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SAIEE THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | JULY 2020

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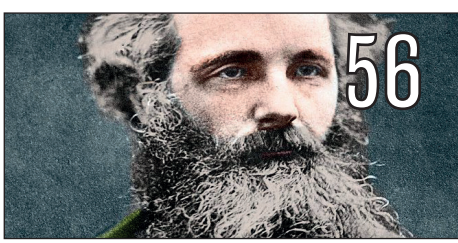

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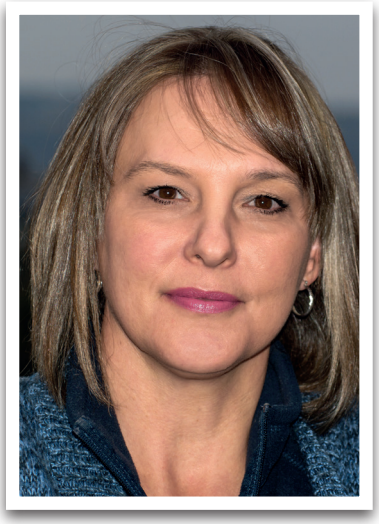

We are nearing the end of July, which means we are in the midst of a South African winter - which to me feels colder than usual - it must be my mind playing tricks on me!

This issue focusses on Communication and our first feature article is on "Television Whitespace" (TVWS) which can be described merely as unused space found between channels that are used in the ultra-high frequency (UHF) spectrum. Read this article on page 24.

Page 32 features an article on AI and ML in Telecommunication Systems, which focusses on Globalisation, and the growing scale of industrialisation, which have led to the formation of complex nexus environments.

The SAIEE has been very busy with webinars in the past month, and I urge you to click here to see our upcoming events/webinars or go to page 71 to find a comprehensive calendar which includes our very successful online CPD Training Courses, powered by the SAIEE Academy.

The next **watt**now Tech Talk will take place on the 20th of August 2020 at 13h00. Watch out for the announcement.

This online version of **watt**now is interactive. So, on the contents page, click on the page number of the article you are interested in, you will be taken directly to the page. When you are done, select the endnote (wn) which will return you to the contents page.

Here's the July issue,
enjoy the read!

Minx

For information on locally manufactured electrical plug ranges, see page 13

Motors I Automation I Transmission & Distribution I Energy Solutions I Electrical Construction

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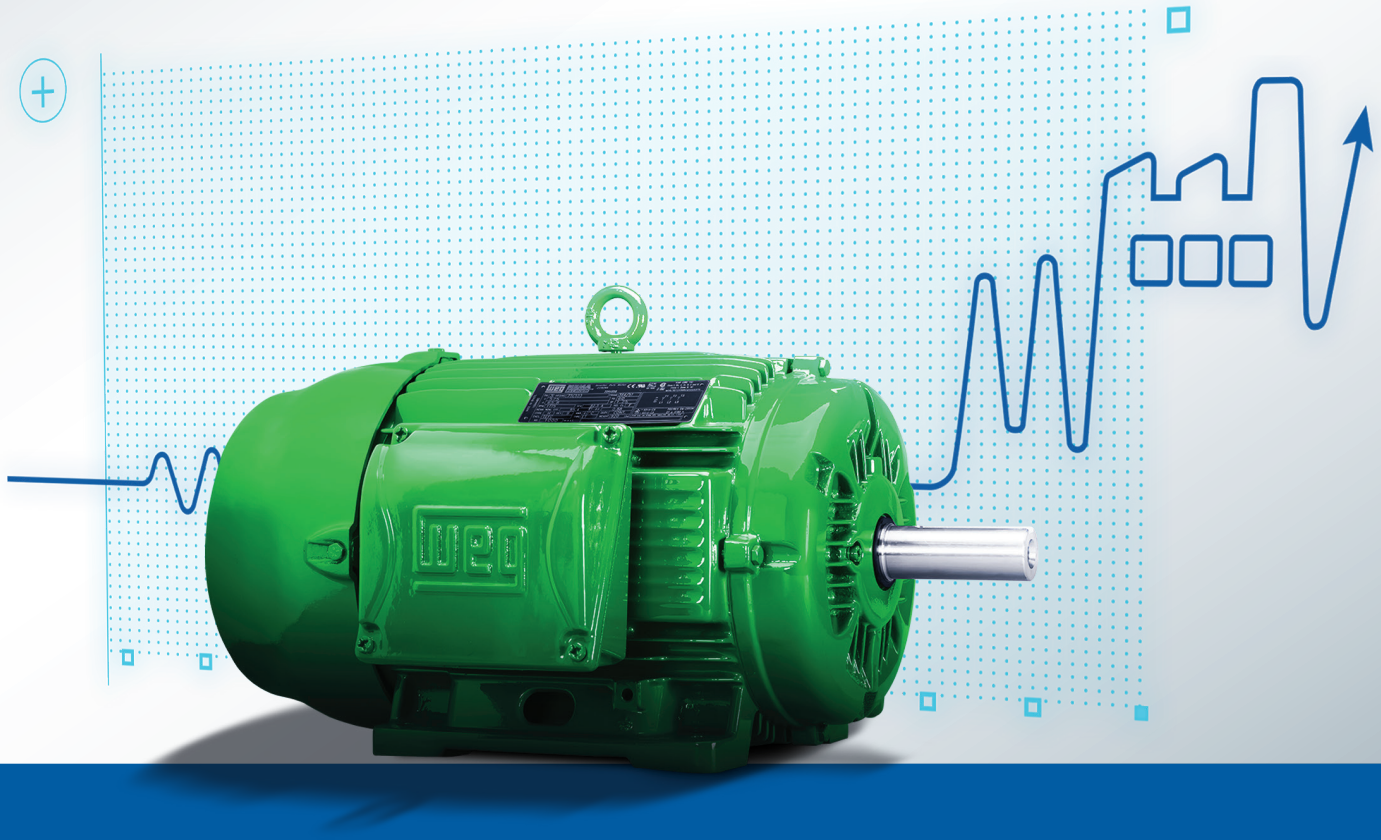

