted tools such as an open-access journal management system, and introduced other approaches to strengthen peer-review quality and approach. In 2018, we received the news that the journal had been finally approved for indexing by IEEE Xplore.

Side-by-side with the journal review process, was another matter of importance – the cost of incorporating the journal into the IEEE Xplore database. Our interest was to have the journal captured from 1909. In addition to peer-reviewed articles, the complete SAIEE journey would be included in IEEE Xplore, which would constitute

a historical archive. Each article would also be accompanied by a recognised digital object identifier (DOI). The cost of such an archive would ordinarily be prohibitive.

IEEE approached the IEEE Foundation, Inc. to assist with this. Working together, resources were sourced from two IEEE held funds - International Electrical Congress Fund and Mailloux Fund - which had recently been repurposed with approval from the New York State Attorney General to augment the content of the IEEE digital library by supporting the hosting of one or more third party publishers content with preference to a non-U.S. publisher.

For the most recent editions of the SAIEE Africa Research Journal, the journal is supported through the following combination – IEEE, IEEE Africa Council and through article processing charges.

Through this convergence of support by SAIEE, IEEE, IEEE Foundation volunteers and staff, and the financial avenues, the SAIEE Africa Research Journal (incorporating the SAIEE Transactions) has now met a major international milestone; it now lists as one of the oldest electrical engineering journals globally.

Journals in this league on IEEE Xplore now include:

- 1884 – Transactions of the AIEE
- 1905 – Proceedings of the AIEE (now IEEE Spectrum)
- 1909 – SAIEE Africa Research Journal (incorporating the SAIEE Transactions)

The publication is indexed and available (open access) here.

Specifically:
Since 2005, the SAIEE Africa Research Journal (incorporating the SAIEE Transactions) and

Since 1909, the Transactions of the South African Institute of Electrical Engineers.

Also acknowledging publication through the IEEE Xplore database, the journal is indexed by Scopus, SciELO SA, and Web of Science (Emerging Sources Citation Index). Through its listing on Scopus and SciELO SA, the journal remains on the accredited list of the DHET.

We remain thankful to the SAIEE community (authors, reviewers, specialist/guest editors and others) who have enabled this journal over more than a century.

For more information click here
Email: researchjournal@saiee.org.za

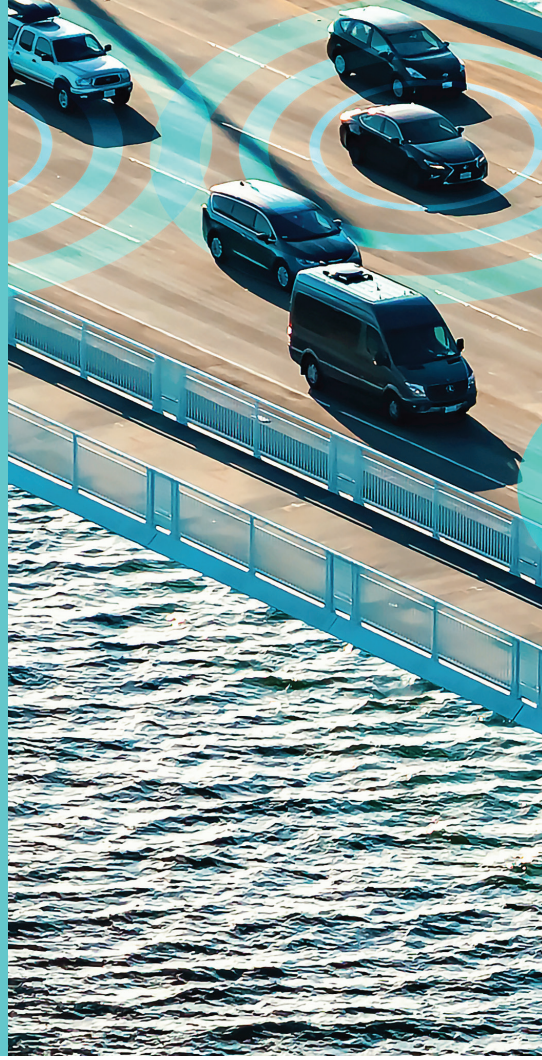
YOU ARE INVITED

Join us for the launch on the 30th of November at 18h00 via Zoom.

Join Zoom Meeting

Meeting ID: 838 9410 2787
Passcode: 449585

ABB leads the way in developing new technology to drive our e-mobility future



Transportation is a major contributor to CO_2 emissions globally, accounting for about 24% of total emissions come from this important sector. Of this figure, more than 75% is from road transportation in the form of cars, trucks and motorbikes. Surprisingly, the aviation sector only accounts for 11% of emissions here, while passenger cars account for 60% of road transportation emissions globally.

BY YURI RAMSAMY
PRODUCT MARKETING SPECIALIST,
ABB SOUTH AFRICA

Electric mobility (e-mobility), paired with renewable energy generation, stands to play a major role in significantly lowering global CO2 emissions in the transportation sector. This will not only help us achieve our global targets, but have a positive impact on the environment and our quality of life due to reduced pollution and noise.

After a decade of rapid growth, the global electric vehicle (EV) stock hit the ten million mark in 2020, reports the International Energy Agency (IEA), which represents an astonishing 43%

increase over 2019. China has the largest fleet with 4.5 million electric cars, with Europe recording the largest annual increase last year of 3.2 million. Globally, governments spent US$14 billion on direct purchase incentives and tax deductions for electric cars in 2020, a year-on-year increase of 25%.

Not to be outdone with accelerating developments in the EV market worldwide, the Department of Trade, Industry and Competition published a Green Paper entitled 'The South African Road to Production of Electric Vehicles' on 18 May 2021. It aims to establish a clear policy foundation to coordinate a long-term strategy to position South Africa at the forefront of advanced vehicle and vehicle component manufacturing, complemented by a consumption leg. It will likely boost our competitiveness in the global race to transition from the internal combustion engine era into e-mobility solutions and technologies.

This follows the Minister of Trade, Industry and Competition challenging major South African automotive manufacturers in 2019 to assist to develop a roadmap for local EV production.

The various workstreams of the automotive industry's Master Plan were launched shortly thereafter, including a focus on technology changes and deeper localisation. The draft Green Paper aims to develop a framework upon which a comprehensive and long-term automotive industry transformation plan on new energy vehicles (NEV) can emerge, with a specific focus on the creation of a high-yielding business environment.

This includes an appropriate fiscal and regulatory framework that will make South Africa a leading, highly competitive location for EV production, not only in Africa but globally.

Another focus is the development and investment in new energy vehicle (NEV) component technology and expansion of the fledgling electric supply chain; reinvestment and support towards reskilling and upskilling of the workforce to ensure the right skills are available for the design, engineering and manufacturing of EVs and related components and systems; the transition of South Africa towards cleaner fuel technologies available globally; and adoption of new and sustainable manufacturing processes to significantly reduce greenhouse gas emissions and improve our environmental wealth.

In a research note on the current EV market in South Africa, Old Mutual notes that the current charging network is still very small, and that it is going to take a long time before there is a widespread distribution of charging points. However, the larger issue is

that a charging network is only as good as its power supply. More specifically, a large network of frequently used charge points needs a reliable industrial-strength power supply. Old Mutual notes: "Much would need to be done to ensure that the national grid has the capacity to cope with the petrol-to-electric switch, and energy producers and government need to anticipate and prepare for higher energy demands."

Therefore, it is readily apparent the e-mobility market segment requires integrated charger and electrical infrastructure architectures that can be rapidly deployed. Here ABB leads the way to a zero-emission mobility future. With its mission and purpose to power e-mobility going forward, ABB engineers the electrification solutions for the transport of tomorrow, today. It ranges from smart transportation solutions from EV chargers for the home and electrified fleet depots and opportunity charging for electric bus and trucks to high-power chargers for the highway stations of the future.

ABB's modular building block approach with integrated communication allows for scalable, repeatable designs for fast implementation in the rapidly developing EV market globally. One particular scalable solution to build depot charging infrastructure, for example, is our eFleet depot solution. Here the combination of modular blocks provides the solution architecture that meets the demand of modern eBus depots. On the other hand, the roadside relocatable EcoFlex with integrated high-power chargers is ideal for highway and public commercial parking. It allows for up to two 350 kW chargers in a relocatable enclosure: A 20-foot enclosure with up to four 175 kWHP cabinets, AC/DC, two 350 kW charge posts and an optional 50 kW DC fast charger.

The EV Site System (EVSS) provides integrated control and management between the chargers, electrical infrastructure and customer systems for seamless operation. The OPC UA protocol provides open communication and common interfaces. ABB chargers have integrated systems for connection to customers' operating systems. EVSS allows for connection to other architectures (battery energy storage system or a MV feeder plus transformer) for easy transition to future needs.

A decade ago, the concept of autonomous driving and full EV fleets was very much a vision. It is fast becoming a reality, with ABB leading the way in developing new technologies and integrated solutions to drive our EV future. ABB entered the EV charging market in 2010 when it launched its pioneering DC charger. Now more than 14 000 ABB DC fast chargers are sold across more than 80 countries, from Peru to Rwanda. ABB is a global market leader in e-mobility charging solutions, with a strong market share in Europe, Asia Pacific and the US.

In 2013, ABB was the first company to develop networks of 50 kW chargers, spanning complete nations. This was paired with a unique cloud-based service for remote monitoring and servicing of chargers, which was a real game changer for connectivity, and now forms part of the ABB Ability™ ecosystem. More recently in 2018, ABB was first-to-market with its liquid-cooled full 350 kW capable charging technology, which delivers higher power and charging speeds.

Early 2020 saw the acquisition of Chinese EV charging provider Chargedot, giving ABB a stronger entry into the largest e-mobility market in the world and broadening its portfolio of DC and AC fast charging.

ABB offers a total EV charging solution from compact, high-quality AC wallboxes and reliable DC fast-charging stations with robust connectivity to innovative on-demand electric bus-charging systems, with infrastructure solutions that meet the needs of the next generation of smarter mobility. In addition, ABB also offers Connected Services through its ABB Ability™ platform to allow charging station owners to monitor and configure charge points remotely, adapt business and pricing models over time, keep charging infrastructure up-to-date with the latest software, service the equipment efficiently and with minimal operational effort, increase charger uptime and the reliability of the charging network, and minimise investment in IT infrastructure and back-end software.

The faster we transition to EVs, the bigger the change will be, and the more stakeholders and OEMs we expect to enter this burgeoning market. We will also see the merging of two worlds, where the automotive world becomes part of the electrical world. In the past, these were two distinct industries, but in the next ten years we will see them coming together to offer a better user experience. wn

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SAIEE Coffee table book

Second Edition

Work contacting organisations started in February 2019 and went well until the onset of the Covid 19 pandemic, after which it gradually became challenging to entice companies to participate. Numerous companies had retrenched staff and were in serious financial difficulties. However, we eventually gathered together sufficient material to make the book viable.

One of the most outstanding inputs is from the Square Kilometre Array (SKA) Radio Telescope organisation in the Western Cape. All inputs are exciting, and we feel confident that the book will be an outstanding success.

This softcover book is now available at R350 (incl. VAT) from the Institute.

To order your book, please contact Dudu Madondo either via email: reception@saiee.org.za or contact her on 011 487 3003.

In 2001 the SAIEE published a coffee table book titled "Sparkling Achievements". The book was compiled and edited by Michael Crouch, a Past President of the Institute and published for the SAIEE by Chris van Rensburg (Pty) Ltd.

This first book surveyed Electrical Engineering in South Africa and included material from 43 local organisations. The second edition's objective is to include new companies and their history and achievements during the past two decades from 2001 to 2021.

AVAILABLE NOW!

SAIEE

Why Become an Electrician?

COMPILED BY | JOHAN BASSON | FSAIEE
JB SWITCHGEAR SOLUTIONS (PTY) LIMITED

Whilst the focus in electrical engineering is often on graduates, one should not forget the vital role of industrial electricians since they are a vital resource in the industry.

One of our most significant challenges is establishing a viable and sustainable base of technical skills in the country. For some years, it became less fashionable to work with your hands, own a toolbox, or wear a set of overalls.

But the reality is that artisans and technicians are vital to our industry and the economy in general. So, in this article, we will focus on industrial electricians.

To become an industrial electrician is not just a simple, laidback affair. It takes commitment to education and an apprenticeship or learnership programme before training to master the trade and then find a job.

When you do, you are on the path to what can become a rewarding career.

You know the rules and regulations to work with different industries and have the experience to work with a diverse variety of industrial systems and machinery.

In some ways, you ensure that businesses continue to receive power to function productively. Take that in for a moment …

I will now look at the four primary considerations when becoming an industrial electrician.

RESPONSIBILITY

As an electrician at an industrial site, your employer or client trusts you with installing electrical power and systems, telecommunications, fire and security systems and electronic controls. Besides that, your job also involves wiring and cabling work, servicing electrical equipment or components.

The electrical work you will perform could include work on new installations or switchgear systems, additions or modifications to work already done.

It could also include maintenance or repair work on some faulty equipment or faulty conditions in circuitry or process control operation.

OPPORTUNITIES

You may not always realise it, but in the industrial sector, your job as an electrician is critical to support the growth and sustainability in the manufacturing and construction industry. Mining, water treatment, materials handling, food, paper and pulp, cement, automotive, power generation … These are just some typical areas of our industrial economy where your contribution adds enormous value.

Through your apprenticeship or learnership programme, you develop skills to read and interpret various electrical drawings and schedules. You learn to understand electrical codes, standards and specifications. You acquire the skills to select, install, wire and test many types of electrical equipment, from simple lighting to complex drive systems and automation products.

OUTLOOK

So as an industrial electrician, what are your prospects?

Well, your role as an electrician is essential in the construction industry and the manufacturing sector. Statistically, it has been proven that the manufacturing sector holds the most significant leverage for job creation. So, to address the challenges around unemployment, a much greater focus should be directed toward manufacturing.

Of course, the existing infrastructure, plants and equipment still need to be maintained, upgraded or replaced, and here also, industrial electricians play a crucial role.

In South Africa, our infrastructure is abysmal, so there are tremendous opportunities in areas such as renewable energy, typically solar and wind power generation.

In addition, water storage, pumping, and water treatment plants are typical examples of critically essential focus areas, which will generate stable employment opportunities in the manufacturing sector, and hence for electricians.

Acquiring as wide a range of skills as possible will create more opportunities for you in various industries.

EDUCATION

So, to become an industrial electrician, after completing your high school diploma, there are two main options for you to consider –

OPTION 1: is that of an artisan as we knew it some years ago, and this option still exists today and elsewhere in the world.

You would need a minimum of a matric certificate with maths and science and complete an official apprenticeship, after which you need to pass a formal trade test at an accredited testing facility. If the candidate has an N3 or higher qualification, they will pursue a national diploma in electrical engineering.

OPTION 2: The ARPL (artisan's recognition of prior learning) process is used to give credit to learners who have no formal qualifications but have the required work experience over several years, subject to compliance with the formalised qualifying criteria.

In this case, also, the candidate has to pass a formal trade test at an accredited testing facility. wn

M&C performs complex stator winding at Eskom's Drakensburg Hydro power station

Marthinusen & Coutts (M&C) performed a significant rewind last year after being contracted by leading international hydro generation OEM Voith Hydro of Germany to wind the stator of Unit 1 at Eskom's Drakensburg Hydro pump storage power station near Bergville in KwaZulu-Natal.

The massive stator winding contract, performed by an M&C winding team under the supervision of Voith, was the final stage in the refurbishment of three of the station's four M&C performs complex stator winding at Eskom's Drakensburg Hydro power station 250MW motor-generator units. Eskom engaged Voith to refurbish Unit 1.

Richard Botton, M&C's Divisional CEO, who project-managed the winding of the stator of the 281,5MVA reversible motor-generator, said: "We have worked with Voith over several years, during which time we have performed similar projects, such as a stator rewind at Eskom's Ingula pumped storage scheme, among others. These have stood us in good stead and almost certainly played a key role in Voith's decision to award us the contract for Unit 1."

The contract was due to have commenced early last year, but only got under way in late-August as a result of COVID-19 occurring and the subsequent strict lockdowns. "This left us with only three months to complete the rewind – half the original period allocated. We introduced two shifts per day with a 10-man team on each shift to ensure the work was completed on time," Richard explained.

The 6,5m diameter stator was wound in situ under Voith's supervision after removal of the rotor. Deploying a Voith-supplied winding kit, the winding teams were required to install a total of 720 heavy duty stator bars that had to be connected in an extremely complex bus arrangement. "Our teams had to undergo special training by Voith technicians beforehand before getting started on it," Richard pointed out. The contract was completed on schedule in mid-November last year. A further demonstration of the depth and variety of expertise M&C has on offer in its field came when M&C's Engineering & Technical Executive Rob Melaia recommissioned the unit.

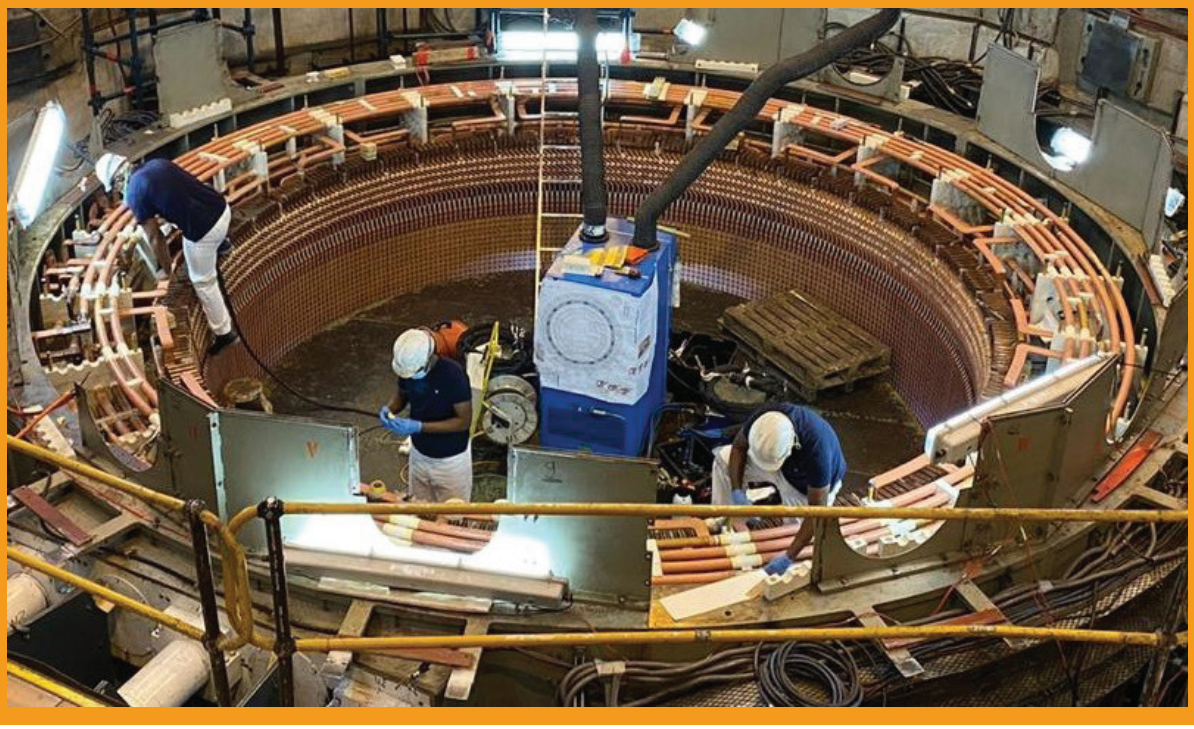
M&C'S ROB MELAIA STEPS IN TO RECOMMISSION UNIT 1 OF DRAKENSBERG HYDRO STATION

When it was brought to Voith's attention that the restrictions on travel between countries resulting from the COVID-19 pandemic prevented it from flying in one of its own senior engineers from Germany to recommission the unit, it asked Richard Botton, M&C's Divisional CEO, if M&C could assist.

He had no hesitation recommending Rob to perform the recommissioning, as Rob has previously commissioned other power plants as part of repair and refurbishment contracts M&C has undertaken. These included the N'zilo hydro station in Katanga province, DRC, in 2013 and the SA Bureau of Standards' National Electrical Test Facility's High Power test laboratory in Gauteng last year. Voith duly assigned the recommissioning to M&C after checking and approving Rob's credentials.

Then followed hours of conference calls between Rob in his office at M&C's main repair facility in Cleveland, Johannesburg, and senior technicians at Voith's head office in Heidenheim, Germany, who provided detailed instructions on the required procedures.

Rob successfully performed the recommissioning of Unit 1 over a period of five days in March this year. Commenting on it, he said: "By the time I got there I was thoroughly briefed about what I was required to do. The process was challenging and I had to give it all my attention. The one single thing that gave me the greatest



M&C technicians are seen working in the large area left inside the stator after removal of the rotor as they install some of several hundred stator bars as part of the complex stator winding operation.

confidence was knowing that M&C had done the winding of the stator; I wouldn't have felt so confident if anyone else had done it."

Richard commented: "It is a massive feather in our cap that M&C was able to offer to put the unit back into service. This is yet another set of skills we have in our division, further demonstrating M&C's ability to partner with international OEM's and proving that local competency is of a high standard." Mike Chamberlain, M&C's Marketing & Commercial Executive, commented: "In this contract M&C have again demonstrated their ability to rewind complex large machines, including complying with the OEM's stringent specifications. M&C also showed flexibility when encountering delays caused by circumstances outside their control by doing their utmost to ensure that the project was delivered on time." wn

ADVERTORIAL

Global Warming Effects set to increase Lightning Strikes

With global warming spiking to code-red status, lightning strikes will multiply at astounding rates, increasing the severity of one of nature's most deadly forces.

It is well known that an increase in lightning strikes has been noted throughout the Cape Peninsula area.

The map (figure 1) is the latest published and verified GFD (Ground Flash Density) of the Cape Peninsula and Cape Town area, in collaboration with the SAWS (South African Weather Services). The latest indication of lightning flashes is measured to be around 0.6 to 1.5 flashes per sq. km per year.

The GFD figures can be referenced in a risk assessment and protection level calculation as per SANS.

As a result, property and equipment damage is increasing due to inadequate or non-existent LIGHTNING PROTECTION.
The solution would be to install certified LPS (LIGHTNING PROTECTION SYSTEMS) in compliance with SANS codes which will act as the only reliable and consistent way of preventing lightning damage to personnel, structures and electronic equipment.

Please forward your enquiries to info@hhk.co.za
Johannesburg 011 476 6917
Cape Town 021 201 1559

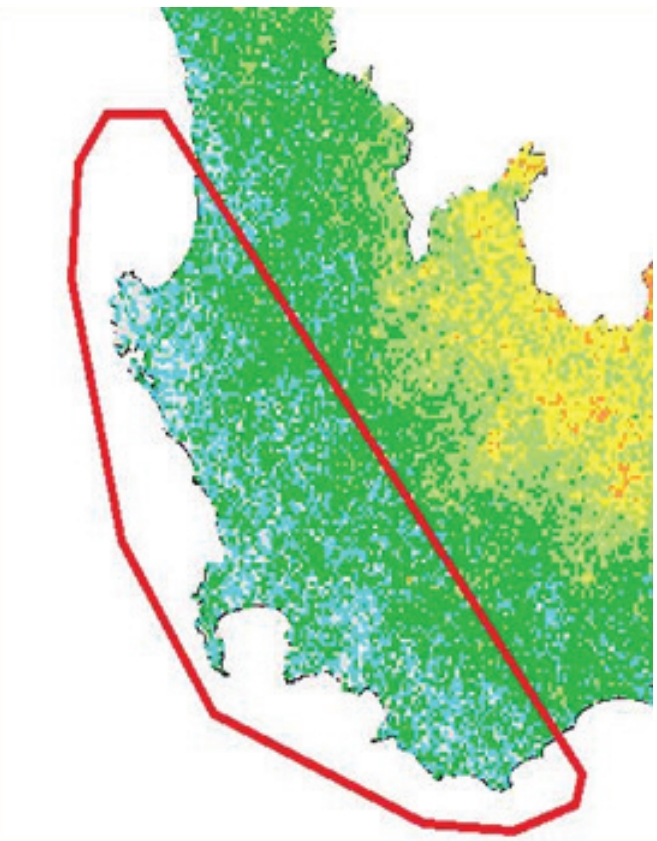


Figure 1

GLOBAL WARMING resulting in LIGHTNING CHANGE

NEW BRANCH OPENING IN CAPE TOWN

HHK Earthing and Lightning Protection Systems (Pty) Ltd is pleased to announce the opening of another new branch office in Cape Town (Bellville).

The new venture has been made possible by your immense support and continued interest in our business, as well as the latest verified Cape Provinces Ground Flash Density (GFD) made official by SAWS. The GFD around the Cape Peninsula range from 0.3 to 1 flash per sq km.

With the newly established branch office we will have an edge on our competitors and offer better quality service to the engineering and construction industry in this region. All work will be fully in compliance with the latest SANS and ELPA standards.

Our new premises is located at 1 Hibiscus Road, Ridgeworth, Bellville.

Contact for enquiries and queries, etc.:

Office Administrator	T: 021 201 1559	E: receptionCPT@hhk.co.za E: info@hhk.co.za

Contact for construction matters and queries, etc.:

Branch Administrator	Robyn Wood	E: coord2@hhk.co.za

Please contact us as it will be our pleasure to assist you with all your projects and will supply the same quality service our company has been known for so many years.

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Transportation in South Africa

- trains, buses, and taxis

Looking to ditch your car but don't feel like braving a minibus taxi? Public transportation in South Africa is improving all the time, with more bus and train options going into service with each passing year.

BY | ADAM NOWEK

Not every commute is easy to make by public transportation in South Africa, but it's certainly possible in many urban areas. Whether you're taking the train in Gauteng or the bus in Cape Town, there are plenty of options to get where you're going safely and efficiently. Here are a few key topics to start your trip, such as:

PUBLIC TRANSPORTATION IN SOUTH AFRICA

For many locals, driving in South Africa is the only realistic option for the daily commute. Although it's touted as the safe option, it isn't necessarily the safest choice for getting around. South Africa has long had one of the highest carjacking rates globally, a trend that shows no signs of slowing down.

What's the alternative, then? South Africa's Department of Transport oversees most transportation methods in the country, from trains to taxis. South Africa boasts Africa's busiest railway network. Many cities are rolling out bus rapid transit routes to improve travel times and safety levels (and for those that don't mind a reckless bus driver, minibus taxis are also everywhere).

Metered taxis and ride-hailing apps are also popular options in urban areas, particularly after sunset.

PUBLIC TRANSPORTATION APPS IN SOUTH AFRICA

Unfortunately, official websites and apps for many of the public transportation options in South Africa are limited, outdated, or even nonexistent. In addition, some official apps are poorly built and have low ratings. There are a few of the alternative options for planning your next trip or daily commute, including the following:

- Travelling on any of the Metrorail networks? Forget the official website (which never updates) and their social media accounts (which post about every train departure): GoMetro has a comprehensive app.
- Living in Ekurhuleni, Johannesburg, or Pretoria? GauRider is a simple, Gauteng-focussed app for looking up departure times, planning itineraries, as well as tracking the credit on your Gautrain Card. The app works both for Gautrain's commuter rail network as well as their bus routes. GauRider is available for iOS.
- Moving Gauteng also provides route information, departure boards, and itinerary planners for various public transportation services throughout Gauteng, including A Re Yeng, Gautrain, Harambee, Metrobus, Metrorail, Rea Vaya, and Tshwane Bus Services.
- Taking the bus in Cape Town? MyCiTi, Cape Town's local bus company, has a mobile app for planning routes, calculating bus fares, and topping up the balance on your myconnect Card. The MyCiTi app is available for Android as well as iOS.

TRAINS IN SOUTH AFRICA

South Africa is home to 23,193 kilometres of railway tracks that carry 530 million passengers per year, the largest and busiest network in Africa. Most rail passengers in South Africa travel on one of the five commuter rail networks.

- Metrorail Western Cape train in Glencairn
- A Metrorail Western Cape train in Glencairn

- The Passenger Rail Agency of South Africa (PRASA) owns and operates almost all passenger rail services.

PRASA itself has three divisions for rail services in South Africa:

- Metrorail: commuter rail services
- Shosholoza Meyl: intercity services connecting every province in South Africa
- Premier Classe: an affordable luxury train running between Cape Town, Johannesburg, and Durban

PRASA also owns and operates train stations in South Africa through its' own property management arm, PRASA Cres.

The four Metrorail networks are commuter rail, connecting suburban areas with urban centres. Metrorail's networks are:

- Eastern Cape (iMpuma-Koloni in Xhosa): two separate lines. One connects Port Elizabeth with Uitenhage, and the other connects East London with Berlin.
- Gauteng (eGoli in Zulu): extensive network connecting cities throughout Gauteng, including Germiston, Johannesburg, Pretoria, Sebokeng, Soweto, and Springs.
- KwaZulu-Natal (iKwaZulu-Natali in Zulu): seven-line network connecting Cato Ridge, Durban, Kelso, kwaMashu, Pinetown, Stanger, and Umlazi.
- Western Cape (Wes-Kaap in Afrikaans): four lines centered on Cape Town. Destinations include Bellville, Malmesbury, Paarl, Simon's Town, Stellenbosch, and Wellington.

Gauteng is also home to one private commuter rail service. The Gautrain has three lines connecting Ekurhuleni, Johannesburg, Pretoria, and Johannesburg's O. R. Tambo International Airport.

Shosholoza Meyl runs long-distance intercity services. In general, most routes radiate from Johannesburg. Major destinations for Shosholoza Meyl trains include Cape Town, Durban, East London, Komatipoort, Musina, and Port Elizabeth.

South Africa is also home to one luxury route between Cape Town and Pretoria: The Blue Train.

TRAIN TICKETS AND COSTS IN SOUTH AFRICA

The operator sets Fares for train journeys. For commuter rail, fares are generally based upon the distance travelled. Up-to-date fare information isn't available from Metrorail, however. Expect the following ticket prices (Metrorail prices are according to GoMetro) for standard second-class travel:

GAUTRAIN

- Single (off-peak hours): R23–200
- Single (peak hours): R29–200
- Weekly: R269–787
- Monthly: R1,085–3,179

METRORAIL EASTERN CAPE

- Single: R7–8
- Weekly: R44–54
- Monthly: R133–173

METRORAIL GAUTENG

- Single: R7.50–12.50
- Return: R14.50–24.50
- Weekly: R46–80
- Monthly: R142–252

METRORAIL KWAZULU-NATAL

- Single: R6.50–12
- Weekly: R41–78
- Monthly: R123–242

METRORAIL WESTERN CAPE

- Single: R7.50–18
- Weekly: R47–115
- Monthly: R140–360

There are also first-class carriages available on Metrorail trains, referred to as MetroPlus.

Metrorail publishes their fares for all networks and lines on their website. However, they're notorious for not publishing any service information online for years at a time. If you rely on Metrorail for your daily commute, consult a more reliable source of information such as Moving Gauteng, Cape Town Train Times, or GoMetro.However, as with Metrorail, Shosholoza Meyl rarely updates its website, which is often not online. Try contacting Shosholoza Meyl directly by calling their reservations office directly at 086000 8888.

INTERNATIONAL TRAINS IN SOUTH AFRICA

There are currently no scheduled international train services linking South Africa with any of its' neighbours. Travel between South Africa and a neighbouring country is only possible by road (either by car or bus) or by air.

Freight rail links exist between South Africa and Botswana, Lesotho, Namibia, Swaziland, Zimbabwe (as well as Mozambique shortly); however, there is no indication that these will expand for passenger rail services any time soon.

BUSES IN SOUTH AFRICA

There is no one singular entity providing bus service across South African cities; each municipality generally has its' own bus company or companies, depending on the size of the city. Many of South Africa's bus companies are municipally-run, while others are private. wn

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State of Affairs of South African Railways

Rail freight transportation is a method of transporting goods and commodities from one place to another through wheeled vehicles (rolling stock) along directionally guided railway tracks.

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It is the safe and cost-effective mode of transport essential for moving freight over short and long distances in inter-city and urban settings [1, 2]. It also features as the main component in the supply chain and logistics systems that enables the trade between regional, cross-countries and inter-continents [1, 3]. The trading contributes to the nation's economic competitiveness and stability within South Africa, with the SADC region, and the rest of the continents [4].

However, the potential of rail freight transport contribution to economic progress is realisable under the right operational circumstances. That is when the services are more organised, specific, regular, and efficient [1]. Unfortunately, the shortfall in these requirements has undermined the potential of rail freight transport. As a result, the dependence on rail transportation has been declining in the recent past. The unavailability and unreliability of train operations amongst the lack of infrastructure maintenance and expansion have been the main contributing factors for customer dissatisfaction [2, 5].

The former issues [unavailability and unreliability] have been associable with increased copper cable theft and vandalism, which have severely impeded the rail operations. In South Africa, these incidents have surged exponentially to over 150% in the last five years, especially during the pandemic [6]. Concurrently, the lack of investment towards the infrastructure upgrades that would help increase the capacity and curb the incidents has contributed to the underperformance. Thus, solution development is needed to address this crisis. While pursuing the reinstating the railway networks to their optimal operation conditions, it remains pivotal for the rail operators to reduce their energy consumptions and greenhouse emission gases – strategic endeavours to achieve the sustainability goals [3].

This article forms part of a series of case studies written by the Energy Efficiency Study Committee, part of the SAIEE's Railway Chapter. The study committee was tasked to investigate railway energy and operational efficiency in the South African context. The article addresses and quantifies the impact of

electrical infrastructure incidents that affect railway operations, evaluates the option of de-electrifying some rail lines faced with frequent cable theft issues. Lastly, it assesses the readiness of the South African Railway Industry for the Energy Storage Systems adaptation into the electric networks and diesel-electric fleet. Further details of these research areas will be shared in the respective sections overleaf.

CASE 1: THE IMPACT OF THEFT AND VANDALISM ON THE OPERATIONAL EFFICIENCY OF SOUTH AFRICAN RAILWAYS:

The decision to transition from steam locomotives to electric locomotives to haul freight was proposed in the early 1900s to reduce the cost of transportation and to increase the tonnages hauled. Over the years, several factors encouraged the expansion and modification of electrification across the country. The infrastructure maintenance requirements have also increased to accommodate heavier loads, frequent trains, and more stringent regulations. On the flip side, these expansions birthed a rise in theft and vandalism of the railway infrastructure, which is now hampering railway operations.

IMPACT OF THEFT AND VANDALISM ON ELECTRIC RAILWAYS:

The electric traction system comprises overhead track equipment, substations, tie stations, track sectioning stations, and track feeder stations. This equipment is made of different materials, including copper, aluminium, and steel, and poor infrastructure protection attracts criminal elements to these materials. Moreover, the theft and vandalism of railway infrastructure are fuelled by the increase in scrap metal prices over the last couple of years. European railway operators are also affected by theft and vandalism of copper cables [7], and detection methods have been implemented, such as infra-red sweep using helicopters [8] to detect activities outside urban areas. With various reports indicating the price of copper to increase to between $15,000 and $20,000 per ton in the next four years, the local demand for scrap copper is unlikely to lessen soon.

Theft of traction substation equipment does not severely affect the train

services because adjacent substations can be used to feed the affected section, whereby the Train loading in the section must be reduced to prevent overloading of the substations. However, when the overhead track equipment is stolen or vandalised, the impact on the train service is severe since there is no redundancy in the system. The track may be constructed as a single or double track. Incidents in a single-track section result in complete closure of the line for repairs to be conducted, whereas incidents on a double section may result in a bottleneck. At the same time, trains traverse on the unaffected line. When an unfortunate electric train is operated into a section with stolen overhead wires, the consequences are devastating to the railway operations. The train can be involved in a pantograph hook-up/dewirement, which means the locomotive's pantograph would be entangled with the overhead wires. There is a resultant impact on the overhead equipment, rolling stock, business reputational and customer confidence. The operational efficiency of electric traction systems is heavily affected by the theft and vandalism incidents plaguing the railways. Figure 1 shows a railway station affected by incidents of theft and vandalism.

Figure 1: The Impact of theft and vandalism [9].

It is estimated that constructing the overhead track equipment is about R3 million per km. The traction substation is about R10 million per unit; consequently, the capital cost required to construct a section of electrified railway is significant. A theft incident resulting in a pantograph hook-up damage of 500 m can result in a six-hour line closure for repairs. The cost of infrastructure equipment and rolling stock damage can be over R500,000.00 per incident. The International Union of Railways' 2013 security report stated the theft problem in Europe affects substation, signalling and telecommunications cables and scrap rails and has resulted in millions of euros in lost revenue [10]. In the South African railway industry, over 5000 railway theft and vandalism incidents were reported by a rail operator between 2019 and 2020 with lost cable of more than 350 km [11]. The railway incidents resulting from theft disrupt the value chain between departure and destination points and causes train delays and cancellations. The Non-Ferrous Metal Crime Combating Committee chaired by the South African Police Services has to multiply its efforts to rein in the theft and vandalism incidents and the subsequent illegal re-selling of scrap non-ferrous metals, which costs the South African economy billions per annum. Theft and vandalism incidents cause low operational efficiency of electric railways locally and globally.

The damage caused by the theft of railway cables has a significant impact on the operational efficiency of electric railways. The increase in metal prices has also driven the theft to occur on a massive scale. Therefore, a multipronged approach that includes law enforcement, legislation, intelligence, technology, and operators are required to deal with the scourge effectively and face the challenge head-on. Some short-term options that can be considered include de-coppering the railway lines and using diesel traction technology. It is noted, however, that criminal elements also target rails. The subsequent case study investigates the life cycle cost assessment of electric and diesel traction technologies.

CASE 2: IS DE-ELECTRIFYING THE INFRASTRUCTURE THE SOLUTION?

The findings from the case study titled "Impact of theft and vandalism on the operational efficiency of South African Railways" outline the impacts of railway cable theft on railways' operational efficiency. This gives rise to the opportunity to explore the possibility of de-electrifying the infrastructure as a possible solution to the challenges outlined in case study 1. This article explores the possibility of de-electrifying the rail infrastructure through a comparative study on the life cycle costs of both diesel and electric rolling stock.

According to [12], the life cycle cost of an asset is defined as "..the sum

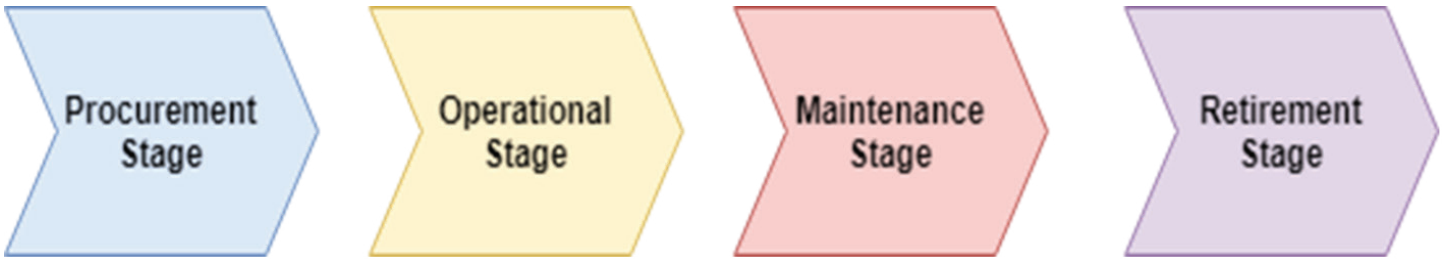

Figure 2: Life Cycle of Rolling Stock Assets

of all the funds expended in support of the item from its conception and fabrication through its operation to the end of its useful life." The life cycle cost analysis theory gives a holistic view of the costs incurred during the life cycle of the rolling stock assets.

METHODOLOGY:

The analysis conducted in this comparative study is based on data sourced primarily from a prominent South African Railway company. However, there are some limitations with the data used in the analysis. The maintenance cost data spans from 2011 to 2020, and thus the cost of the maintenance for the remaining years of the life cycle of the rolling stock is forecasted. Furthermore, the traction energy cost data was not available at the time the article was compiled. An assumption is made that both diesel and electric locomotives have a lifespan of 30 years.

LIFE CYCLE COSTING MODEL: DIESEL VS ELECTRICAL ROLLING STOCK:

This article adopts the mathematical model proposed in [13] to compare the life cycle cost of diesel and electrical rolling stock. The life cycle costing model documented in [13] consists of the stages shown in figure 2, in line with the international standard for life cycle costing IEC 60300-3-3.

PROCUREMENT STAGE:

The procurement stage is associated with the initial investment or purchase costs. The purchase cost is obtained by averaging the cost of each of the locomotives in their respective fleets. The average initial investment or purchase cost of the electric and diesel locomotive were found to be R40 million and R38 million, respectively. Therefore, the electric locomotive has a slightly higher average purchase cost compared to the diesel locomotive. However, as shown in figure 2, the life cycle of the rolling stock assets consists of other stages, with each stage having a cost associated with it. These costs are discussed below.

OPERATIONAL STAGE:

The daily operational costs required to operate assets such as rolling stock form part of their life cycle cost, and the operational costs consist of the traction energy costs. However, as aforementioned, the traction energy cost data was unavailable and thus neglected in this analysis.

MAINTENANCE STAGE:

The primary objective of the maintenance intervention is to sustain and maintain the rolling stock assets over their life cycle. Maintenance costs include costs for direct labour and materials/spares used in the maintenance process. The maintenance costs contribute significantly towards the total life cycle cost of the rolling stock assets. The total maintenance costs for the electric and diesel locomotive over an assumed life cycle length of 30 years are found to be R81 million and R132 million, respectively. The diesel locomotive maintenance costs are higher compared to the electric locomotive. This observation is cemented by the plot of the observed maintenance costs from 2011 to 2020 in figure 3 (next page).

As observed in the blue bar chart, generally, the maintenance costs for the diesel locomotive are higher for both Opex (light repairs or minor service) and Copex interventions (primary services including component overhaul or refurbishments).

RETIREMENT STAGE:

Upon reaching the end of its useful life, the rolling stock spare parts can be of value through their disposal. This value is called the salvage value and can be defined as the resale value of the rolling stock asset at the end of its useful life. The salvage value for the electric and diesel locomotives are found to be R4 million and R3.8 million, respectively.

TOTAL LIFE CYCLE COSTS:

It is essential to consider the time value of money; therefore, as mentioned in [13], [14] and [15], since life cycle costing considers costs that will be incurred in the future, it is essential to discount or escalate these costs to a particular decision point to ensure comparability. A discount rate of 10% was used in the computations. The total life cycle cost for a single unit of an electric and a diesel locomotive

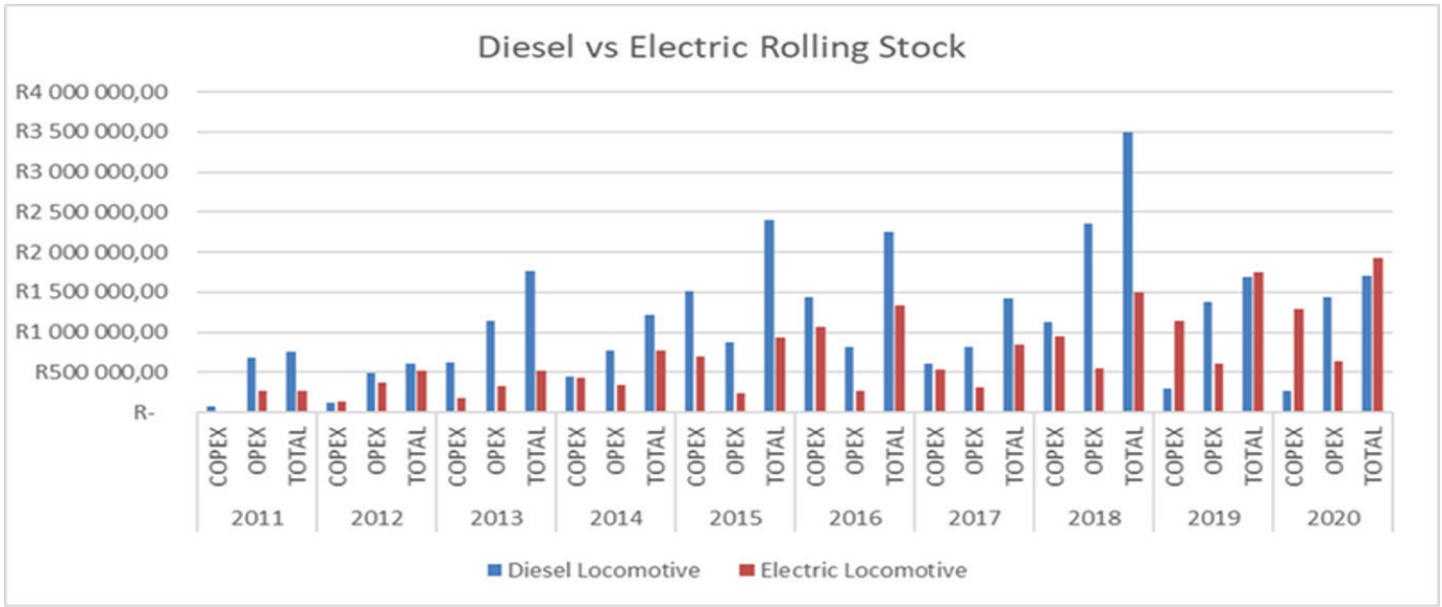

Figure 3: Actual maintenance costs collected from 2011-2020

is found to be R117 million and R166 million, respectively. A diesel locomotive's total life cycle cost is much higher than an electric one by a difference of about R52 million.