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SAIEE - in a time of Covid...

SY GOURRAH
2020 SAIEE PRESIDENT

Just as we thought COVID-19 was hard enough to handle, load-shedding was thrown into the mix. This has added to the already subdued economic growth that we currently face as a country.

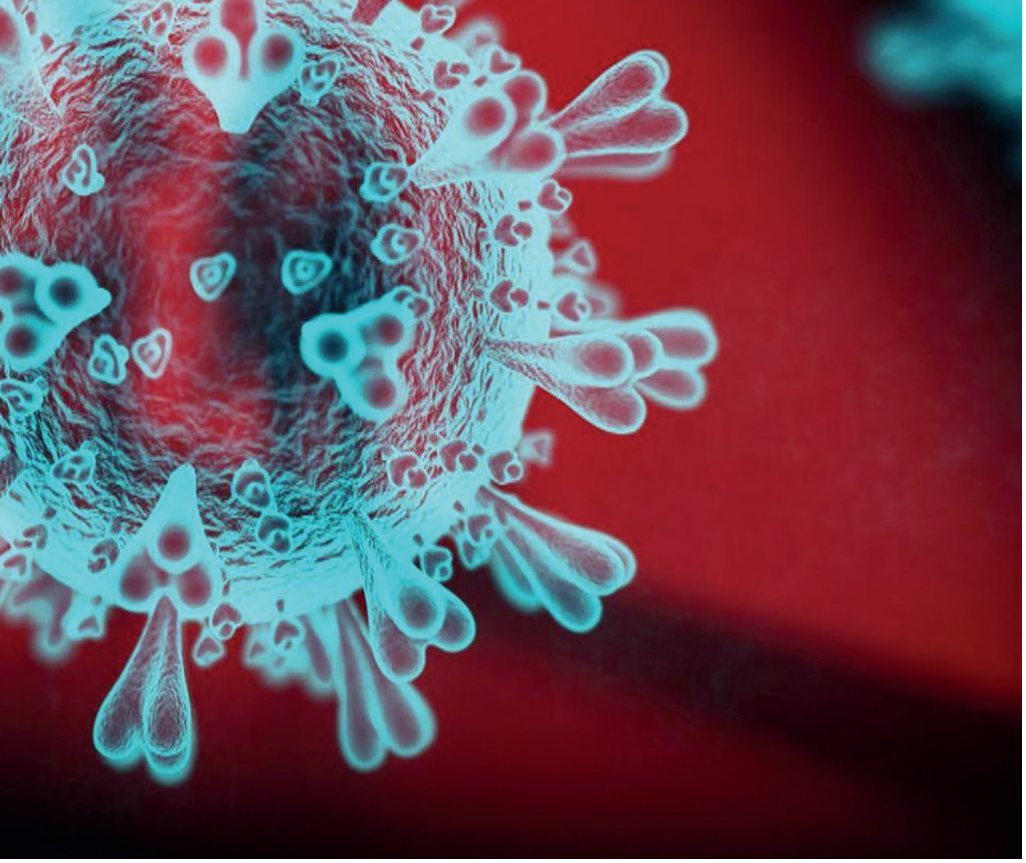
Eskom is said to have attended to much of its maintenance during the lockdown, the increase in demand, during the last cold spell, led to yet another shortfall in Eskom's generating capacity which resulted in rolling blackouts.

This has raised the question as to whether we should rely more on Renewable Energy to secure the country's electricity supply. This has thrust Renewable Energy into the forefront once again. The Minister for Minerals, Resources and Energy, His Excellence Gwede Mantashe, has called for a Ministerial Engagement with the various stakeholders of the Power Industry.

SAIEE was allowed to present our views on the roll-out of Renewable Energy. I must take this opportunity to thank our members who responded immediately to the call for comments. These were taken into consideration, given the limited time that we had, when we raised three issues. The Minister has further committed to exploring Renewable Energy by establishing a 25 member team representing all stakeholders.
The transitioning to renewable energy has increased the focus on a "Just Transition" state. The hydrogen economy has recently started to gain traction.

Our Chairperson of the newly formed Energy Storage Chapter, Professor Chandima Gomes, has a keen interest in the evolution of this emerging economy.

With the increased use of the internet, and with this, online meetings, cybersecurity has become one of the biggest concerns to any company. We have established a Cybersecurity Chapter, headed by Michelle Govender, and look forward to some exciting outputs from this Chapter. Another field of interest is the computing and automation of systems. With this in mind, the Electronics & Software Section approached Professor Fulufhelo Nelwamondo and Sam Lefohane to establish the Computing Chapter. Pascal Motsoasele is at the forefront of the establishment of the



Control & Automation Chapter. Watch this space!

The SAIEE WiE Chapter, chaired by Makgola Mokololo, had its inaugural webinar, and I look forward to engaging with them on the current issues facing women in the energy transition. Women contractors and women ownership have a significant role to play in many of the suggestions for future renewable projects.

Since the onset of COVID-19, our webinar offerings have increased exponentially and have been well received by our members. We have teamed up with the IEEE, and in collaboration with Cigre and the Southern African Power Pool, to host a series of webinars with the IEEE President-Elect candidate 2020, Professor Saifur Rahman, Virginia Tech, USA.

Council and committee meetings are being held online. However, the face-to-face contact meetings, along with the networking opportunities, is sorely missed.

With the increasing numbers of positive COVID-19 infections, it is of paramount importance to that you stay safe.

Please take the necessary precautions of wearing a mask, washing your hands or sanitising regularly. We have the power to flatten the curve.

Take care of yourself and your family, and stay safe.

Kind regards

S Gourrah I SAIEE President 2020
Pr. Eng I FSAIEE

COMMUNIQUE ON SAIEE PAST PRESIDENTS FORUM

GEORGE DEBBO
IMMEDIATE PAST PRESIDENT

The purpose of this communication is to give background and an overview of the Past Presidents Forum so that readers understand the history behind this forum, its status and meaning, and its relationship to the South African Institute of Electrical Engineers (SAIEE).

The SAIEE Past President's Forum (PPF) was formed about ten years ago by a group of Past Presidents with the prime objective of providing financial assistance to cover some of the costs for the serving President. In the past, serving Presidents were required to cover their SAIEE related entertainment costs themselves, for example, the refreshments that are served after Council meetings. In most instances, these expenses were in effect covered by their employer. As the Presidents elected began to come from local government and government institutions who did not provide their employees with such expense accounts, previous serving Presidents recognised the need for a fund at the time. Thus, Past Presidents personally contributed to a separate fund to assist the serving President. This was the embryo group of Past Presidents who invested the proceeds of their contributions in the Johannesburg Stock Exchange and made disbursements as seen fit. The Honorary Treasurer of the SAIEE was nominated to manage this fund, called the President's Purse.

Over time the PPF's purpose has also evolved to providing support, advice and guidance to the President and Office Bearers of the Institute using the vast amount of institutional knowledge and experience that resides within this group of living Past Presidents. The funds that have been accumulated by the PPF within the Past President's Purse have also over the years been used to grant scholarships and bursaries to candidates with exceptional academic records and to fund a pension scheme for the SAIEE staff recruited from the defunct AS&TS.