The results from the comparative study show that the diesel locomotive has a much higher life cycle cost than the electric locomotive. However, it is essential to note that these calculations neglected the traction energy costs since the data was not available. This could potentially tip the scales in favour of diesel locomotives in terms of life cycle costs. Therefore, based on the results of this study, de-electrifying the entire rail infrastructure may not be a feasible option. However, further studies are recommended to investigate the traction energy costs for diesel and electric rolling stock.

CASE 3: IMPROVING ENERGY EFFICIENCY IN SUPPORT OF THE SOUTH AFRICAN RAILWAY OPERATIONS:

In response to the issue of theft and vandalism, the case study above concluded that de-electrifying the entire rail infrastructure may not be a feasible option. Therefore, in support of the electrification of railway systems, this case study discusses ways in which energy demand can be reduced in the South African rail industry by absorbing regenerative braking energy using energy storage systems (ESS).

Most of the locomotives used in South Africa have regenerative braking capabilities. In a regenerative braking system, the kinetic energy is converted to electric energy by the 3-phase traction motor, which acts as a generator when the train decelerates [20, 21]. In a rheostatic braking system, however, the energy is dissipated as heat in braking resistors. The regenerated energy can either be fed back to the grid, stored through ESS (such as supercapacitors, batteries, flywheels, etc.) for later use or used by other trains in the powering mode on the same section of track.

The use of ESS could reduce carbon emissions, energy consumption and, therefore, significant cost savings. The regenerated power cannot all be stored because of limiting factors such as the voltage at the contact wire, location, traffic density, train power profiles, electric network configuration, rolling stock, track profile and length of feed sections, and train auxiliary power [20].

Wayside and onboard storage are the two options in which regenerated energy can be stored [21]. With onboard storage, the regenerated energy is stored onboard the train. Because it is positioned closer to the source of regenerative power, they offer lower transmission losses. The disadvantage of these systems is that they increase train mass/weight and limit the storage facility's size due to space availability on the locomotive.

The energy can also be transferred to a stationary energy storage facility called the wayside energy storage system. With the use of wayside ESS, there is no restriction or constraints regarding the device's size, allowing one to freely design based on the demand [21]. It is, however, essential to find a suitable location for these storages based on topography and locomotive traffic patterns because when the train brakes far away from the storage location, regenerative power loss in

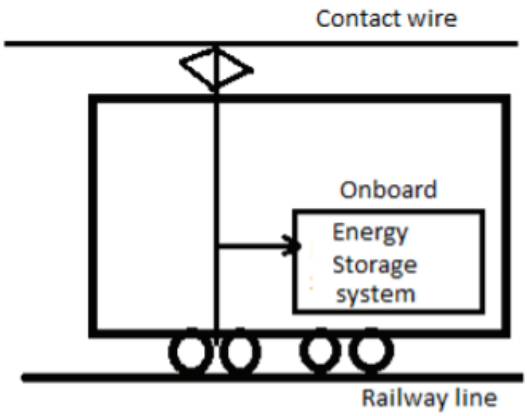

Figure 4a: Illustration of onboard ESS

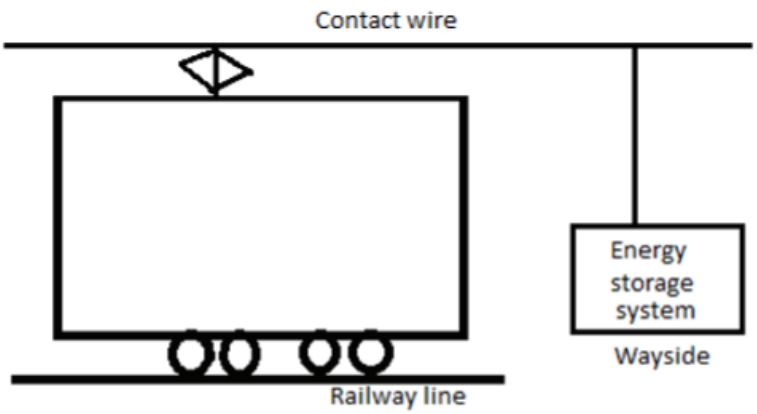

Figure 4b: Illustration of Wayside ESS

the transmission line is higher.
The two regenerative storage options are illustrated in Figure 4.

Reducing electricity consumption goes hand in hand with a reduced carbon footprint but is an additional regulatory advantage that can lead to additional cost savings. The carbon tax is in response to climate change, aiming to reduce greenhouse gas emissions in a sustainable, cost-effective and affordable manner. It came into effect on the 1st of June 2019 in South Africa.

The proposed tax is R120 per tonne of CO_2 equivalent emissions. This rate will increase annually by inflation plus 2 per cent until 2022 and annually by inflation thereafter [22]. The South African railway industry consumes large amounts of energy which will be subjected to the carbon tax, be it direct carbon tax by the use of fossil fuels or indirect carbon tax by the use of electricity. This carbon tax will affect future operating costs.

South African rail network currently uses 3kV DC, 25kV AC and 50kV AC. With ESS on these lines, approximately 25% of the consumed energy could potentially be regenerated. Even though savings would be realised with the installation of the ESS, specific considerations need to be made before investment. The cost of installation on the AC and DC lines costs billions of rands [23]. The payback period is also longer as it would take approximately 15 years and 25 years for the AC and DC line, respectively. In diesel trains, approximately 40% of energy from the locomotives is wasted in the form of heat. Energy efficiency improvement is therefore necessary due to high fuel prices in South Africa. Based on studies conducted, the ESS can save about 15% of these wasted energies with a payback period of fewer than three years. However, the tender car solution would be more practical if there were space constraints [24].

It can be concluded that the use of ESS assists in reducing energy consumption and carbon emissions. The onboard storage is generally efficient; the wayside might have additional losses, and feeding back into the grid would be more complex. Considering the costs of investment and maintenance, the use of ESS in the South African railway industry may not be a financially viable solution currently due to more extended payback periods and space constraints on the existing locomotives.

SUMMARY CONCLUSIONS:

Theft and vandalism of electrical assets in South Africa have reduced economic activity and cost billions of Rands.

Many have felt the impact, including commuters and businesses. Measures are being undertaken to reduce the amount of copper in the equipment provided it is technically and practically feasible to minimise the incidents.

Theft incidents affect the operational efficiency of electric railways; this may be in the form of disruptions to the power supply of locomotives or delays in trains due to theft of signalling and telecommunication cables. Solutions are required, which will ensure that businesses can deliver on their targets and bring value to the shareholders. Using diesel traction is a possible solution to minimise disruptions.

However, the financial impact of completely switching to diesel traction is that the operational budget would increase as the life-cycle costs of diesel locomotives are higher than those of electric locomotives. At least twice as many diesel locomotives would be required to replace the electric locomotives.

The impact of emissions from diesel combustion engines on the environment would increase significantly, and the carbon tax. Some railway operators globally are considering migrating completely from diesel locomotives to reduce emissions. Utilising diesel traction systems as the only traction technology poses some drawbacks to the potential benefits derived from the regenerative braking capability of locomotives. It is noted that the investment required for energy storage systems in diesel traction is lower with a shorter payback period; however, the potential energy savings are higher in electric traction.

The Study Committee intends to continue with focus areas to include key performance indicators of the traction locomotives and energy storage systems, routes that can benefit from the energy storage systems, and technological innovations that can be implemented to detect and deter theft and vandalism incidents. wn

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Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities:

Lessons from Johannesburg, South Africa

There have been growing concerns about the state public transportation systems, particularly in the cities of developing countries. Chief among these concerns has been the lack of well-coordinated, efficient, and reliable transportation systems. The city of Johannesburg, just like any other fast-growing municipality in developing and emerging economies, has not been spared concerning ongoing public transport challenges. Consequently, there have been collective efforts from public and private stakeholders to invest immensely in innovative rail and road transport systems in the past decade.

BY | TRYNOS GUMBO & THEMBANI MOYO

This article sought to achieve twin objectives. First, the work identified the state of connectivity between the rapid rail transportation and rapid bus transit systems based on Geoweb 2.0 data. Second, the work visualised the connectivity between these two modes to develop and formulate policy frameworks in integrating public transit systems in cities of the developing world, learning from the metropolitan city of Johannesburg. A mixed-method approach consisting of spatial and quantitative aspects was used to examine the state of connectedness and the promotion of access and mobility between the two modes. The local Moran's I index was used to compute node clusters within the public transport system. The analysis demonstrated that both high-clusters and low-clusters exist in the public transportation network, which has a high degree of centrality. It was revealed that commuters navigate from these nodes/stops with relative ease due to the short walking radius. However, the work revealed that most rail networks and bus routes, as well as the stations and bus stops, are not connected and are not significant in the local Moran's I index, thus, making it difficult for commuters to move from the Gautrain to the Rea Vaya bus conveniently. There are, therefore, gaps with regards to the sharing of infrastructure between the two public transport modes and systems.

1. INTRODUCTION

Over the years, public transportation has been seen as a service that should prioritise accessibility in a package of flexible travel modes for various users [1,2]. Contemporarily, there have been growing concerns about the state of public transportation systems, particularly in cities in developing countries [3–5]. Most commuters characterise traditional public transportation in developing

cities as unreliable and not spatially integrated, mainly due to hindrances, such as overcrowding and lack of connectivity between the various modes [6,7]. Given the design of the traditional public transportation system of fixed routes, which does not always cover the entire urban area, there is a need to assess the robustness of such systems [8].

Unpacking the existing spatial relationships in such complex networks will inform public transportation operators and urban planners to identify influential nodes and allocate funds to upgrade such nodes. Navarrete and de Dios Ortúzar [9] have articulated how the identification of influential nodes would lead to improved connectivity in public transportation systems, which, in turn, would lead to a sustainable urban public transportation system.

Poorly connected transportation systems negatively impact commuting trips, as they have longer travel times, which delays the destination arrival. Zhu et al. [10] assessed connections between nodes; their results revealed that measuring the identifying connectivity patterns in public transportation systems had significant policy implications and can inform future infrastructural expansions. Castanho et al. [11] evaluated connectivity with movement between cities. Their results revealed that identifying important nodes has led to previous locations in the core-periphery becoming more accessible. Creating a sustainable transportation system requires individuals and stakeholders to be socially included in the developmental process [12]. In the Gauteng province, South Africa, the Metro Railway has been the traditional railway line responsible for transportation commuters regionally and nationally. In 2010, a modern train was developed to transport commuters across three metropolitan cities. Since its inception, the Gautrain has been identified as the backbone of the future public transport system in the province [13]. The Gautrain railway tracks have a spatial coverage of 80 km, with top speeds of 160 km/h. Due to an increase in travel speeds from the traditional Metro Railway, which averages 90 km/h, the Gautrain has been coined a rapid transit system. It is currently the second-fastest train in Africa, similar to the Coradia Algiers Oran Express Train in Algeria.

Currently, there are ten operational stations across three metropolitan cities in the Gauteng province. However, the railway network is not currently integrated into other public transportation systems in the province. Mishra et al. [8] have outlined the merits of a multi-modal transportation system over singular networks. The use of a multi-modal transportation system has positively affected urban development and spurred new economic activities along with transportation nodes.

In this paper, we propose examining the benefits of developing integration of services offered by the Gautrain, Gaubus (a rapid bus transportation service offered by the Gautrain) and Rea Vaya (a rapid bus transportation).

In theory, this should enhance the commuting experience. The paper is organised as follows. In Section 1, we present the status quo and show how it relates to the addressed problem. In Section 2, we outline the methodology, while in Section 3, we present the findings of the study; in Section 4, we discuss the findings in detail while at the same time outlining the implications of planning. Lastly, in Section 5, we present recommendations of the study and conclude from the results.

1.1. RELATED WORK

In transportation planning, connectivity-related literature typically focuses on the key themes, such as accessibility, infrastructural development collaboration, and policy initiatives that encourage inter-modality [14].

Despite significant research on intermobility [15–17] and public transportation connectivity [18–20], few studies have focused on connectivity between rapid rail and bus transit systems in developing countries. Literature has shown that the connectivity of people, services, information, places, and infrastructure can contribute to urban areas' regeneration and developmental pursuits [21–23]. For example, the development of a high-speed railway train station, such as Gautrain in South Africa, has led to an appraisal of the property value of properties surrounding the train stations [24]. This also resonates with a study by Emeric and Newman [22], which reveals that locations within proximity to transportation hubs have a more well-developed space.

Ho et al. [25] have articulated how previous studies of transportation nodes assume that all nodes are distributed homogeneously. In assessing node connectivity, it is essential to take note of the influence of activities in the surrounding environment [26,27].

To examine the importance of connectivity on the distribution of transportation nodes in urban areas, there is a need for innovative means to identify spatial locations that will influence commuting trends. Urban planners and researchers are increasingly developing new models and frameworks to enhance transportation networks, emphasising the interconnectivity of services

[28,29]. Generally, commuters can be referred to as active agents in the mobility system, as they are a potential source for change in shifting transit-share.

Furthermore, enhancing connectivity between public transportation services and infrastructure can lead to the hedonic of placemaking. Through weighting links between nodes, we can identify influential nodes along with a public transportation system. Consequently, a sustainable-oriented mobility system should take an active role in creating a system that allows for seamless transfer between various public transportation systems.

To assess the connectivity of transportation networks, several scholars have investigated the factors of service quality, such as proximity [21], travel time, waiting time, the number of destinations served, and the number of transfers required to complete trips. The commuter's mode choice is usually influenced by the ability of a mode to connect them between their homes, workplaces, or recreational locations—also known as places of interest. Accordingly, accessibility can then be translated to the distance between commuter points of interest and the public transportation nodes/stops [30]. Given how the spatial network of a multi-modal transportation system has numerous stops, these can also create a mobility hub that serves multiple transportation networks.

Previous studies have developed models and indicators to assess the level of connectivity, such as using node measure indicators [31,32]. Centrality measures were initially developed to assess connectivity in social networks [33]. Over the years, applications of centrality have been used to understand other forms of networks. Curado et al. [34] used centrality measures to understand the diversity of relationships that influence tourism trends in urban networks. Findings from the analysis revealed that urban planners could use centrality measures to rigorously evaluate the urban spatial networks, as nodes can be ranged by their level of importance to surrounding nodes, such as assessed land value based on the centrality of nodes. Locations with high order nodes would attract higher rental fees and more commuting trips towards them. Whilst centrality regarding tourism data would mean locations with high order, nodes would attract the most tourists, and their accessibility should be prioritised for developmental projects. The number and diversity of relationships between spaces, information, and social processes endow the city with a complex system. One way of dealing with the complexity of the city is through networks since they capture the relationships (edges) between objects. By measuring the closeness and centrality of the system, we can identify influential nodes along with a public transportation system and, in turn, inform policies regarding the expansion of the systems. This is in line with national policies, which seek to establish an environmentally friendly transport system. There are efforts to achieve integrated intermodal coordinating structures and promote seamless intermodal services [35,36].

1.2. GEOWEB 2.0

The growth in Web 2.0 data with geographical information in this paper has led to rapid growth in a social network pattern analysis [37]. Derudder and Taylor [38] undertook a study to determine the comparative connectivity in the world-city network. The study explored the position of an "interlocking network model" in city developments. Their research revealed inter-urban flows that rely on location, social interaction, and economic activities. Drawing from the results, city developments can be understood by representing them "on and off the map" to their specific interlocking with the global economy [37,38]. Regarding public transportation connectivity, a station or stop's connectivity would be influenced by the geolocation of the station or stop, commuter social interactions, and, finally, the land use in the surrounding environment.

Cheng et al. [39] demonstrated how human mobility could be understood using spatial-temporal and social data from location-sharing services. Check-in data was collected from Facebook Places, Foursquare, and Gowalla to investigate factors that influence human mobility.

From their findings, through the comparison of population density and income density, we learned that people in the densest areas travel more than people in sparse areas, whilst those located in the sparsest areas travel farther than people in slightly denser areas [39]. A possible explanation for this phenomenon could be the variations in connectivity levels within the study area. Connectivity, hence, is related to service accessibility [40].

Hollenstein and Purves [41] also used Web 2.0 data in their research to delineate the core of a city. The study involved analysing Flickr data—that is, picture tags that contained the following categories: "Downtown"; "City Centre"; central business district "CBD." Analogous to preceding research, Thurstain-Goodwin and Unwin [42] used the kernel density estimation technique to convert the geotagged pictures to spatial points to map out the city core. This technique

of using Web 2.0 was consequently adopted in the current study, as geotagged data from social media was used to map and create a continuous spatial density to show connectivity variations in the city. The article, consequently, seeks to unpack how mobility can be improved in the city by visualising the points of interest of public transport commuters and using these locations as a starting point to promote connectivity in the urban transit system.

The granularity of Web 2.0 data has many merits to unpacking mobility research. The digital footprint left by users allows researchers to quantify the socio-economic groups of users. Common limitations of Web 2.0 include the data internet connectivity issues and the missing geographic coordinates of data. Users may also opt to switch off their mobile data. Furthermore, in developing countries, such as South Africa, mobile data costs are high, limiting the frequency of commuters utilising social media platforms. Figure 1 reveals the distribution of social media users in South Africa as of January 2020 by age group and gender. To assess connectivity for public transportation, we draw from previous studies on the statistics of how communities have embraced the use of social media in their daily lives [39,43–46].

A public transportation system, such as the Gautrain and Rea Vaya, has commuters from all income groups, biased to the middle-income group. Given the socio-economic dynamics of the commuters of these two systems [24], Web 2.0 data will capture commuters who are in the 18 to 44 age groups.

2. MATERIALS AND METHODS

This section presents the step-by-step approach on how the technical architecture of collecting and analysing GeoWeb 2.0 (see Table 1) and public transportation network data was undertaken. Social media posts from Facebook and Twitter with geolocations were collected from January to June 2019, with the Gautrain and Gaubus having 6548 posts and the Reva Vaya 2383 posts.

We then performed a geographical analysis and a connectivity analysis. The flowchart summarises the data analysis process (see Figure 2).

- **Step 1:** Data from public transportation providers were collected in shapefile format (point data proximity analysis was conducted. All bus stops within a 50-metre radius from each

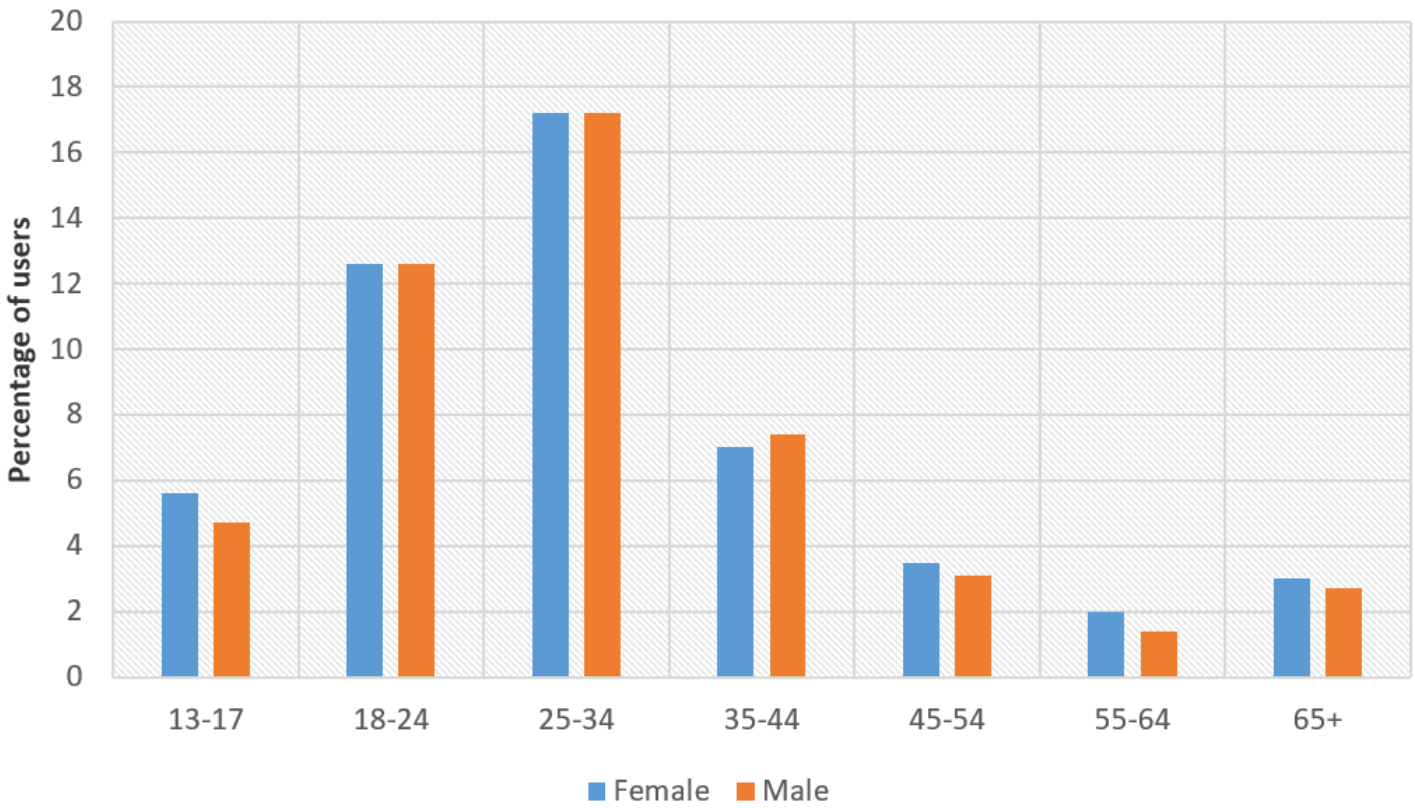


Figure 1: Distribution of social media users in South Africa.