In terms of governance, it is essential to note that the PPF is an independent body and is not subject to the Constitution or By-Laws applicable to the SAIEE. The PPF and any of its assets exist separately from the SAIEE, and this includes the Past President's Purse which was created using funds donated by previous Past Presidents and invested wisely and not funds derived from the SAIEE's operations. However, for the time being, the funds within the Past President's Purse are

managed by the SAIEE, and for this, the PPF pays the SAIEE an annual management fee. This arrangement is like any of the other external funds (e.g. SAUPEC) that are managed by the SAIEE.

The PPF is chaired annually by the Immediate Past President (IPP) and in terms of its policy is required to meet twice a year. At its first meeting which is held around May, the Past Presidents may deliberate on the composition of Council in terms expertise, racial and gender mix, and make recommendations to the President including possible candidates for co-option onto Council. It is also at this meeting that the Past Presidents will discuss and decide on any new scholarships or bursaries that are to be awarded from the Past President's Purse.

At the second meeting which is held in November, the Past Presidents discuss and agree on a nomination for Junior Vice President for the following year which is presented to Council by the IPP at the Council meeting at which the Junior Vice President is elected. The PPF nomination for Junior Vice President fully aligns with the requirements for this position as laid down in the SAIEE Constitution and By-Laws and competes against any nomination for Junior Vice President made by any other members of Council.

In conclusion, the PPF is simply a social gathering of living Past Presidents. It has no official or decision-making responsibility or power within the SAIEE, and there is no obligation on the part of the President or the Office Bearers to heed any advice or recommendations made by the PPF. It is responsible for its own funding which it uses to support the award of bursaries or scholarships as well as to finance its own operations.

G Debbo | SAIEE President 2019
Pr. Eng | FSAIEE

INDUSTRY AFFAIRS

Hitachi ABB Power Grids commences operations

In accordance with the agreement signed on 17 December 2018 [1], Hitachi Ltd. and ABB Ltd announced the completion of all required procedures as planned and the formation of Hitachi ABB Power Grids Ltd. on 1 July 2020. Hitachi has an 80.1% stake in this new joint venture entity, which has a business volume of approximately US$10 billion, and ABB holds the balance.

Toshikazu Nishino, Executive Vice President of Hitachi, is the Chairman of the new entity and Claudio Facchin the CEO. The new entity is headquartered in Zurich, Switzerland. The current management team will ensure business continuity.

"Hitachi's leading digital technologies merged with world-class power grid solutions will help us to play an active role in the global transformation and decarbonisation of energy systems for a sustainable energy future. Intelligent solutions for a more dynamic grid will also contribute to the UN's Sustainable Development Goal 7 of 'affordable, reliable and clean energy'," said Nishino.

The joint venture brings together two highly respected companies to create a new global power leader. The alliance with Hitachi will facilitate expansion opportunities for the new entity in areas such as mobility, smart cities, industry, energy storage and data centres, besides providing financial muscle to support ambitious projects and enabling access to Japan, the third-largest economy in the world.

"Synergies and access to new and growing markets provided by Hitachi will help take Power Grids to the next stage of its development, further strengthening its leading position," said Timo Ihamuotila, CFO of ABB and Director of the Board of Hitachi ABB Power Grids. *"Hitachi brings long-term commitment to the new entity and strengthens the existing business partnership between our companies,"* he added.

"Combining our respective technology strengths will bring us new market opportunities and enable us to deliver greater customer value," said Facchin. *"We remain committed to powering good for a sustainable energy future, with pioneering and digital technologies, as the partner of choice for enabling a stronger, smarter and greener grid."* wn

Pump manufacturer's message to Southern Africa

Hundreds-of-millions of people throughout Southern Africa who rely on KSB pumps for their everyday water and sanitation, electricity, agriculture and industrial requirements can remain safe in the knowledge that the pump manufacturer is fully supporting its products through the Covid-19 pandemic.

KSB Pumps and Valves in South Africa has worked tirelessly through trying times to service the needs of branches and customers throughout the region. The company even made special arrangements to manufacture essential equipment, travel and supply services during the toughest Level 5 lockdown level in South Africa.

KSB Pumps and Valves board are from left (back) Dr Sven Baumgarten, Chairman, Mr Clinton Harris, Operations, Mr David Jones, Sales and Marketing, Dr.-Ing. Stephan Bross, Director, Mr Grant Glennistor, SupremeServ, Mr Peter Weber, Managing Director, Mr Friedrich Gorgens, Technical, Mr Michael Erasmus, Finance. Front: Ms Nonhlanhla Ngwenya, Director, Mrs Shonah Smith, Human Resources, Ms Matshepiso Finca, Director.

Some of the efforts have been shared in a special video message, which details some of the lengths the company has undertaken to "keep the lights on and water flowing". The video also serves as a warm message from the company while its sales and after sales staff are unable to travel across borders.

WATCH the KSB Pumps and Valves video. wn

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For more information visit the SAIEE website or email reception@saiee.org.za.

SAIEE

MTN and Ericsson launch live 5G network in Bloemfontein and Port Elizabeth

From left: Giovanni Chiarelli (MTN) and Fadi Pharaon (Ericsson)

MTN South Africa announced the availability of its 5G commercial offering using Ericsson (NASDAQ: ERIC) products in the cities of Bloemfontein and Port Elizabeth.

The MTN 5G launch is central to the mobile operator's commitment towards accelerating Africa's growth plans. The launch confirmed Ericsson's ability as a Core and Radio Access Network (RAN) infrastructure enabling the deployment of next-generation technology to deliver rich consumer experiences while building a robust, future-proof 5G network.

MTN previously upgraded to Evolved Packet Core (EPC) by Ericsson which enabled MTN to launch 5G services based on new radio (NR) non-standalone (NSA) while paving the way for a smooth evolution into NR Standalone and 5G Core (5GC) in future.

Under the 2019 Memorandum of Understanding (MoU), Ericsson committed to provide MTN with radio access network equipment from its Ericsson Radio System portfolio, which enable 5G services on both low- and mid-band. Ericsson's solutions to MTN also includes the award-winning Ericsson Spectrum Sharing.

Giovanni Chiarelli, MTN SA's Chief Technology and Information Office says: *"5G has the potential to accelerate the digital transformation of industries, as well as empower consumers with innovative applications. Our strategic partnership with innovative partners is integral to our efforts."*

Fadi Pharaon, President of Ericsson Middle East and Africa says: *"Today's event means that the 5G era in South Africa is becoming a reality. Soon, South Africans will be able to experience 5G in their daily lives and witness its positive impact on society and industry. We have a rich history of working in close partnership with MTN and now we are going live with 5G in South Africa. With many live commercial 5G networks across the globe, we look forward to continuing our long-standing partnership with MTN, jointly leading and driving innovation to ensure the digitalization of Africa."*

Ericsson Spectrum Sharing will enable MTN to quickly launch 5G services over a wide area and successively expand 5G coverage in a tailored way by re-using existing network infrastructure and taking advantage of previous spectrum investments.

MTN can therefore provide 5G commercial services and move towards Standalone (SA) 5G without the need for blanket costly re-investment. Industries such as transportation, healthcare and manufacturing can leverage 5G capabilities to accelerate digital transformation and deploy advanced automation technologies.

Ericsson currently has 95 commercial 5G agreements and contracts with unique operators, of which 55 are publicly announced 5G deals, including 43 live 5G networks on five continents. wn

Commuting will benefit from 5G connectivity.

The winning tech solution for Hackathon Life 2.0!

Capitec Bank, South Africa's leading digital bank, is pleased to announce the winner of its first-of-its-kind hackathon competition. The finalists presented their tech-led solutions to simplify post COVID-19 last week. After long consultations, the seasoned judging panel was able to decide on a winning idea and award the incredible R100 000 grand prize to the Guardian Health team.

Francois Dempers, Capitec's Manager for Innovation and Digital Strategy, says, *"We devised this hackathon to bring brilliant minds together to solve shared challenges and help South Africans to live better in a post-pandemic world. We were blown away by the results. It was extremely tough to select a winner and we congratulate the Guardian Health Team. The elegance and simplicity of their design absolutely aligns with Capitec's continuous drive to innovate through smart solutions that add real, lasting value."*

The winning Guardian Health team – comprising Tsitsi Marote and Tino Manhema – focused on facilitating virtual interactions between the public and health professionals. They created a digital filing system of user profiles so that patients can access their own data and set up virtual consultations to limit the risk of going into overcrowded hospital spaces.