Column ID	Column Name	Unit	Interpretation
1	Lat	Degree	Latitude reference of GeoWeb 2.0
2	Lon	Degree	Longitude reference of GeoWeb 2.0
3	Message		Information conveyed in social media post
4	Location		Suburb or city post was made from
5	Source	T or F	Social media platform Twitter (T) or Facebook (F)
6	Date	YYYYMMDD	The day of the month or year
7	Time	HMS	Time of day

Table 1. GeoWeb 2.0 dataset

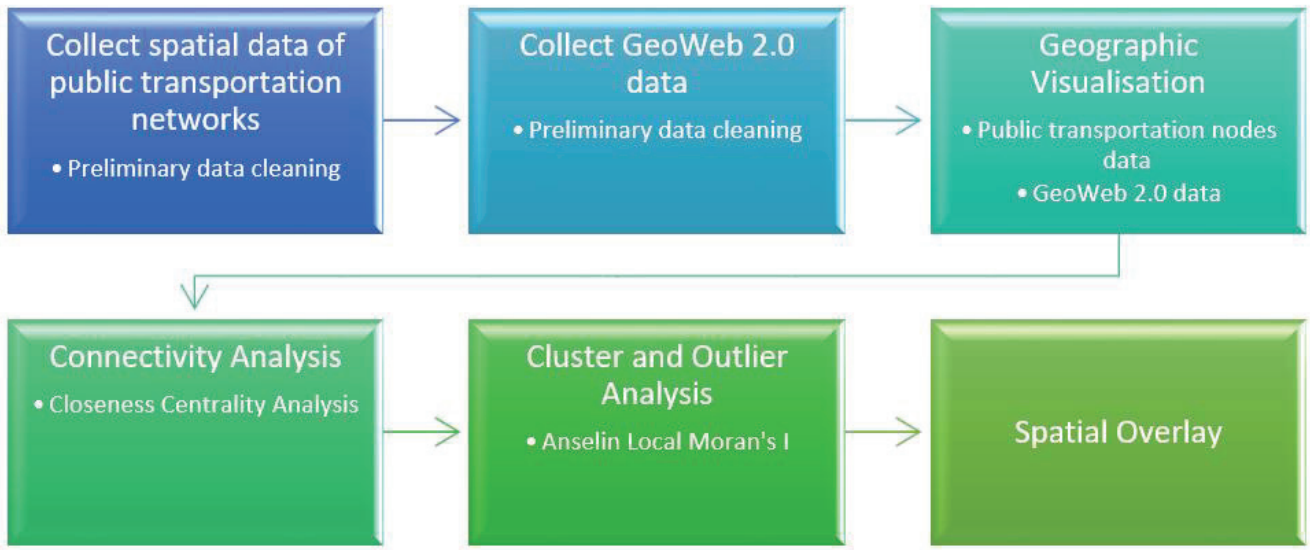


Figure 2. Flowchart of the proposed method.

other were active. The public transportation system in the city is comprised of a mix of motorised and non-regarded as a single node. These data are currently not open source but available on request from the public transportation providers.

- **Step 2:** GeoWeb 2.0 data were collected, and posts were filtered to retain only the posts with the keywords "Gaubus", "Rea Vaya", and "Gautrain".
- **Step 3:** Spatial visualisation: new public transportation node data and GeoWeb 2.0 data were loaded on ArcGis Pro software.
- **Step 4:** The connectivity analysis was computed using the centrality extension in Matlab.

Defined by $d(i,j)$, the distance between vertices i and j and the closeness of a bus stop i were computed as

$$C_c(i) = \frac{n-1}{\sum_{j \in \subseteq} d(i,j)},$$

with n being the number of buses stops in the public transportation network. In this work, the distance was computed according to the Euclidean distance between bus stops. It should be noted that though it was highly efficient in determining the influential bus stops, the closeness centrality due to the computational complexity involved in the calculations was not easily applicable in large-scale networks [47].

- **Step 5:** A local Moran's I analysis [48] was developed using the centrality indicator, and a heatmap was created for the spatial concentration distribution of nodes. Arc GIS Pro was used to calculate the local Moran I index to visualise the distribution of nodes and the public transportation networks. Arc GIS Pro was chosen as it provides a myriad of spatial statistical analysis tools for mapping clusters.

To identify the distribution of hot spots and the public transportation networks and rank these hot spots, the degree centrality was used to take into account the network relationship of the bus stops. Consequently, this was used to articulate why some bus stops were hot spots and others were not. When calculating the local Moran's I index, we used a fixed distance band to conceptualise the spatial relationships, ensure all nodes had a neighbour and uniform distribution.

$$I_i = \frac{c_i - \overline{C}}{S_i^2}, I \sum_{j=1, j\neq i}^{n} w_{i,j}\left(c_j - \overline{C}\right) \quad (1)$$

where c_i is the closeness centrality of the bus stop at location i, $\overline{X}$ is the mean of the corresponding attribute, and $w_{i,j}$ is the spatial weight, being the travel time between bus stops i and j:
where n equates to the total number of bus stops.

$$S_i^2 = \frac{\sum_{j=1 j\neq i}^{n}\left(c_j - \overline{C}\right)^2}{n-1} \quad (2)$$

- **Step 6:** Spatial overlay: finally, the three public transportation network data were overlaid, and the connectivity of the multi-modal network was visualised.

The metropolitan city of Johannesburg is commonly known as "Jozi" due to its economic activities. The public transportation system in the city is comprised of a mix of motorised and non-motorised modes. Moreover, given how the city has invested in public transportation infrastructure since 2010, the modal share of rapid rail and bus transit systems has increased immensely. The Gautrain (a rapid rail transportation system) and Gaubus (a rapid bus transit system) have routes that serve the Northern portions of the city (see Figure 3), whilst the Southern portions of the city are served by the Rea Vaya (a rapid bus transit system). The routes of the latter link commuters to various points of interest. Currently, connectivity in the city is limited, with little to no connectivity to the existing public transportation systems. We proposed identifying the connectivity of bus stops (which we refer to in the paper as nodes) and proposed connecting the two public transportation systems to enhance intermodal travel in the city (see Figure 3).

RESULTS

Assessing the connectivity of transportation networks is essential in facilitating inter-modality. A societal analysis of the GeoWeb 2.0 data revealed patterns in social media posts. The social media posts, which mentioned the three modes of public transportation, revealed that commuters media posts, which mentioned the three modes of public transportation, revealed that commuters associate these modes mainly with three trip typologies (see Figure 4).

The month of February had approximately 3700 posts associated with commuting for work purposes, whilst January had 967 posts associated with commuting home. Overall, most posts were associated with work trips, with February, June, January, May, April, and March having 3700, 2000, 1999, 1803, 801, and 701, respectively. Leisure trips were mainly in February and June, with approximately 2500 and 701 respectively. Leisure trips mainly were in February and June, with approximately 2500 and 1300, respectively.

Figure 5 presents the top 17 words mentioned in the social media posts. The results revealed that nodes, followed by the Gaubus. Notably, the Gaubus and Rea Vaya degree centrality were in most scenarios; when commuters post about public transportation systems, they link them with a similar for these nodes and create augmented public transportation of the two networks location or point of interest. Soweto had the highest mention of 8002. Soweto is a township to the south of the city that provides housing for a large middle- to a lower-income group. Auckland Park had the second-highest mention of 4187. Auckland Park houses media companies and tertiary institutions, such as the University of Johannesburg and Rosebank College. (See Figure 5).

Other notable locations are Fourways (2106), which is the fastest-developing commercial and residential hub; Constitution Hill (4032), which is located in proximity to the city municipal offices; and Randburg (4012), which is well known for its surplus of shopping centres and entertainment areas.

SPATIAL CONNECTIVITY

The growth in intermodal commuting in Johannesburg promises to improve the citizens' quality of life in the city. In this paper, we assessed the connectivity of two modes of public transportation: the rapid rail transportation system and the rapid bus transit system. Nodes with a high degree centrality index had the uppermost number of associations upon the node. Figure 5 reveals that of the three networks, the Rea Vaya network had the peak number of higher-order nodes, followed by the Gaubus. Notably, the Gaubus and Rea Vaya degree centrality were similar for these nodes. The two networks' augmented public transportation would be easy, as their operational

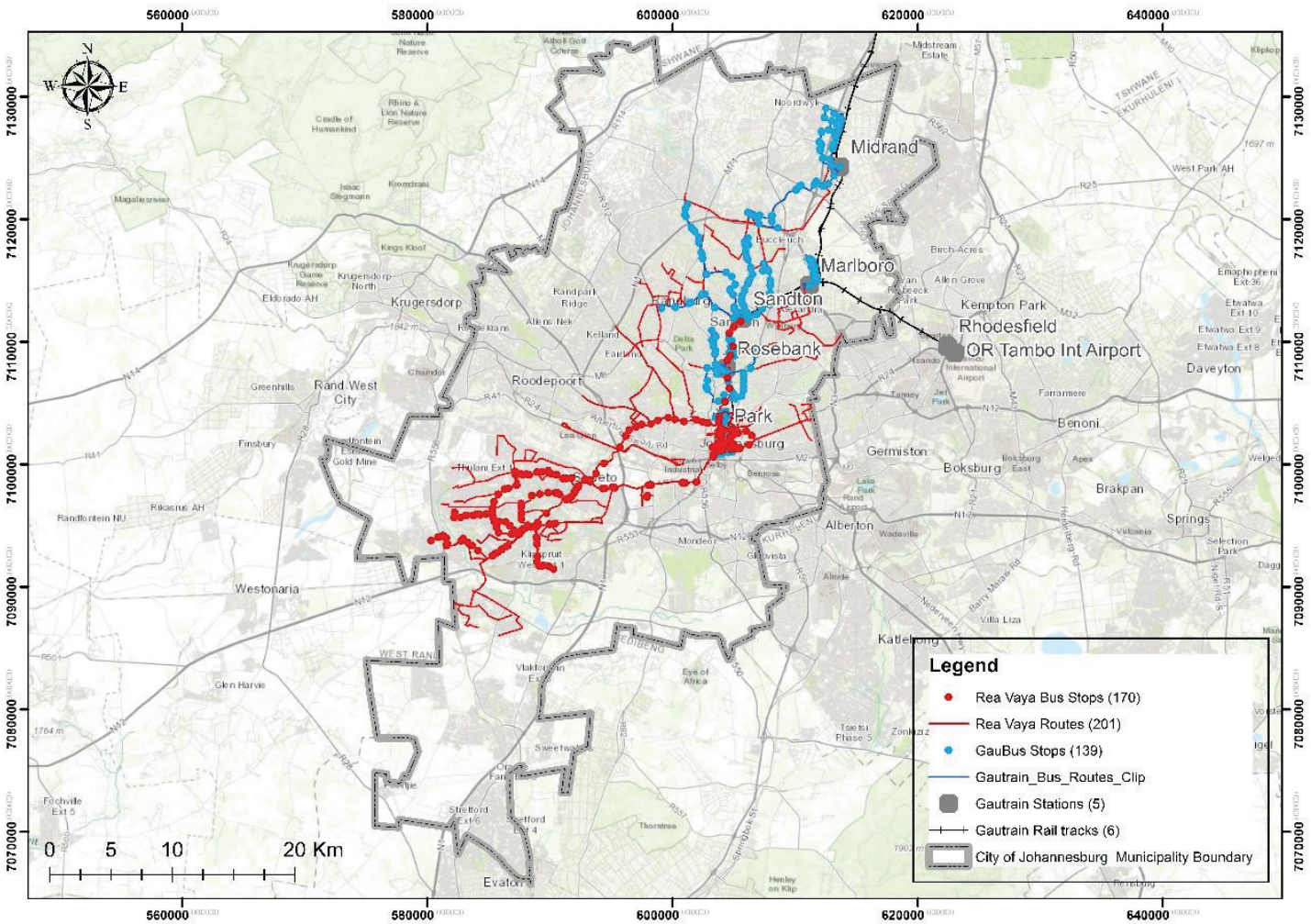


Figure 3: Study Area

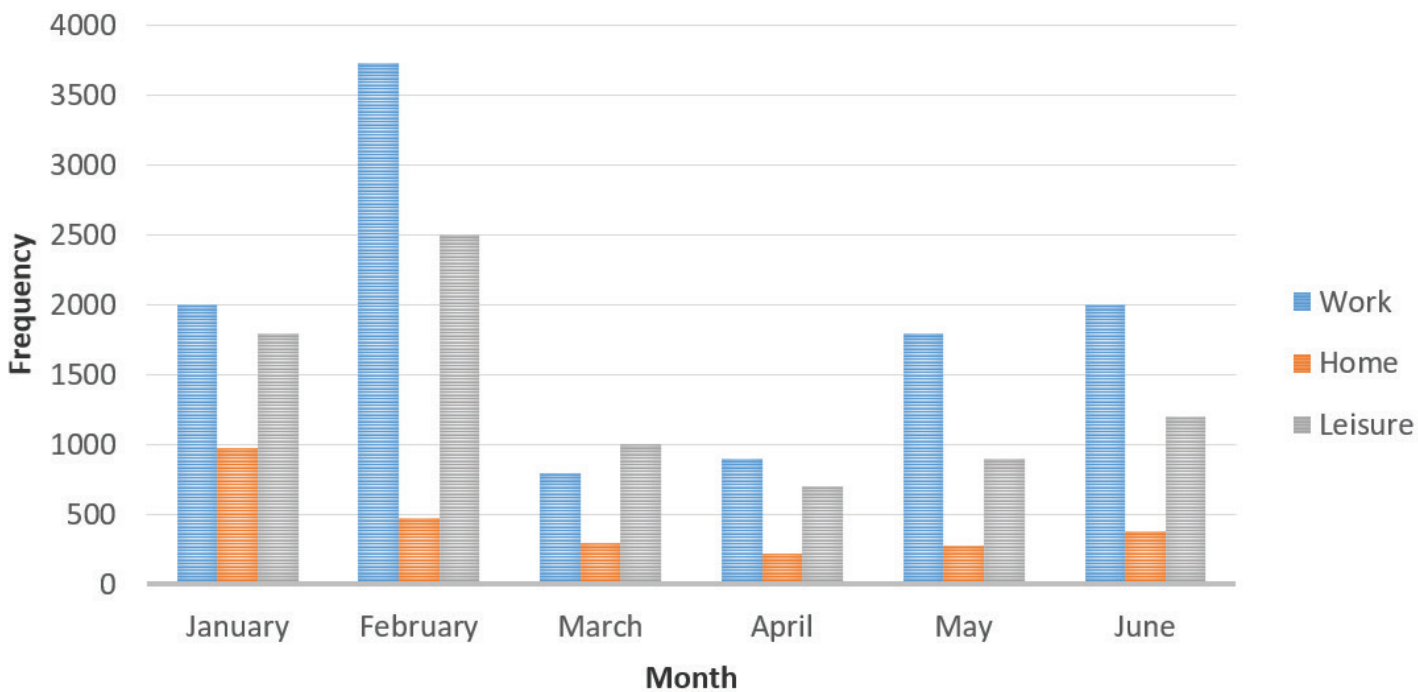


Figure 4. Time series analysis of daily GeoWeb 2.0.

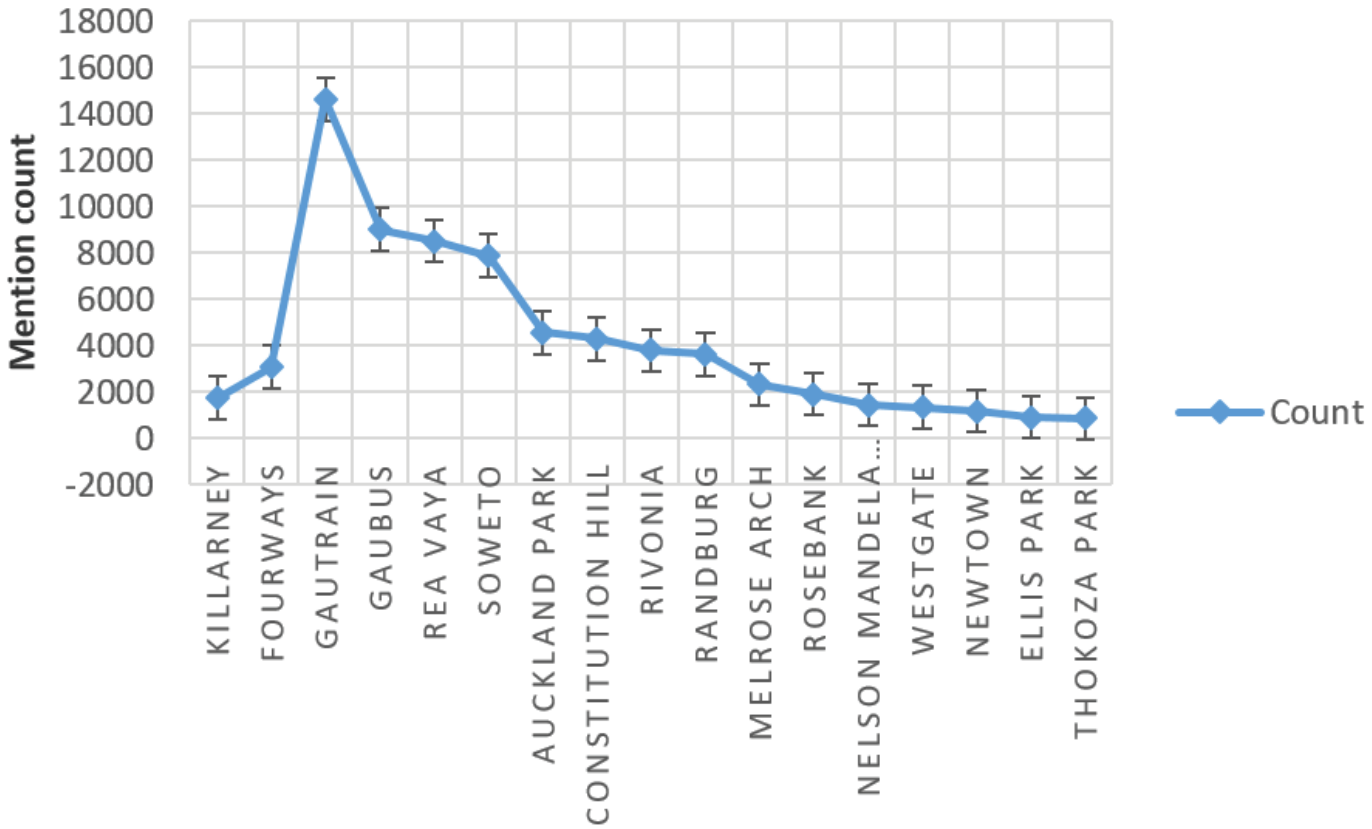


Figure 5: GeoWeb 2.0

dimensions are similar. However, the travel timetable and pricing would need to be adjusted to ensure the seamless interchange of commuters between these two networks to meet the underlying commuting requirement of ease of use.

A spatial statistical analysis of the public transportation nodes revealed hot and cold spots. Overall, the local Moran I classification of the Gautrain–Gaubus network nodes revealed notable high-cluster nodes at Park Station, Rosebank, Sandton, Malboro, and Midrand (see Figure 6). These nodes are located within economic and business nodes in the locations; hence, commuters traverse between these two locations frequently. Given the spatial concentration of economic activities in Rosebank, notably, the highest number of high-cluster nodes are present in this location. From Figure 6, no existing nodes linked commuters who resided to the south of the city to the Gautrain network. Consequently, commuters who resided to the south of the city, such as in Soweto, must use another form of mobility mode before accessing the Gautrain system.

Accordingly, a partnership seems worthwhile for the Gautrain and Rea Vaya networks, as the Rea Vaya has an existing road network that flows from Soweto past Braamfontein (see Figure 7).

The Moran's I classification for the Rea Vaya network revealed significant higher cluster nodes in the Johannesburg Central Business District (Braamfontein and Marshalltown) and to the south of the city in Soweto (Orlando and Dobsonville).

A few notable low outliers were also located within proximity to Braamfontein (see Figure 8). A low cluster was also evident to the south of the city at Protea Glen. Currently, the Rea Vaya is expanding the network to the Northern part of the city. A collaboration between the Rea Vaya and Gaubus would ensure a more significant spatial coverage of the rapid bus public transportation system. See Figure 8.

We then used the degree centrality to compute the robustness of the connected public transportation system comprising the Gautrain, Gaubus, and Rea Vaya. Figure 9 reveals there were more high order nodes along with the three public transportation systems. The Rea Vaya network had the most higher-order nodes with a degree centrality of 4. Another interesting pattern was that the Gautrain had a node with a degree centrality of 4.