"COVD-19 came at a time when the world, including South Africa, was not ready in terms of digital platforms. One thing we've learned is that we need to change how we do things to meet such challenges," said the Marote and Manhema.

The judging panel consisted of Sbusiso Kumalo - operations manager at Capitec Bank, Dave Glass - CEO of Electrum, and Nicola Nel - founder of Atmosphere Communications. Deciding on the winning idea was no easy feat, with all three judges stating the level of creativity and ingenuity made it tough to choose a clear front-runner.

Dempers finds the quality and quantity of entrants very encouraging. *"It was clear from the start that there is no shortage of great ideas coming out of South Africa. Capitec is guided by simplified solutions in all aspects of our business. This competition is an example of all the kinds of transformation we need."*

The Hackathon was themed around innovative ideas – from automated keypads to making healthcare more accessible – and all the teams and their amazing ideas have been actively showcased on the Capitec LinkedIn page.

The advisors included well-known tech leaders such as Baratang Miya, CEO of GirlHYPE; Annette Muller, founder of FlexyForce; and Charl Greeff, Head of Engineering at One Day Only. Rounding out the mentors were Stuart Ntlathi, founder of the Stuart Ntlathi Science, Engineering and Technology Institute; Tumi Sineke Head of OfferZen Foundation; Luvuyo Rani Founder of Silulo Ulutho Technologies; and Francois Dempers, Innovation Manager at Capitec.

Sbusiso Kumalo hopes that other industries will create similar initiatives to inspire solutions to problems facing local and global communities. *"All of the ideas that were presented had amazing resourcefulness and creativity. I'd like to see other companies foster the support to see these ideas brought to life."*

NWU engineers walk away with international award for tackling Covid-19

An initiative from the Faculty of Engineering at the North-West University (NWU) was recently honoured with an international award from the Covid-19 Innovation Challenge of the United Nations (UN) Africa Innovation and Investment Forum 2020.

According to Jean-Paul Adam of the United Nations Africa Innovation and Investment Forum, the novel coronavirus is threatening to undo the hard-earned health, economic and social development gains that Africa has registered since 2000.

"Covid-19 has overrun the well-resourced healthcare systems of some developed and developing countries, and several organisations, including the World Health Organisation, have issued cautionary statements encouraging African countries to boost their healthcare capabilities to meet the impending surge in infections."

Adam says Africa traditionally depends on external supplies of medical equipment, diagnostic reagents and tools, protective gear and medicines.

"With a global scramble for limited medical supplies, Africa may have to turn inwards. The continent may need to leverage the limited technology and innovation capabilities and harness and stimulate its full entrepreneurial talent to respond, deepen national and regional supply chains and optimise global knowledge partnerships to meet the challenges posed by Covid-19 and beyond."

It is in this regard that the United Nations Economic Commission for Africa and its partners invited researchers, firms, public and private development agencies, government leaders, innovators, youths and development partners to showcase their innovations at the first Africa Innovation and Investment Forum 2020. The focus of the forum was on Covid-19, and it took place from 15 to 19 June 2020.

According to Prof. Leenta Grobler, project leader and specialist in health-related engineering innovations, their Covid-19 screening solution involves the digitalisation of the screening and data-capturing process.

"TjopTjop is a mobile app-based system that conveniently collects and stores the health vitals of students, learners, staff and customers without the paperwork. It saves considerable time and effort at screening points, stores data safely off site and relays or reports selected data packets to designated addressees. It requires basic electronic thermometers and smartphones that are commonly available. It currently operates on Android phones, but the Apple app version is already under development."

An Excel-format list can be created for participating schools, containing every authorised person's identification number, name and designation (grade and class, teacher, parent or department) and an emergency contact number. This information is encoded by the NWU's engineering team as a QR code and printed on an ID card, which can be provided to every learner.

Prof. Leenta Grobler, project leader and specialist in health-related engineering innovations

The UN's Innovation Challenge 2020 identified and showcased some of the top technologies and innovations from across Africa and beyond, explored investment and market needs and identified business opportunities.

The NWU's TjopTjop initiative came out top of its class. *"In the category of 'contact tracing', we would like to congratulate Prof. Leenta Grobler and her team for the excellent innovation that they presented. It is wonderful to see Africa responding to the Covid-19 challenges,"* Adam says.

Prof. Leenta Grober was over the moon about receiving the award for the TjopTjop initiative! *"It is a great honour to receive this recognition from such a prestigious organisation. I sincerely hope that TjopTjop will help us all get back to school and back to business and move towards a post-Covid-19 world."* wn

ACTOM awarded MV switchgear replacement contract at Tutuka power station

Eskom has awarded ACTOM a R1.18-bln contract to perform comprehensive MV switchgear replacement at Tutuka power station near Standerton in Mpumalanga.

The six-year contract, one of the largest-value contracts ever to be won by the group, was signed by Eskom on December 5, 2019, after a prolonged tendering and negotiation process dating back to mid-2016. It involves replacing and upgrading the medium-voltage switchgear and all associated equipment and systems in the power station's six generator units and in its common plant.

Tutuka, one of many of Eskom's coal-fired power plants that have been in operation for more than 30 years, has been selected by the utility for comprehensive refurbishment to extend the life of the station.

Five ACTOM divisions are involved in the project, with ACTOM MV Switchgear as main contractor and ACTOM Contracting taking overall responsibility for the project management and coordination of the contract as a whole.

The contract – divided into six contract packages allocated to ACTOM MV Switchgear, ACTOM Protection & Control, Static Power and ACTOM HVAC Systems.

Kevin Saunders, ACTOM Contracting's Contracts Manager and Principal Project Manager for the total Tutuka refurbishment contract, who the respective contract managers responsible for each of the six contract packages will report to for the duration of the contract, said: *"We devised the overall management structure to handle the contract both on and off site. Among the things this covers are the overall coordination of the business units involved and a single point of contact with Eskom. It is also aimed at ensuring that there is no duplication of facilities within the group.*

"All the design issue responsibilities rest with the individual business units, including each being responsible for the interface between them and the other units," he added.

ACTOM Contracting's contractual and project management responsibilities include contractual due diligence, scheduling and time management and the commercial and financial aspects of the contract. In addition, it is responsible for human resources (HR) and industrial relations (IR) functions for the entire contract, as well as attending to all quality, safety, health and environmental requirements. *"We also have to conduct the scheduling and timing to align with the outages, which involves fitting in with Eskom's requirement of when outages take place,"* Saunders commented. wn

Tektronix' Industry-First with New All-In-One 2601B-PULSE System SourceMeter®

COMTEST is pleased to announce Tektronix Inc.'s new 2601B-PULSE System SourceMeter® 10µs Pulser/SMU Instrument, integrating a high-speed current pulser with DC source and measurement functions in one instrument. The new system incorporates PulseMeter™ technology for sourcing current pulses as short as 10µsec at 10A and 10V without the need to manually tune the output to match device impedance up to 3µH. This is critical for minimizing device self-heating, which for optical devices, can result in erroneous measurements and the potential for damaging test equipment. The new 2601B-PULSE also includes all current and voltage source measure unit (SMU) ranges that are available in Keithley's standard Model 2601B System SourceMeter® (40V, 3A DC, 10A Pulse). In addition, Tektronix is also releasing version 2.3 of Keithley's Instrument Control Software "KickStart" to support the pulsing function of the 2601B-PULSE. For more info, email: sales@comtest.co.za wn

ABB to power the world's largest diamond recovery vessel for De Beers

ABB will supply an integrated power system package that will ensure the world's largest and most technologically advanced diamond recovery vessel meets exceptional safety, efficiency and availability requirements. The vessel is being built by Damen at Damen Shipyards Mangalia on the Black Sea in Romania. Financial details of the order were not disclosed.

With a total cost of $468 million, the vessel is the largest single investment ever made in the marine diamond industry. It deploys advanced subsea crawling – a technique for recovering diamonds from the seabed. The newbuild will be delivered to Debmarine Namibia, a joint venture between the Government of the Republic of Namibia and De Beers Group in 2022. De Beers Group is the world's leading diamond company, with unrivalled expertise in the exploration, mining and marketing of rough diamonds, driving it forward since 1888.

Namibia has the richest known marine diamond deposits in the world, with Debmarine Namibia extracting some of the highest quality diamonds available anywhere from water of between 90-150 meters deep off the south west coast of the country. Traditionally, onshore along the coastline of Namibia, diamond mining is done in open-cast mines, however, with the land-based output in Namibia expected to run out in 15 years, offshore mining is on the rise.

The new 177-meter ship has been designed by renowned Norwegian naval architects Marin Teknikk. It will become the largest ship in the owner's fleet, exceeding the size of Debmarine Namibia's current largest vessel, the Mafuta, by 8,000 tons displacement (vessel weight based on the amount of water displaced by the hull). It is expected to increase the shipowner's annual production by 35 percent, contributing additional 500,000 carats to today's production levels.