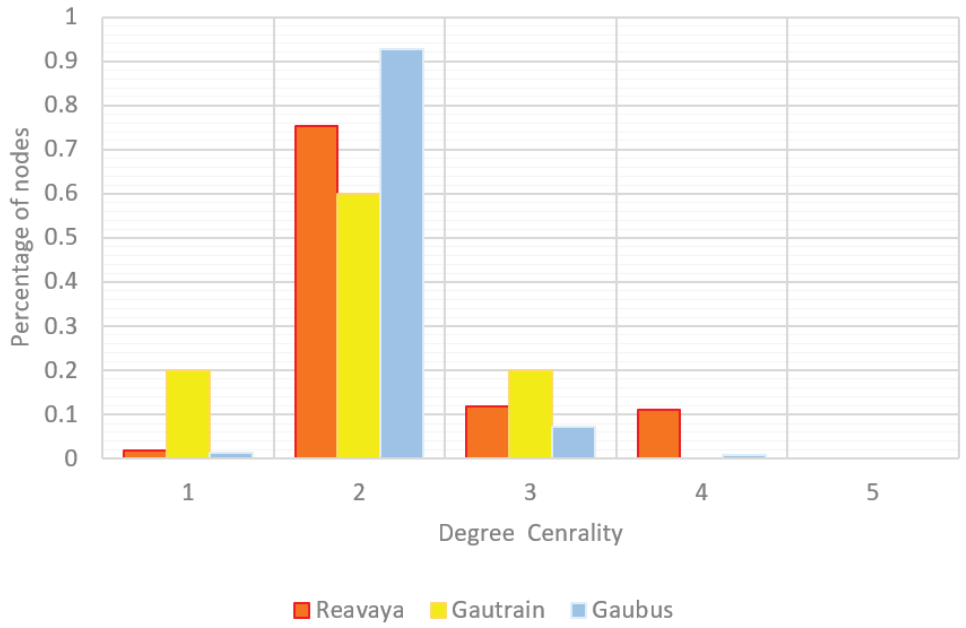


Figure 6: Degree centrality of existing networks.

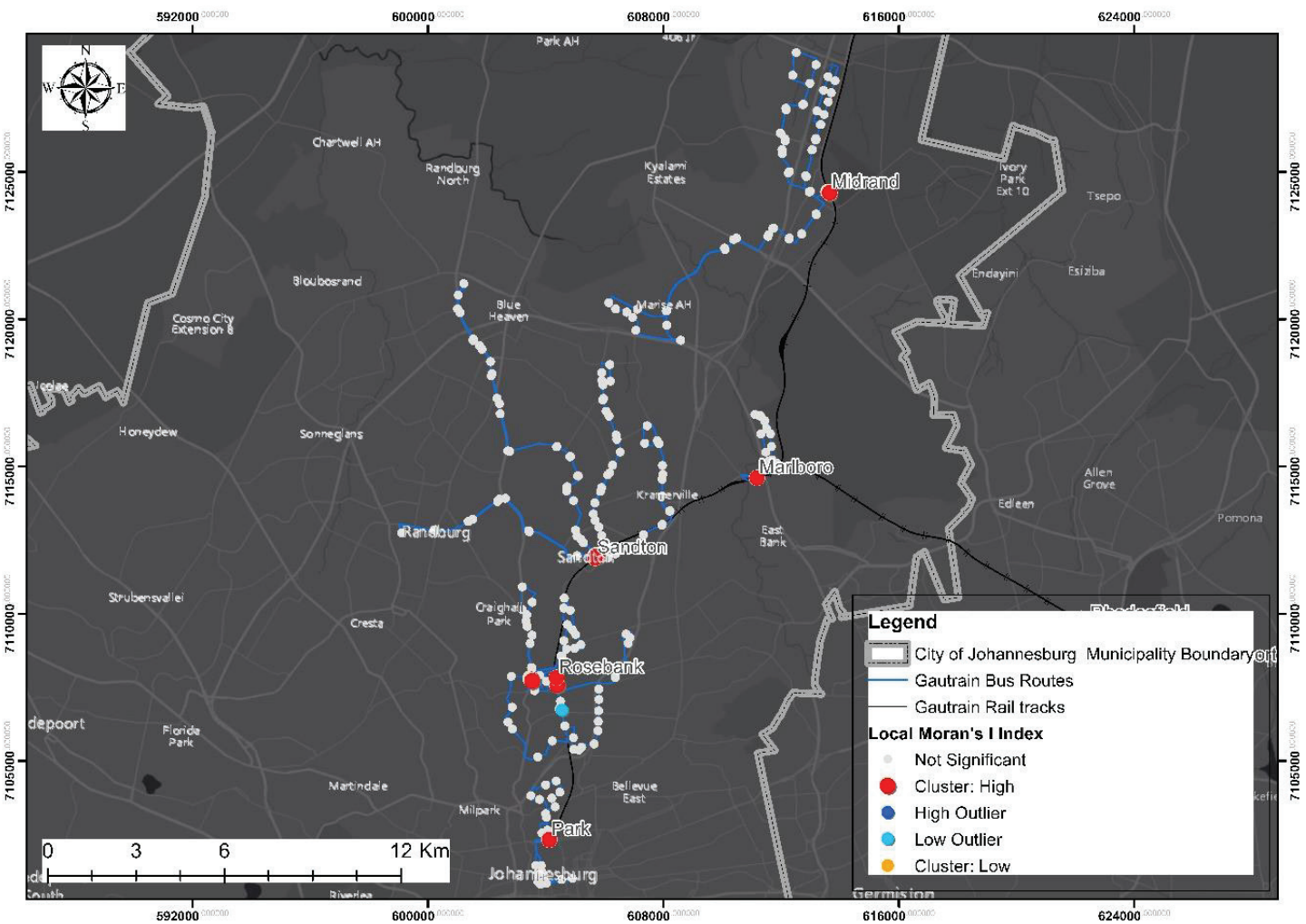


Figure 7: Local Moran's I index of Guabus and Gautrain Network.

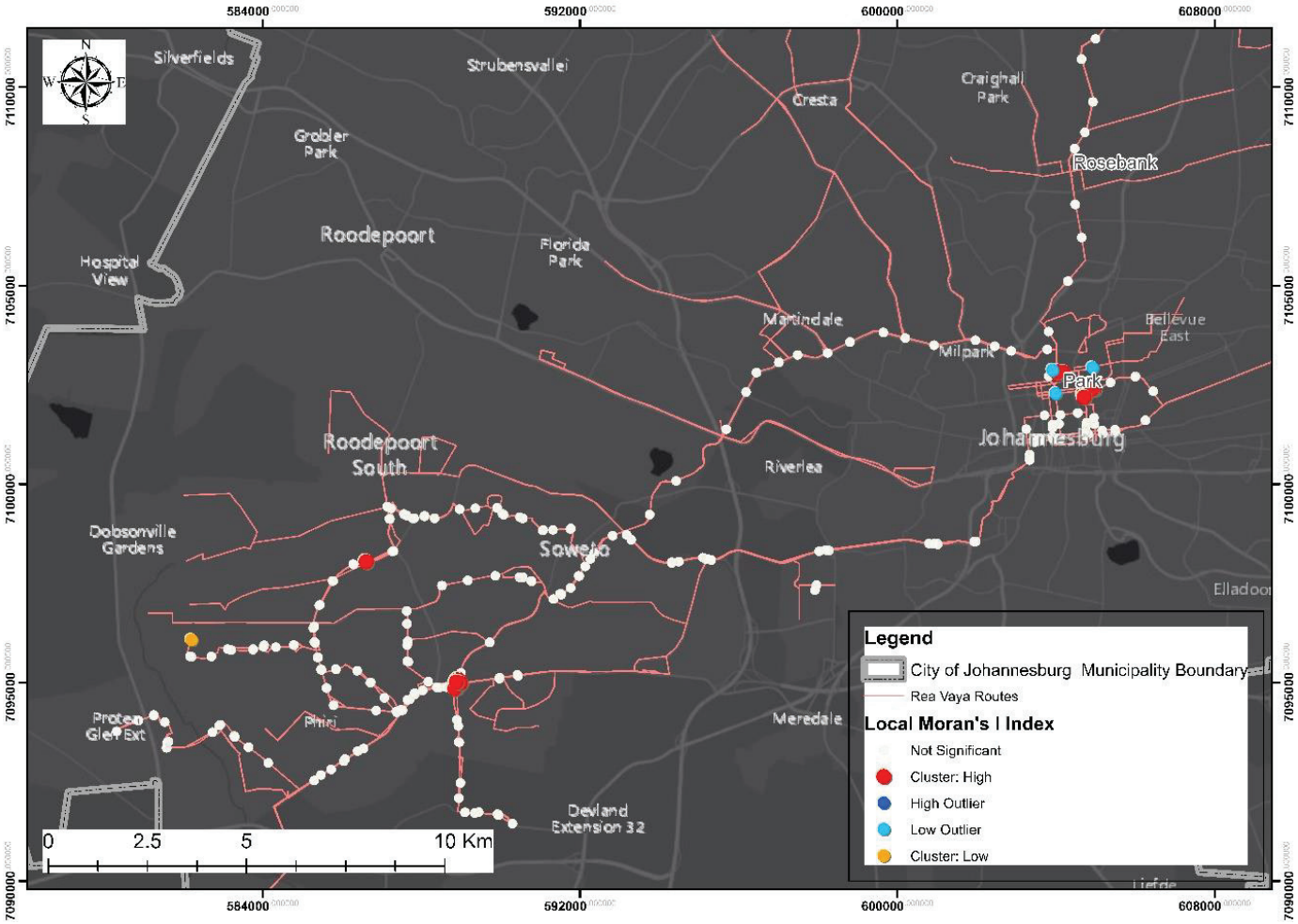


Figure 8: Local Moran's I Index of Rea Vaya Network

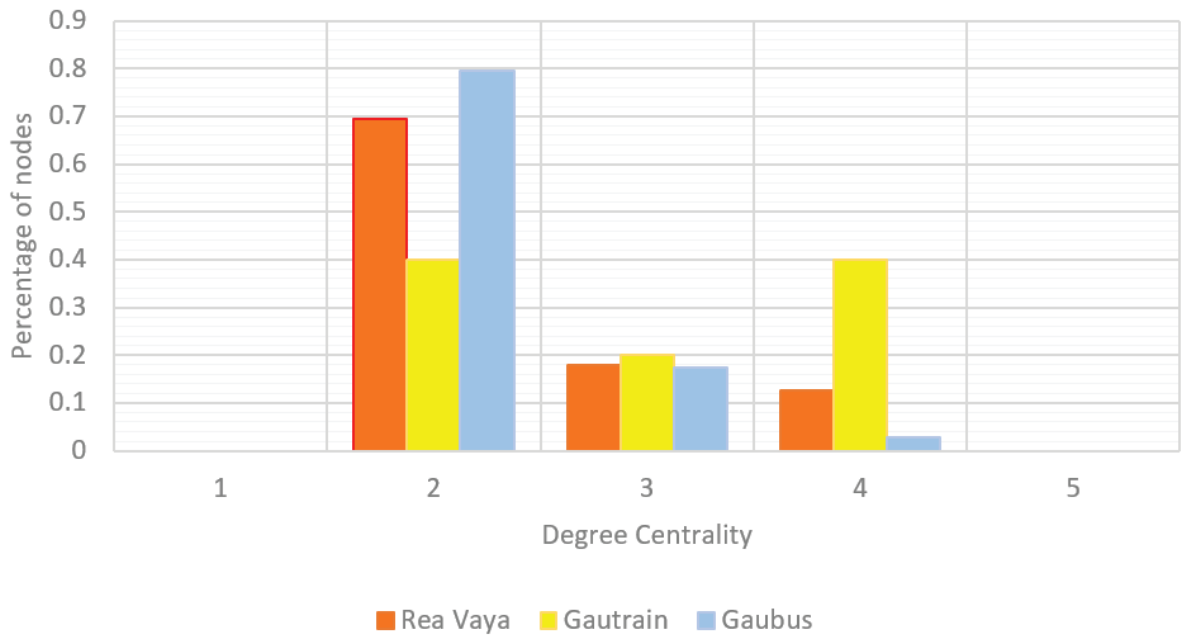


Figure 9. Degree centrality of connected network

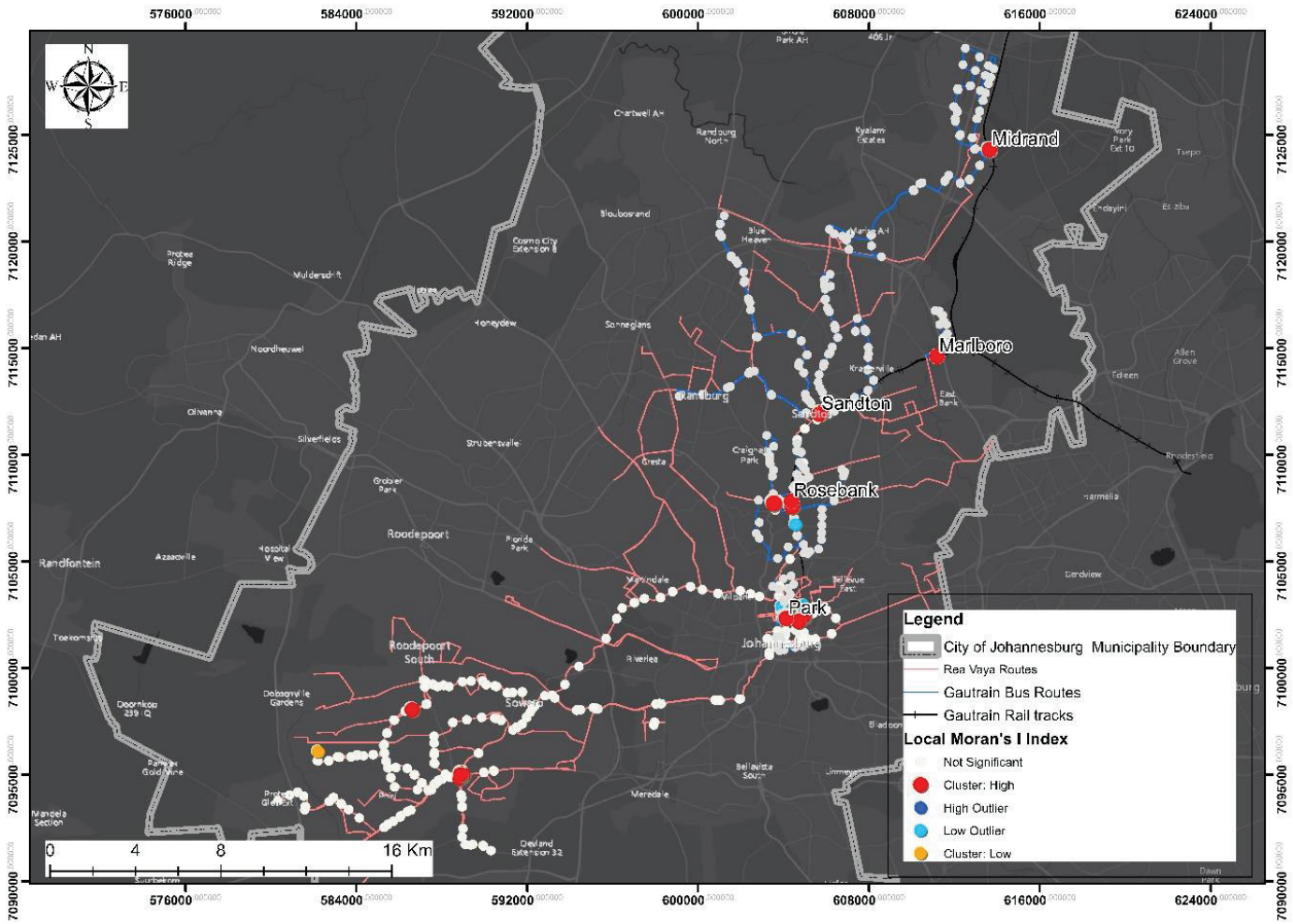


Figure 10. Local Moran's I index for a connected network

Figure 10 reveals the location of nodes concerning a cluster and outlier analysis. More high cluster nodes were prominent in Midrand, Rosebank, Sandton, Dobsonville, Orlando, Naledi, Phiri, Auckland Park, Protea Glen, and Roodepoort, whilst low cluster nodes were more prominent in Braamfontein and Marshal town. One notable aspect of the connected public transportation system was the high number of high-cluster nodes.

DISCUSSION

The development of a sustainable public transportation system is essential for urban development—this being another lacuna that justifies this current study by advocating for improved access to areas of economic and business nodes in the city. The results revealed that the Rea Vaya network has successfully improved commuter accessibility to economic and business nodes for commuters residing in the Southern parts of the city. Given the previous results, the commuter concentration zones of the Gautrain and Rea Vaya were then overlaid to identify which nodes should be used as the initial geolocations to promote multi-mobility within the city (see Figure 11). The results revealed that Park Station has the highest integrated commuter concentration. With this high commuter convergence, improving commuter transfer, such as with geolocations, would be a good starting point, as there is pre-existing transport infrastructure. While variations in income levels may be a factor to prevent inter-transfer between the two modes, commuters should be given an incentive for using both modes of transit in one trip, such as a discount in commuter fares or points that can later be redeemed for a discount. This would build on the existing commuter concentration and attract other commuters to join the system. The introduction of a multi-modal transport system would be cost-effective for the two public transit providers to promote multi-mobility within the Johannesburg city region instead of building separate infrastructure (as is the current case with the Gautrain and Metrorail). The Gautrain would link commuters to economic and business nodes in the Northern parts of Johannesburg

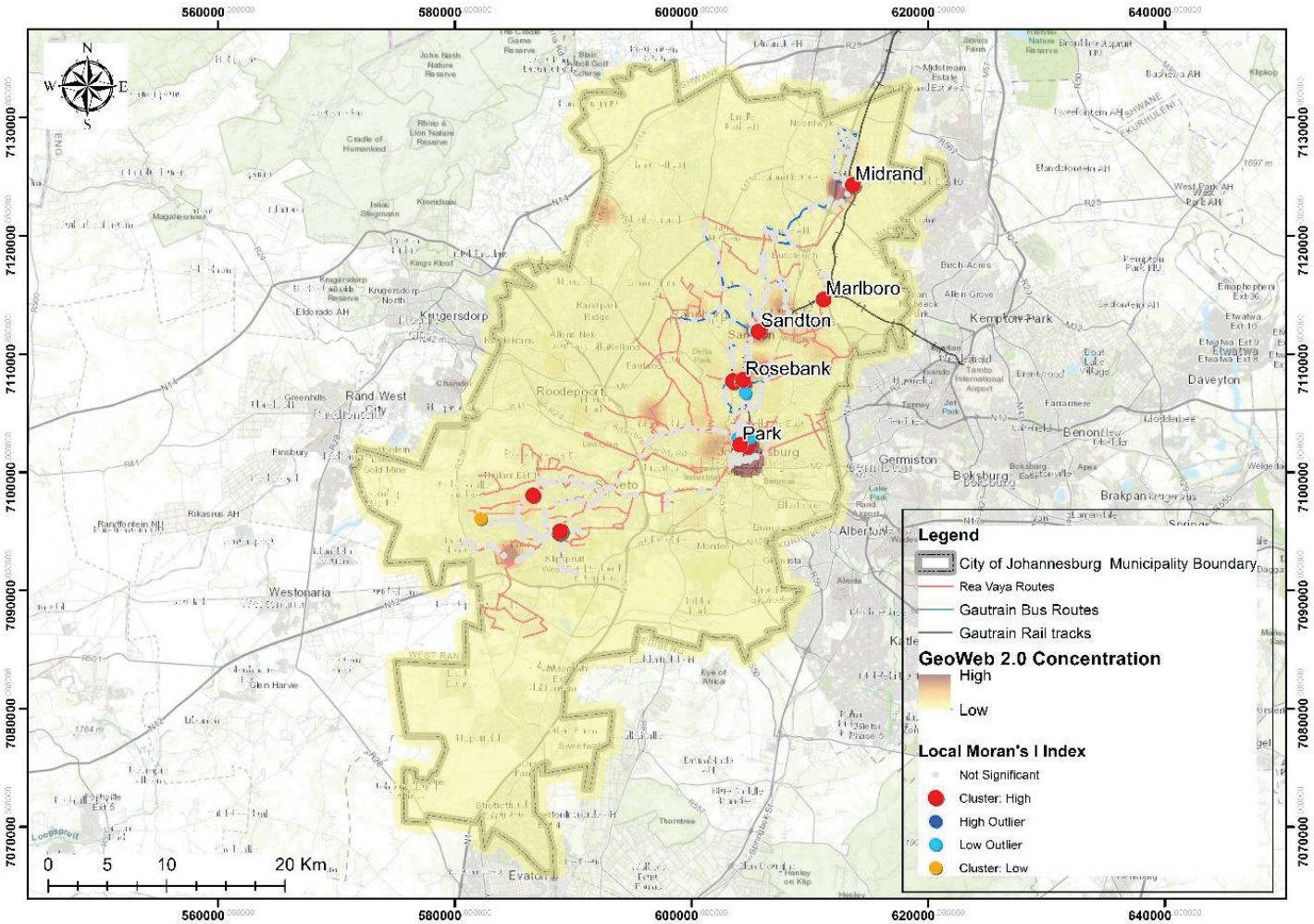


Figure 11. Spatial connection of all nodes

(namely, Rosebank, Sandton, Marlboro, and Midrand). The Rea Vaya would link commuters to economic and business nodes in the Southern part of the city.

IMPLICATIONS, REFLECTIONS, AND GENERALIZABILITY OF FINDINGS

This work has several implications concerning the new knowledge generation for academic purposes and policy formulation and implementation in the local, provincial, and national spheres. The methodology proposed in this paper can be adapted to inform interventions that integrate the network designs of numerous public transportation systems in the country's numerous cities: particularly metropolitan cities. This paper has proposed the integrated network design framework of multiple public transportation systems using a case study of South Africa. We, therefore, propose a scenario that illustrates the benefits of integrated network designs. Commuters who reside in the south of the city of Johannesburg (for example, in Soweto) but work in Sandton, which is on the North of the city, are currently utilising more than one mode of transportation to traverse daily from home to work since there are no direct public transport or routes that service these two locations. The integration of payment systems and the creation of transfer points at influential nodes, which may result from policy recommendations and implementation may lead to the improved and smooth movement of commuters within and between metropolitan cities.

A close reflection reveals that contemporary public transportation systems in cities of the developing world seek to become highly flexible and demand-responsive [49]. Currently, knowledge gaps exist in transportation policies on how existing public transportation systems can be integrated. Several public transport modes are currently managed and operated separately in South African cities. Moreover, given the lack of integration of the transport modes,

the commuters currently cannot plan their trips, as the timetables are not integrated, and the payment systems are di rent. In addition, the fare payment systems are not harmonised. Commuters who utilise mini-bus taxis pay in cash, where commuters utilising the Rea Vaya have the option to utilise an e-ticketing system. Commuters who utilise the Gautrain and Gaubus use smart cards linked to both the Gautrain and Gaubus e-ticking system.

Given that these numerous payment methods are not interlinked, the ease for a commuter to utilise all three modes is hindered. With regards to the city of Johannesburg, to create a bridge between the different parts of the city, the creation of enabling platforms for commuters to use both the rapid bus transit and the rapid rail transportation systems in an integrated format would lead to the improved use of multi-mobility within the cities. The flexibility in travelling between various places within the city, particularly the Southern and Northern points, will lead to reduced travel times (as the Gautrain and Rea Vaya are currently the fastest modes of public transportation) and, overall, this would lead to a reduced reliance on private vehicle travel.

The results of this study are generalisable and can be replicated in several cities of the developing world. In this paper, two public transportation systems are considered: the rapid bus transit system and a rapid railway transportation system. However, these modes are only located in a few locations of the city. The data and methodology can be applied in other metropolitan cities within the Gauteng provinces, such as Tshwane and Ekurhuleni, to determine ways of integrating the rapid bus transit systems within the Gautrain, which also serves these two cities. Researchers can incorporate the mini-bus taxis in other metropolitan cities of South Africa and other developing cities, which are sometimes referred to as informal public transportation systems. However, they are very robust and dominant in several cities of the developing world. Considering that the majority of commuters are already familiar with mini-bus taxis in cities of the global south and that innovative urban public transport systems are being slowly developed in such cities [2], linking the various transportation modes would lead to sustainable transportation systems in these cities.

To adopt such urban public transportation network systems, the choice of parameters should be more appropriate to include the flexibility of mini-bus taxis.

This work has brought several findings to attention; consequently, several lessons and points are to consider. Firstly, integrated urban public transportation systems can enhance the overall commuting experiences, as they allow for more multi-modal trips. Secondly, influential nodes exist within a public transportation network; as a result, the properties surrounding these nodes should be used to enhance commuting experiences, as they offer gateways to surrounding communities. Thirdly, to ensure the ease of transfer between various modes of public transportation - the introduction of e-ticketing systems is essential. Public transportation systems without harmonised fare systems lead to delayed travel times, as commuters change their payment methods at each boarding point.

CONCLUSIONS

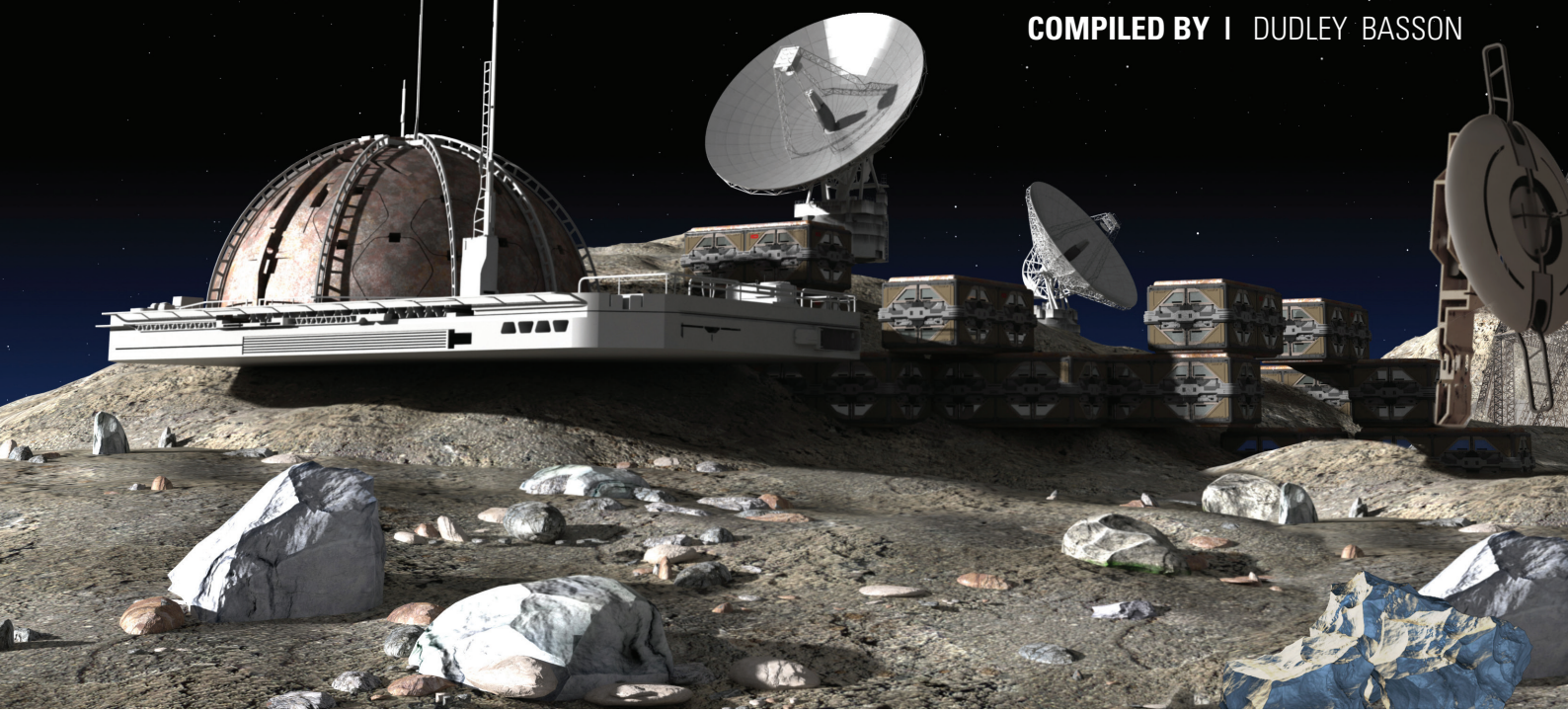
Although the improvement and efficient development of public transportation is an effective means of ensuring sustainable mobility within urban areas, most travellers in the city still favour the use of their private automobiles. An understanding of commuter points of interest would lead to a better understanding of commuters' travel patterns.

Contemporarily, there still exists a knowledge gap regarding the planning and implementation of sustainable intermodal public transportation systems. The Green Transportation Strategy for South Africa (2018–2050) seeks to address the current and future transport demands [35]. Identifying hot spots along public transportation networks will inform investment decisions on which nodes require infrastructural upgrades to meet the transportation demands. Regarding the article, the identification of hot spots is premised on creating an integrated transportation system. The use of Geoweb 2.0 data in this article is one step towards understanding commuter travel patterns, as citizens have grown accustomed to using social media in their daily lives. Hence, linking GeoWeb 2.0 data and the public transit system would bridge improving commuter access to their point of interest, such as economic and business nodes. As the findings are funnelled by the need for innovative means to inform multi-mobility planning, a statistical analysis approach was adopted to predict the sphere of influence of the Gautrain and Rea Vaya based on GeoWeb 2.0 data. To this end, the Rea Vaya, which has an extensive network in the Southern parts of the city, can improve the accessibility to economic and business nodes in the south. In contrast, the Gautrain, a rapid rail transportation system, has an existing network system between Park Station and Midrand that provides access to the city's northern parts. wn

Click here for references

Asteroid and Moon Mining

The mining of heavy metals and rare earth elements on Solar System bodies other than the Earth remains an impossible quixotic dream, awaiting significant advances in space exploration technology. The challenges and rewards will be enormous.



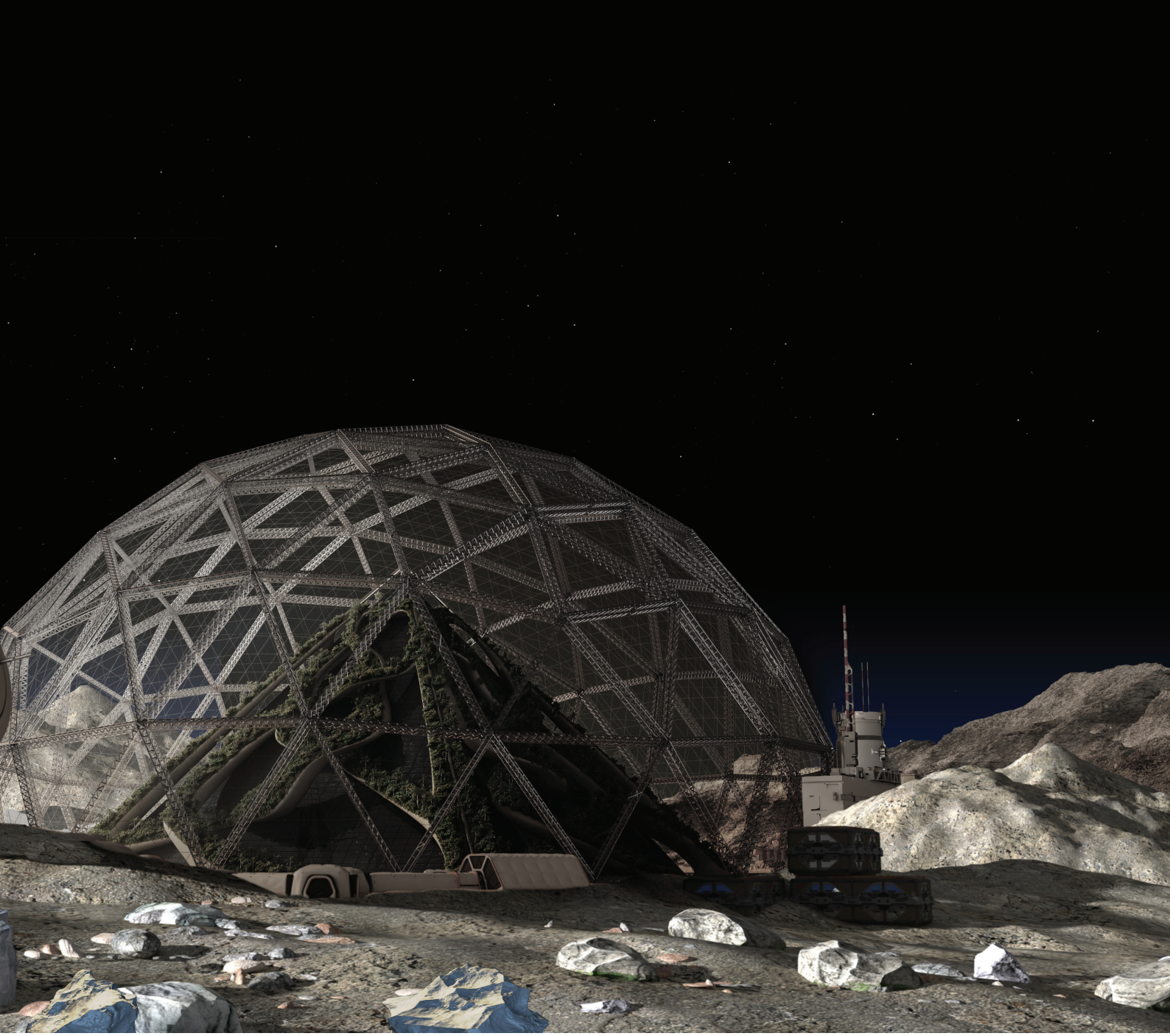
COMPILED BY | DUDLEY BASSON

There is a natural scarcity of the heavy elements in the crust of the Earth due to these elements settling deep within the interior when the Earth was still in a molten state.

Much of the heavy element material found in the crust of the Earth is from meteorite strikes in the early days of the Earth's formation. These meteorites were essentially the same asteroid material from which the Earth was initially formed. Meteorites commonly show high iron and nickel content. The vast complex of Witwatersrand goldfields became accessible to mining by the Vredefort meteorite impact, which uplifted a 300 km circle of gold-bearing basement granite. It has been suggested that diamonds may be found in large quantities on asteroids.

In ancient Egypt, meteorites were the only accessible source of iron which was highly prized for weapon manufacture. The metal in common usage at the time was copper. Asteroid 16 Psyche, with a maximum dimension of 278 km, is estimated to contain 1016 tons of metallic iron, nickel and cobalt worth $ 700 quintillion, which would exceed current production for millions of years. It has also been suggested that Psyche might have a solid gold core. For details of the NASA Psyche Mission proposed in 2015, to be launched in 2022, and to arrive at Psyche in 2026, click here.

Psyche will transmit data optically to Earth while in orbit around the asteroid and achieve the end of the mission in



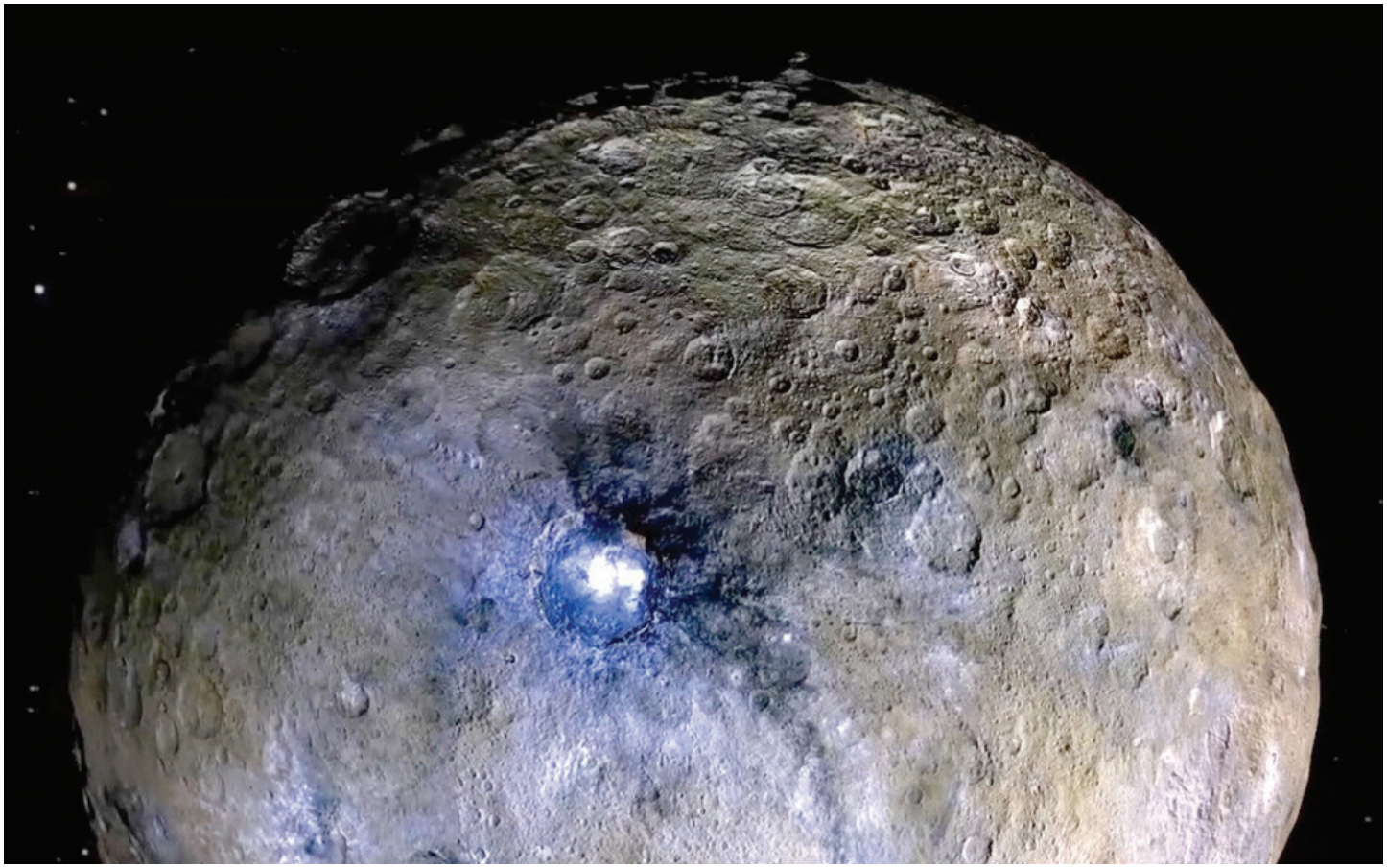
Oct 2027. Two other similar asteroids have been identified as 'mini-Psyches'. For details and extensive references of asteroid Psyche, click here.

If huge quantities of gold and platinum can be recovered from asteroids, this would cause a sudden drop in the prices of these metals and make them more available for engineering and scientific use. Gold is an excellent electrical conductor, and platinum has beneficial catalytic properties.

The numerical prefixes to asteroid names are incremented each time a new asteroid is discovered, starting from 1 Ceres.

Using ESO's VLT, astronomers have obtained the sharpest and most detailed images of the asteroid 216 Kleopatra, with a maximum dimension of 276 km. The astronomers have determined this peculiar asteroid's 3D shape and mass, which resembles a ham-bone, to a higher accuracy than ever before. Their research provides clues as to how this asteroid and the two small moons that orbit it formed. They have also accurately determined the moons' orbits, named AlexHelios and CleoSelene, after the Egyptian queen's children. It is possible that Kleopatra could be an accumulation of debris and not a solid body. Asteroid 130 Elektra has a size of 182 km and is another asteroid with two moons, which have sizes of 4 km and 2 km.

An enormous comet of some 100 km in size was discovered in June



Asteroid Ceres

2021, hurtling towards the inner Solar System, returning from its previous visit 3,5 million years ago.

Named Bernardinelli-Bernstein, it is at present cruising through the Oort cloud some 29 AU away. It is expected to make its closest approach of 10,97 AU to the Sun in 2031. It has already started to acquire a tail for its solar flyby.

Ceres is the largest astronomical object in the asteroid belt between the orbits of Mars and Jupiter.

The first asteroid discovered, Ceres, was observed on 1 January 1801 by Giuseppe Piazzi at Palermo Astronomical Observatory. Initially considered a planet, it was reclassified as an asteroid in the 1850s after discovering over 20 other objects in similar orbits. In 2006, it was reclassified again as a dwarf planet because, at 940 km in diameter, it is the only asteroid large enough to be rounded by its own gravity. This makes Ceres both the smallest recognised dwarf planet and the only one inside Neptune's orbit.

The robotic NASA spacecraft Dawn entered orbit around Ceres on 6 March 2015. Dawn found Ceres's surface to be a mixture of water ice and hydrated minerals such as carbonates and clay. Gravity data suggest Ceres be partially differentiated into a muddy (ice-rock) mantle/core and a less-dense but more robust crust at most 30% ice. Despite this, Ceres's small size means that any internal ocean of liquid water it may have possessed is likely frozen. In January 2014, emissions of water vapour were detected around Ceres.

For details of dwarf planet Ceres, click here.

The Moon will be of primary importance in space mining.

Mining under the Moon's surface could significantly reduce the reliance on transporting materials from Earth for future lunar stations. Materials that could be mined on the Moon include rare earth metals and titanium, gold, platinum, and helium-3. Rare earth metals brought to Earth could help build medical equipment and smartphones and supply the massive demand for permanent magnets, while helium-3 could fuel nuclear power plants on Earth (If still required) in the distant future. 3D printing will be necessary for manufacturing tools and other equipment that would otherwise have to be transported from Earth.

It will be necessary to explore for ice to provide water for the lunar stations and produce oxygen and hydrogen fuel for the asteroid missions. There will be no shortage of sunlight for powering the solar panels, which will power the various industries. Solar panels could quite likely be robotically manufactured on the Moon.

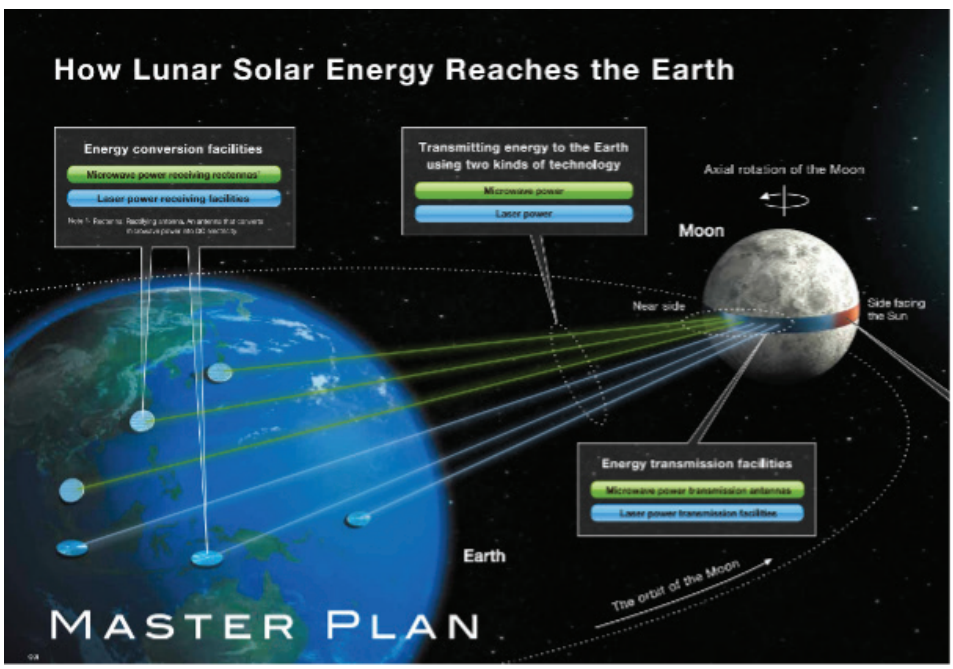
Numerous space missions have searched for water-ice on the Moon, particularly in craters at the poles, which have areas never penetrated by sunlight. These areas have dark shadows as there is no light reflected from an atmosphere or even from the Earth. For more details, click here.

NASA's uncrewed VIPER (Volatiles Investigating Polar Exploration Rover) will explore the South Pole region in 2023 and enter the polar craters in search of ice which could well be covered by regolith.

Engineers Lyndsey McMillon-Brown and Timothy Peshek of the NASA Glenn Research Centre lead a project to test perovskite solar cells, which could be an alternative to silicon solar cells currently used in space. This material is a relatively new discovery, and it has many advantages for solar technology. Not only is perovskite an excellent conductor of electricity, but it also can be transported into space as a liquid and then printed onto panels on the Moon or Mars, unlike silicon panels that have to be built on Earth and then shipped to space.

With just one litre of the solution, astronauts would have enough material to generate a megawatt of solar power, which is far more power than is required to run the International Space Station. The perovskite material is only part of what makes Glenn scientists so excited for the potential of this project. The other is the new method for assembling solar cells called electrospraying that researchers of the University of California at Merced have developed.

Electrospraying works like an inkjet printer, and it makes assembly quick, easy and efficient. It requires a small nozzle to deposit the perovskite solution as a thin film, of less than a micron thickness, on a substrate that acts as the structure for the panel.



For details of the revolutionary Lunar Ring photoelectric proposal click here.

Because perovskite is essentially a salt, its greatest downfall is its inability to handle moisture. This creates challenges for applications using the material on Earth, and researchers are working to overcome this obstacle by encasing it in plastic. This weakness is a reason scientists are interested in testing perovskites in space. In environments like those of the Moon and Mars, moisture is not a concern.

With the research in its early stages, there are still many unknowns, but Glenn's scientists are beginning test flights to see how the material responds in harsh environments. The perovskites are scheduled to fly on the Materials International Space Station Experiment 13, and further testing will be conducted over the next two years.

Since 2001, the Materials International Space Station Experiment (MISSE) series has tested some 4,000 material samples and specimens - from lubricants and paints to fabrics, container seals and solar cell technologies - to demonstrate their durability in the punishing space environment.

Fixed to the exterior of the International Space Station for periods of up to four years, these innovative experiments endured extreme levels of solar and charged-particle radiation, atomic oxygen, hard vacuum, temperature extremes and contamination, giving researchers unprecedented insight into developing durable materials for spacecraft, flight hardware and even astronaut clothing.

"To be working on technology to print solar cells on the Moon while we're

working on a return mission to the Moon is really exciting," McMillon-Brown said. "If this project goes well in the next two years, there might actually be space for us to demonstrate this on the Moon in the next four to eight years. It's authentic. And it's possible."

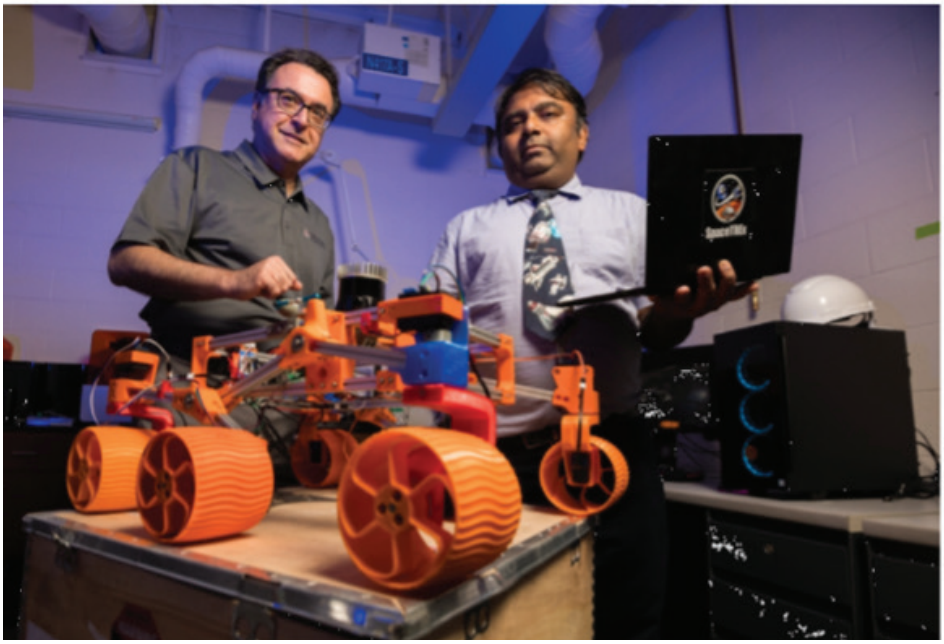
Biomining is another fascinating experiment that has been performed in the ISS. This is a space mining technique for rare earth elements using bacteria. For details, click here.

Shimizu Corporation has proposed a mind-boggling system of photoelectric panels encircling the Moon, continuously capturing the entire Earth's electricity requirement and transmitting it to Earth from the near side of the Moon. The 11 000 km Luna Ring would initially have a width of a few km which could be extended up to 400 km. For details of the revolutionary Lunar Ring photoelectric proposal, click here.

The power would be transmitted from 20 km dishes as microwaves or lasers. One can only wonder what might happen if a multi TW beam inadvertently zaps the wrong target. The side of the Moon facing the Earth is not entirely static – it has a slight libration that would require the dishes' aim to be continuously adjusted. Having a single supplier for the entire planet's electricity requirement might make many people nervous – what could go wrong?

NASA's 'Break the Ice' challenge called for entrants to design a rover that can land in the Aitken Basin at the lunar south pole, which is believed to hold approximately 70 million kg of ice, and mine for resources at the location.

A team of researchers of the University of Arizona recently received a $500 000 grant from NASA to develop space-mining methods. The result is the development of a swarm of autonomous robots that could search and mine for rare earth metals and other minerals on the Moon.



A university of Arizona engineering faculty members Jekan Thanga (right) and Moe Momayez pictured with a low-cost, rapdily engineered 3D-printed roer prototype for testing a new generation of miniature sensors for applications in lunar mining.

The robot team developed an electrochemical process that drills through rock five times faster than any other method. This is combined with a neuromorphic learning architecture technique called the Human and Explainable Autonomous Robotic System (HEART) that trains robots to work together and improve their collaboration skills over time via machine learning. The team will build and train the robots on Earth to hone their teamwork skills in a safer environment before going to space. Ultimately, the team aims to deploy the swarm of robots on the Moon, where they will build basic structures and mine for resources without instruction from Earth.

Jekan Thanga, who developed the HEART learning architecture, likens the swarm of robots to a herd of animals or workers on a farm. "In a sense, we're like farmers. We're breeding talent out of these creatures, or a whole family of creatures, to do certain tasks," he said. "By going through this process, we help perfect these artificial creatures whose job it is to do the mining tasks."

The team believes that the swarm of robots could free up astronauts to spend more time on critical mission operations while performing dangerous construction tasks. "The idea is to have the robots build, set things up and do all the dirty, boring, dangerous stuff so that the astronauts can do the more interesting stuff," Thanga said.

The University of Arizona team is not the only one aiming to send mining robots to the Moon. California-based Masten Systems announced it was developing a lunar rover that could blast through Moonrock to reach the ice, providing vital water resources to future lunar stations.

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Rocket Engines Could Be Fired at the Lunar Surface to Get Water

Masten's Rocket M rover will use controlled rocket blasts to break up the soil or regolith underneath the rover, extracting the ice. The company, which has also built a lunar lander, says the rover "is projected to mine up to 12 craters per day and produce 100 kg of ice per crater."

Thanks to a lander that doubles up as a support station, the rover (1118 kg) will land on the Moon. Once at the required location, it will use a rocket placed under a pressurised dome, allowing it to mine 2 meters below the lunar surface.

The solar-powered rover will be capable of travelling at speeds of up to 3,45 km/h and could also climb 20 per cent inclines, which means it can potentially be valuable for future Mars missions.

The company's statement also says that "stored water can be electrolysed into oxygen and hydrogen utilising solar energy to continue powering the rocket engine for more than five years of water excavation."

Masten's new system was designed as part of a collaboration between Honeybee Robotics and Lunar Outpost. For a four-legged "spacebok" (space springbok) Mars robot info and video, click here.

Rolls-Royce is working on a nuclear reactor to power mining operations on the Moon and even Mars. The firm released a joint study into nuclear power options for space rockets with the UK Space Agency earlier this year (2021).

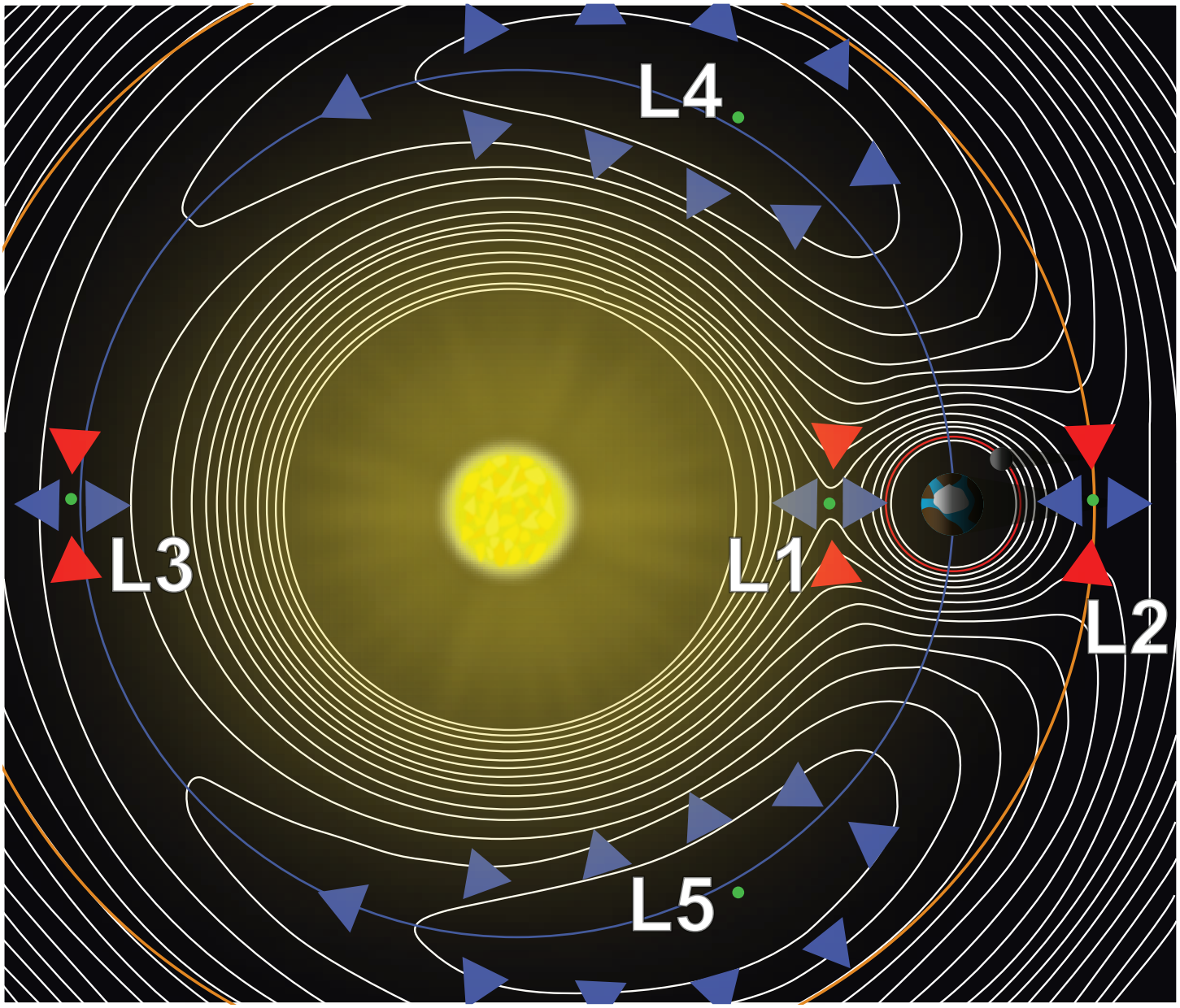
The firm is looking into how a micro-nuclear reactor could be used to propel rockets while in space at tremendous speeds and how that technology could then be redeployed to provide energy for drilling, processing, and storage for "Moon mining" and possibly "Mars mining."

Space mining is set to go beyond our celestial neighbour to asteroids, providing minerals transported back to Earth. Sourcing materials off-world could shape the future economy, with resources mined autonomously with little human intervention.

Earth appears to have a second moon, asteroid 3753 Cruithne. This is an Aten asteroid (Earth-crossing) in 1:1 orbital resonance with Earth, making its closest approach every November. It has an elliptical solar orbit, but it appears to have a bean-shaped orbit relative to Earth. It is approximately 5 km in diameter. No space missions to Cruithne have been planned.

In 2058, Cruithne will come within 13.6 million kilometres of Mars. For more info on Cruithne, click here.

Another near-Earth asteroid, 99942 Apophis, has a 370 m diameter and was discovered in December 2004. Recent calculations show that it is



The five Langrangian points of the Earth orbit

unlikely ever to strike the Earth and pass Earth within 32 000 km on 13 April 2029.

Near-Earth asteroid 2021NY1 passed Earth on 22 September 2021 within four times the Earth-Moon distance.

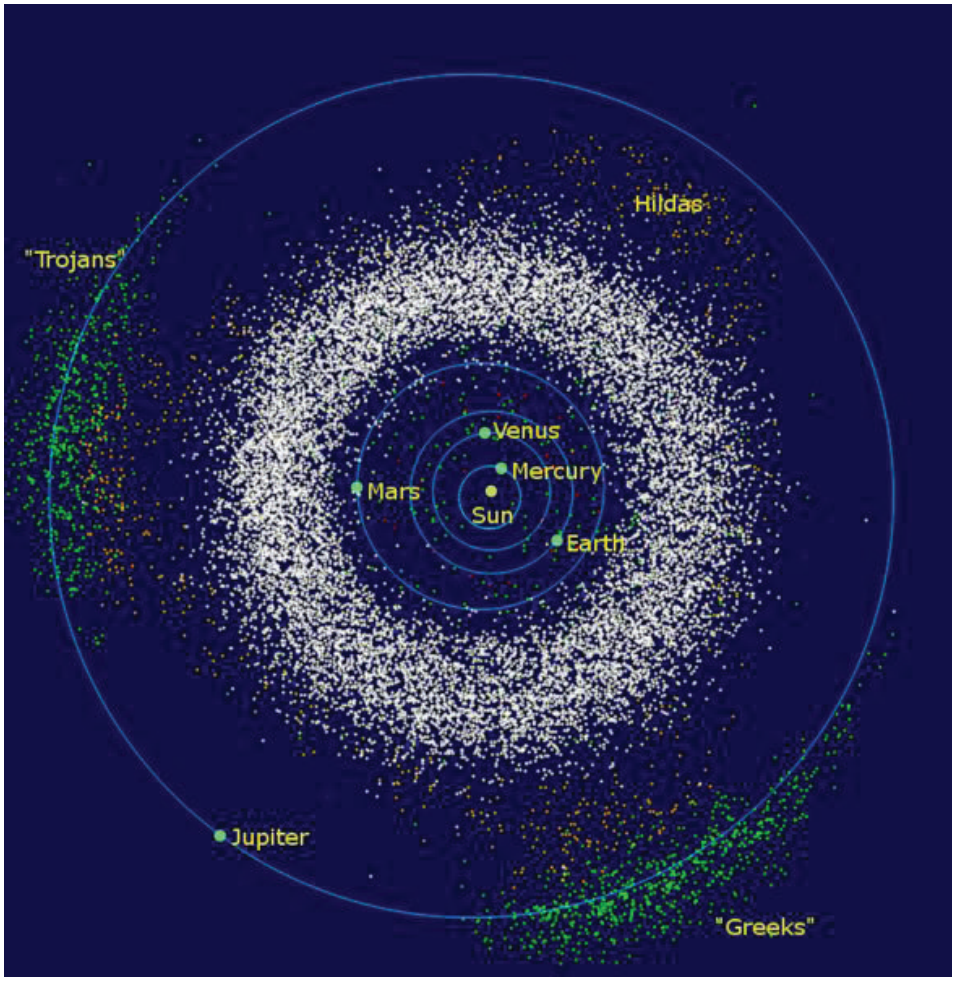
Planet orbits may have Trojan objects at their Lagrange points – Earth has one, Jupiter has millions.

NASA's spacecraft LUCY was launched on 16 October 2012 on a 12-year mission to visit several of Jupiter's Trojan asteroids. This mission will take three gravity assist flybys from Earth to visit Trojans at Jupiter's L4 and L5.

The Lagrange points of Earth's orbit are excellent spots for placing space missions – L2 was chosen for the JWST. It will be placed in a halo orbit to prevent the Earth's shadow from disabling its solar panels. L2 is about 1,5 million km from Earth and too far for human space travel.

L1 is well suited to heliophysics studies. No use has been found for L3 as it always remains obscured by the Sun. At L1, L2 and L3, objects can be placed in Lissajous orbits without any mass at the Lagrange point.

For a complete list of space missions utilising the Lagrange points of the Earth and other planets, click here.
The Hill sphere or Roche sphere of an astronomical body is the region in which it dominates the attraction of satellites. For more info, click here.



Distribution of Solar system Asteriods Jupiter Trojans are shown in green.

Mining activities on asteroids will be pretty different to Moon mining. It will not be possible to use roving vehicles due to the very low gravitation.

Mining will require machines tethered to the asteroid to prevent them from drifting away but will more likely be limited to gathering loose material or capturing whole asteroids. Capturing asteroids will require taking them to the Moon or placing them in an Earth orbit or a geostationary point to be processed further.

De-orbiting asteroids will be hazardous – a misdirected asteroid could become a high-speed meteorite that could cause catastrophic destruction on Earth.

The Chelyabinsk meteorite of 2013 had a size of 17 m and exploded at 23 km above ground, causing damage to 7200 buildings. Meteorites approaching the Earth can potentially reach escape velocity - 40 270 km/h.

For a video on dealing with asteroids threatening the Earth, click here.

NASA's OSIRIS-REx is an ongoing mission at asteroid 101955 Bennu, a 500 m wide carbon-rich rock hosting traces of the early solar system. The spacecraft arrived at Bennu on 3 December 2018 and successfully went into orbit around the asteroid on 31 December 2018.

In 2023, OSIRIS-REx's sample return capsule is scheduled to bring a piece of Bennu back to Earth. But first, the spacecraft will conduct an in-depth study of the rocky body and help scientists learn more about how sunlight can shift an asteroid's position.

The $800-million OSIRIS-REx (Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer) mission was named a finalist for NASA's New Frontiers mission class in 2009, along with missions to study Venus (Surface and Atmosphere Geochemical Explorer, or SAGE) and the Moon (MoonRise). In 2011, OSIRIS-REx was chosen as the winning proposal.

For extensive information and references on asteroid mining, click here.

Possibly the single most challenging, dangerous and costly part of any space mission from Earth is getting the payload launched, navigated and accelerated to escape velocity (40 270 km/h). The payload size seems almost insignificant compared to the gigantic launch rockets and thousands of tons of fuel, and rocket propulsion is highly wasteful of fuel.

Other proposals have been suggested, but let us first look at one that has actually been discussed for millennia.

This is the "Space Elevator", or as we shall see later, the engineering version of the "Beanstalk". The space elevator would consist of a tether of super-strength tensile material reaching from the ground to a space station in geostationary orbit or geosynchronous equatorial orbit (GEO).

The values of the various parameters are phenomenal. The distance to GEO is nearly 36 000 km (nearly the circumference of the Earth), but the

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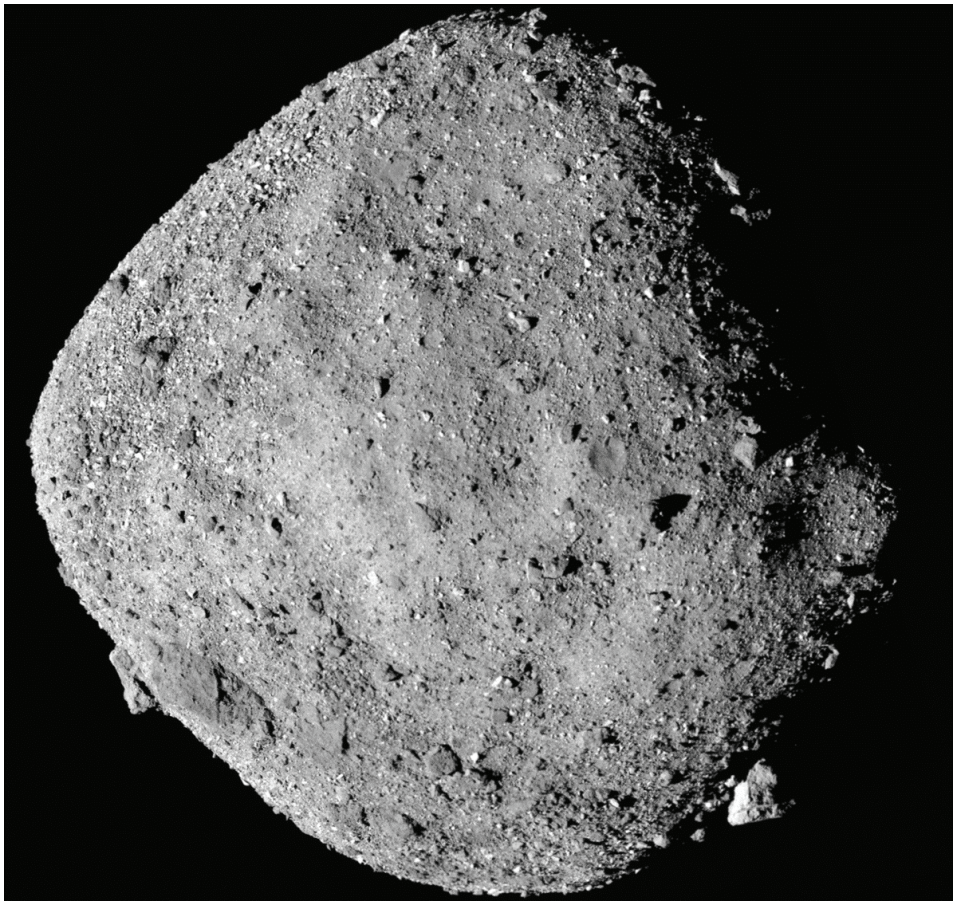


Asteriod Bennu as seen by NASA's OSIRIS-Rex probe on 2 Dec 2018.

tether would need to be much longer to reach a counterweight which would tension the tether.

This could be a captured asteroid or a giant space station for launching, receiving and refuelling spacecraft on asteroid or Moon mining missions. The station at GEO would be floating weightless and would not be able to provide any support to the tether. Applying force to the GEO station would cause it to de-orbit.

The GEO station will be a convenient spot for parking elevator cabins and mining spacecraft while not in use. Cabins running up and down the tether at 200 km/h would require 7,5 days for each trip. Operating the elevator would not require any energy as the energy required to run up would be more than compensated for by cabins coming down with payloads, which would generate surplus energy that the top stations could use.

The tether would need to be made of super-strength material with tensile strength in the hundreds of GPa range. The only possible candidate at present is graphene.

As an electrical conductor, it could also supply electrical DC power to propel the cabins. A worse problem for protection against lightning can scarcely be imagined. Supplying beamed power might be difficult or impossible to cabins swaying from the effects of wind and Coriolis forces.

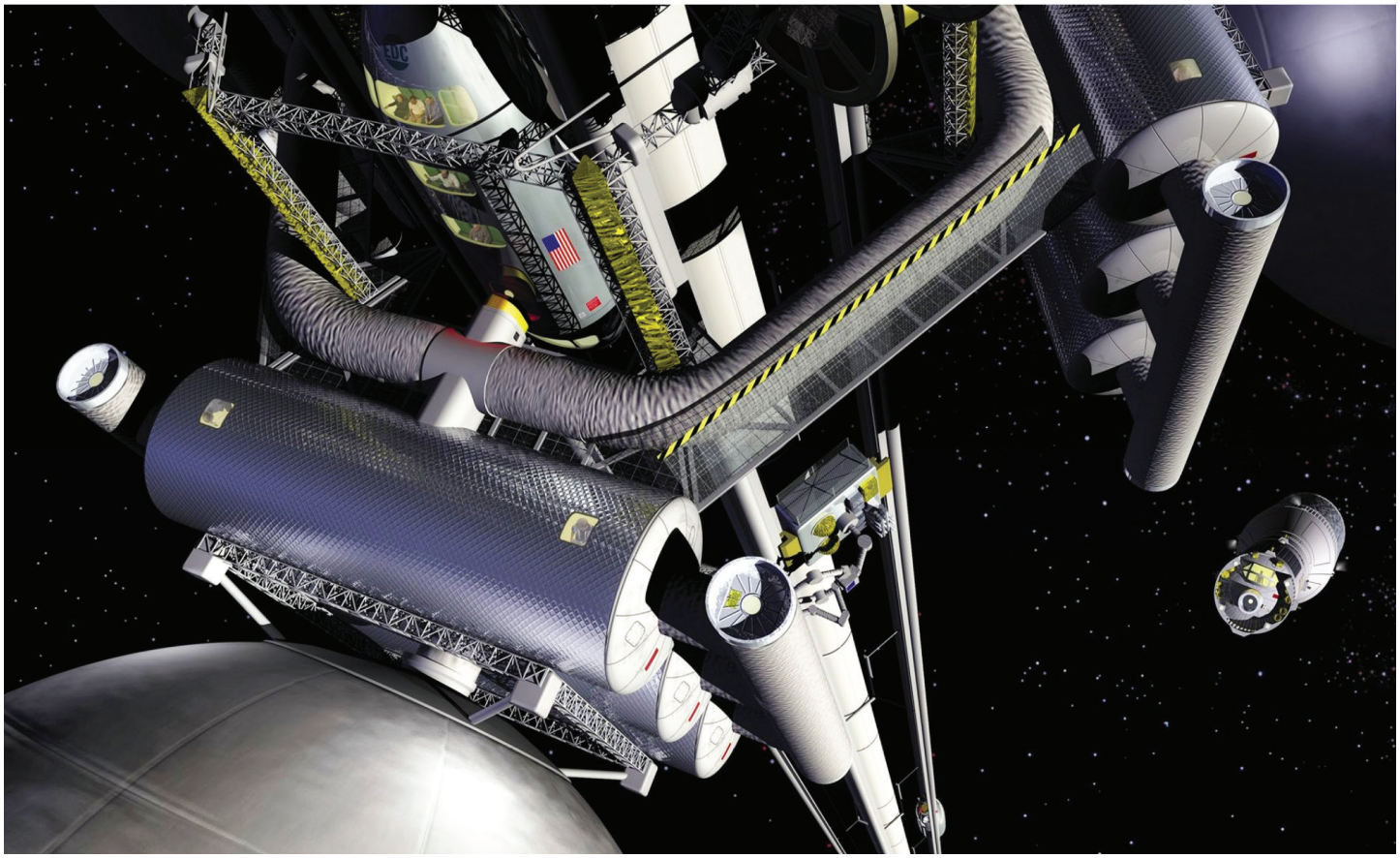
A large Ilgner set could be used to balance the power to and from the cabins. This massive piece of machinery could also help prevent the tether from being uprooted by the counterweight.

Construction of the elevator would have to start with the upper station and counterweight at GEO and extend simultaneously in both directions. There is no possibility of starting construction at ground level. If the tether can be made serviceable at an early stage of construction, it could be used for hoisting material for its own further construction. The GEO station and counterweight will require thrusters to keep them precisely above the Earth station if they drift out of position. It has been suggested that the Earth station should be installed on a ship so that the tether could be moved away from severe weather conditions.

An exciting aspect of the project is that Coriolis effects will play a significant role. Coriolis effects occur when a mass is moved inside a rotating reference frame. These are usually too small to be noticed but are highly significant to ocean currents and weather patterns. The movement and rotation are vector quantities requiring the use of vector algebra.

The simplest example of Coriolis force can be explained by considering a high-speed lift in a high rise building or a gold mine shaft.

As the lift moves upwards, there will be an eastward force on the cabin and going down a westward force. This force compensates for the change in tangential velocity as the distance from the centre of rotation changes. In the space elevator, with a cabin of 1000 kg and a speed of 200 km/h, the Coriolis force would be 4,04 N – not much, but sufficient to cause a considerable sway in a tether secured thousands of km away. It would be advantageous if the tether could accommodate cabins moving in both directions at the same time.



The Spaceline: an Elevator From the Earth to the Moon

Using multiple cabins in both directions will induce physical waves and harmonics in the tether, which will need to be considered in the tether design. Human occupants and the electronics of the cabins will need to be protected from the van Allen radiation belts.

The Coriolis effect is, like gravitation, an acceleration, which, if resisted, will be noticed as a force. The north-south rotation vector of the Earth, when taken as a cross-product with the vertical velocity vector of the cabin, will give an east-west acceleration vector.

Financing and managing the project would require the collaboration of the largest economies on the planet. The cost would be immense – possibly the greatest cost of any project ever contemplated.

The risks involved are quite possibly too significant even to consider the project at all. All the material, including an asteroid, would have to be taken to GEO by rocket propulsion. The tether would be continuously at risk from meteoroids, aircraft collisions and space junk.

The tether would also be at risk from stormy weather, lightning and sabotage.

Once severed, the lower part would collapse to the ground, and the upper part and counterweight would drift off into the ecliptic and possibly collide with the Moon.

For an optimistic look at the space elevator project, click here.

The cost estimate is given as $10 billion. For a detailed treatment of the space elevator, click here.

For a 2012 paper on geostationary points and centrifugal force of the counterweight, click here.

The space elevator concept is similar to the "Jack and the Beanstalk" fairy tale, sometimes used in Christmas pantomimes. The English fairy tales and nursery rhymes form part of the English cultural heritage.

Some of these have ancient origins; others are thinly veiled critical political comments from a time when making critical political comments was not a good idea. Reading absurd stories of brutality and violent death to children may seem questionable, but this is another story. Even the modern videos

of Tom and Jerry cartoons contain scenes of extreme brutality.

The story of "Jack and the Beanstalk" portrays Jack as either the heroic boy who brought great prosperity to his family or the villain, who stole the gold, talking harp and a golden egg-laying goose, from a cannibalistic ogre, who lived with his wife in a castle in the sky. Jack then murdered the ogre by chopping down the beanstalk.

The story does not mention the height of the beanstalk, but Jack was able to climb quickly up and down. Some versions of the story attempt to legitimise Jack's theft of the ogre's treasure and claim that the ogre came crashing down unharmed on a mountain's far side.

Researchers have determined that the story has Proto-Indo-European origins going back five millennia in ancient Sanskrit writings.

Shakespeare gives the story a fleeting mention in his play 'King Lear' by quoting the ogre's call-sign "Fee-fi-fo-fum".

The old idea of a ladder from Earth to the heavens as "Jacob's Ladder" was famous among great classical and romantic artists. Many magnificent works of art have been produced. Notable huge murals on the Jacob theme by Delacroix can be seen in the Paris St Sulpice.

Many artists depicting the ladder use all manner of ladders, including staircases, spiral stairways and even DNA molecules. An electrical Jacob's Ladder allows a high voltage arc to rise between two vertical, slightly diverging electrodes. In South Africa, this can be called a 'Jakobregop'.

The idea of building the Space Elevator, at present, seems to have little prospect of ever-rising above the ground. However, there is another fanciful idea, with no positive prospects yet, but Nikola Tesla is the protagonist. We come now to a discovery that will, for the first time, be more important than the discovery of the wheel and will launch the planet into an undreamed-of golden age of prosperity.

Tesla's famous comment:
"Throughout space, there is energy. Is this energy static or kinetic! If static our hopes are in vain; if kinetic - and this we know it is, for certain - then it is a mere question of time when men will succeed in attaching their machinery to the wheelwork of nature."

It is not known precisely what Tesla had in mind. Still, it would have been some theory of electro-gravitation that would allow gravitation control and provide some access to unlimited zero-point energy from space. We have a direct clash with general relativity where no control of gravity is possible and can never become repulsive.

Relativity describes gravity as a curvature of space-time that can have nothing to do with electromagnetism. (Few people can confidently claim to grasp the concept of curved space-time.) Gravitation can, however, produce gravitational waves which propagate at precisely the same velocity as electromagnetic waves. Newton described an inverse square law for gravitational attraction but could not explain how objects with mass could attract each other.

Newton also endorsed the particulate nature of light. Maxwell and Young proved the wave nature of light, after which de Brogli and Planck showed that particles have a wave nature. The clash of giants showed that both sides were correct – light has a particle-wave duality. Can we hope for a similar outcome for the clash between Einstein and Tesla?

With the implementation of electro-gravity and zero-point energy, it would be possible to dispense with all fuel and power distribution forms. With the required navigation systems in place, it would be possible for a child to safely fly a passenger aircraft using nothing more than a cell phone.

Autonomous containers could be used to move goods from anywhere to anywhere at negligible cost. How about placing a human habitat as large as an ocean liner on Mars? The possibilities for optical and radio observatories in space would be phenomenal.

Many pseudo-science books have been written over the decades, describing electro-gravitation and access to unlimited energy. However, we still do not see vehicles moving about without wheels or aircraft flying without wings.

There are numerous reports of UFOs seemingly flying about with apparent gravitation control and access to unlimited energy, but photographs of these are invariably blurred and out of focus. It seems that we will have to remain accepting that there is no such thing as a 'free lunch.

All is not lost – on 25 September 2021, it was announced that a multidisciplinary team from NASA, DARPA, MIT and Air Force personnel has been having Zoom meetings discussing the future of propulsion and anti-gravity. wn

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TOUCHING BASE WITH SAIEE BURSAR:

The Story Of Nonkululeko Mgidi

2020 Bursary Recipient

BY I EDUCATION AND TRAINING COMMITTEE, NONKULULEKO MGIDI.

The SAIEE Education and Training Committee touched base with Nonkululeko, the 2020 SAIEE bursar. The aim was to gauge her experiences as our bursar and hear what her career plans are as she takes on the next steps.
Nonku's story has a happy ending, and it is a feel-good story!

Q: Who is Nonkululeko? Where are you from, and how was the situation at home?

A: I am Nonkululeko Mgidi, a Bachelor of Technology (BTECH) graduate, born in Tweefontein G, KwaNdebele in Mpumalanga province. I grew up in a family of seven and my dad. My mother passed on when I was 12 years old. My background was not good at all, but my dad made means so that we would survive. I was the first one in my family to go to University, and that was pleasing because I wanted to set an example to my siblings since I was the fifth born. I was always passionate about education, so much so that most of my conversations with my peers were education-based. I knew that through education, I would be able to change my family's situation. I, therefore, needed to strive for greatness! I was chosen to be part of a maths and science program called Metropolitan Actuaries on the Move. They were tutoring us in Mathematics, Physical Science and English on Saturdays and holidays for free.

Q: What did you want to be when you grew up, what subject did you do at school, and how did you get to know about electrical engineering?

A: I wanted to do Chemical Engineering, Biotechnology or Biochemistry due to the program I entered in 2010, called Eskom Expo for Young Scientists. My project was about flu medicine "umhlonyana/inghana" in our language. My dream was to develop it and help people heal. I didn't apply before University when I finished my matric. I had to look for space, and I didn't find it on the Pretoria campus. I, therefore, chose electrical engineering because I didn't want to stay at home, but when we started doing practicals and the lights switched on, I fell in love with the course, and I knew I was at the right place.

Q: Getting to tertiary: which institution did you attend, how did you hear about it, and how was your experience as a tertiary level student?

A: I attended the Tshwane University of Technology Emalahleni Campus. When I was stranded looking for space in Pretoria, I saw a post on Facebook one of my friends posted saying she's going to Witbank. I enquired with her and then went there the following day and applied and got accepted. There were challenges, a lot of them because one had to be responsible and attend classes and complete assignments. You have to choose whether you are

going to attend that party before a test, or you will study. I won't lie, I did get carried away by the lifestyle at some point, and it cost me some years and my NSFAS financial support! I had to remind myself where I was coming from and why I was there in the first place. I was then able to pick myself up and choose to finish the race no matter the circumstances. It was not easy, but I managed to pull through.

Q: What financial complications did you face at tertiary?

A: There was a time when things got so bad when my dad lost his job, and I knew I would not have any money from home anymore. I then worked as a student assistant to be able to survive while I was accumulating outstanding fees. At some point, I attended without being officially registered! I had faith and a dream to complete my course and was not going to give up because things were not going the way I wanted. It took me negotiating year in and year out to make it through my tertiary studies. I finished my diploma but did not receive a certificate due to outstanding fees.

Q: How did you get to know about SAIEE and its bursary scheme?

A: In 2019, I was looking for employment after finishing my practical Training with Samancor Chrome Ferromatals. I decided to go back to school full time and do my BTECH. At the time, I needed funding, and I was looking and applying. One afternoon going through my LinkedIn account, I saw a post shared by SAIEE CEO about the bursary; I did not hesitate and applied. I then started paying attention to the organization and conferences. I got an opportunity to attend the Women in Engineering Breakfast by writing why they should choose me. That year, I attended two conferences with SAEEC, where I presented my Renewable energy paper. In 2020 I also attended a Fluke course with SAIEE that I managed to get four certificates that added to my CV.

Q: What impact did the bursary make on you and your future?

A: For me, this was a life-changing opportunity! For the first time, I received my Diploma in May 2020, and I was able to apply and attach my certificate, which felt terrific. This bursary came when I needed it the most during the pandemic, and I have served the purpose by ensuring I had the funding required for me to finish my qualification. When I graduated in June 2021 for my BTECH, I was pleased and proud that I would be receiving my certificate – unlike when I did my diploma. I am grateful for everything that SAIEE has done for me.

Q: What would you like to say to other black young women faced with the same difficulties?

A: Never sacrifice yourself and your integrity to have a seat at the table; the fact that you have started is proof enough that you will finish. Be firm and resilient both in the tertiary and the workplace. It took you years to acquire that degree/diploma and never allow the world to tell you otherwise. Be willing to work hard, believe in yourself and do your work so well that you are addressed as Engineer and not that female engineer.

Q: What do you do now? Are you where you wanted to be?

A: I am currently doing my Electrical Engineering Trainee program at Actom, Reid and Mitchell. I am planning on registering as a candidate Technologist with ECSA and acquiring electrical and mechanical experience. I may write my GCC factory in two years and become a professional certified Engineer. I am looking into furthering my studies next year, starting with my Master's degree, and I want to be a Doctor of Philosophy in Electrical Engineering.

Q: Where do you see yourself in the next 5-10 years?

A: I will Advance in my career, and I will probably be a mother and wife by then. The world is changing, and I will need to evolve with the fourth and the fifth Industrial revolution. I'm looking to enhance my skills in project management, renewable energy, and business courses to venture into business at some point and look into a management position. This means I want to learn and acquire knowledge with time and be relevant in the future.

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NOVEMBER 2021

DATE	TITLE
16/10/2021	An Introduction to Artificial Intelligence for Engineering Professionals
16/11/2021	Planning Strategic Feasibility Studies
17/11/2021	Power & Energy Section presents: Blockchain-enabled Transactive Energy Use Cases
18/11/2021	LV/MV/HV Switchgear Operation, Safety, Maintenance and Management
18/11/2021	KZN Webinar - LIGHTNING THREAT MANAGEMENT - What has changed and what will change?
23/11/2021	Finance Essentials for Engineers
23/11/2021	LIGHTNING CHAPTER - Lightning Evidence - the empirical data
24/11/2021	Writing Good Technical Specifications
24/11/2021	Design Thinking and Innovation for Engineering Professionals
29/11/2021	Fundamentals of Renewable Energy Plants
30/11/2021	Africa Research Journal Virtual Event

DECEMBER 2021

DATE	TITLE
01/12/2021	Fundamentals of Financial Evaluation of Projects
01/12/2021	Fundamentals of Power Distribution
01/12/2021	Technical Report Writing
01/12/2021	Legal Liability: Mine Health and Safety Act
07/12/2021	SDN/NFV Standards and Applications
07/12/2021	Fundamentals of Lighting Design
07/12/2021	Operational Regulations for HV/MV Systems
09/12/2021	Transformer Construction, Operation, Maintenance, Testing and Protection

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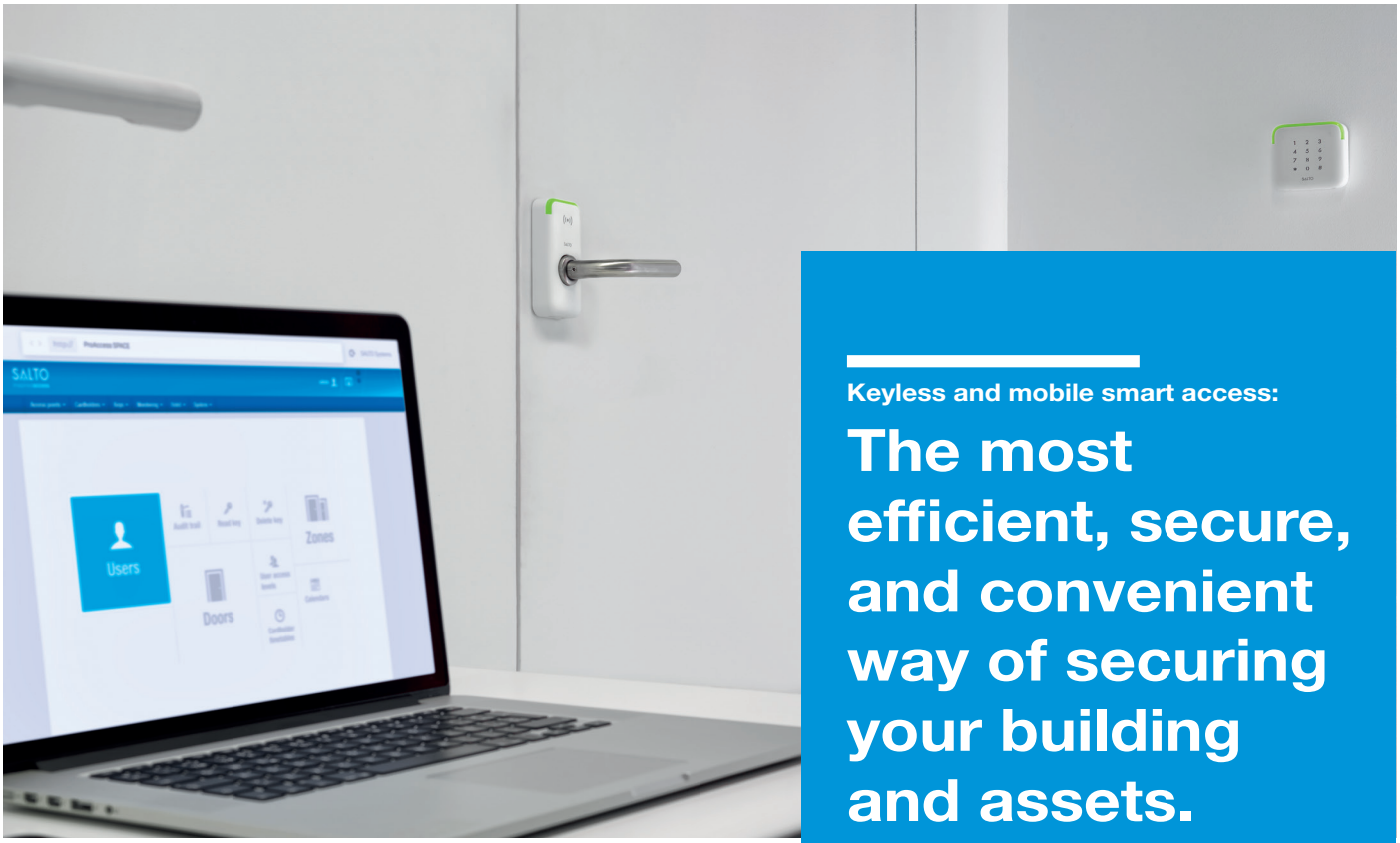

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