The offshore mining specialist has previously installed ABB's power systems on board the SS Nujoma (SSN), Debmarine Namibia's deep-water diamond exploration and sampling vessel. *"The success of the SSN, with high reliability, efficient positioning and low fuel consumption coupled with safe operation, was instrumental in selecting the same systems for the new diamond recovery vessel, with ABB's power systems being and integral part of the solution"* said Michael Curtis, who is heading the newbuild project for Debmarine Namibia.

The latest ABB technology will ensure that the vessel achieves unsurpassed uptime. In addition to the advanced system for power generation, distribution and variable speed drive propulsion systems, the solution includes a large online double-conversion marine uninterruptible power supply (MUPS) to support the ship's vital control processes, significantly reducing the risk of critical power loss and downtime. ABB's MUPS is designed for undisrupted availability, ensuring power backup for the vessel's onboard control systems of the subsea-crawler and processing plant that sorts through sediment lifted from the seabed to extract diamonds.

"ABB is trusted globally as a leading engineering company capable of delivering solutions for advanced and complex custom-built vessels. We are delighted to be working with them as part of a landmark newbuilding project for both companies," said Mark Vermeulen managing director Damen Offshore & Transport. wn

ZEST WEG GROWS AFRICA BASE WITH LOCAL PARTNERS

Zest WEG on a copper Mine in Kitwe, Zambia

"The key to sustainable growth in Africa is partnering with locally owned companies who have proven track records, are technically sound, have a strong market knowledge and business culture aligned with our own", Taylor Milan, Africa business development executive at Zest WEG.

The company, a fully owned subsidiary of WEG, currently has 28 appointed partners in 22 sub-Saharan African countries outside of South Africa, and is expanding its footprint into new sectors across the regions. With extensive manufacturing and assembly facilities in South Africa, Zest WEG is driving its African growth strategy through local partnerships with carefully selected Value-Added Resellers (VARs).

"The local content mandate is playing an increasingly important role in the supply of equipment and services into the formal business sector across the African continent," says Milan. *"It brings services closer to the customer, while empowering local business and building local economies."*

He highlights that the company's VARs are also chosen for their technical and operational capability and capacity to offer customers more of Zest WEG's portfolio of products and services.

"While our early offerings focused primarily on electric motors, the company now promotes a comprehensive portfolio of electrical products and solutions," he says. *"These include geared motors, low and medium voltage drives and automation, panels, MCCs, E-houses, power and distribution transformers, mini-substations, a selection of traditional and renewable and hybrid power generation solutions as well as electrical infrastructure and mobile solutions."*

Milan notes that the business is also diversifying beyond mining into other sectors, notably oil and gas. On a global level, WEG has been active in this industry for many years and has built a strong industry specific product portfolio and knowledge base. Other sectors where gains are being made in sub-Saharan Africa are agriculture, general industry, water, cement and utilities.

The company's on-the-ground presence has been strengthened recently with the appointment of established local company Panaco as its VAR in the Katanga region of the Democratic Republic of Congo, Magare Company Limited in Tanzania, and Repelectric in Kenya with a number of other appointments currently being finalised across sub-Saharan Africa.

"Zest WEG's Africa network is also increasing the number of local repair facilities that meet OEM standards," Milan says.

"It is of considerable benefit for customers to have localised WEG-accredited repair facilities in-country," he says. *"This increases local support, while ensuring that equipment repairs are carried out in accordance with WEG specifications to deliver the performance and longevity that customers and OEMs expect from WEG products."* wn

Electricity tariff complexity could see more defaulters, municipal strain

Many South Africans have been working from home over the last three months. Together with the electricity tariff hikes in effect from 1 July, most residential users will be in for a shock when it comes to their electricity bill. Complex tariffs are not only frustrating, but are hindering attempts by the consumer to manage their electricity costs in a time when, for most people, every cent counts.

"Electricity tariffs factor in the costs to build, finance and maintain the grid. It is both reasonable and desirable that Eskom and our municipalities receive enough funding so that, with proper management, they can keep the lights on and our economy growing. The trouble, however, is that over the years our electricity tariffs have become so complex that consumers are bearing the brunt of an opaque creation that is resulting in higher bills and defaulting consumers," says Michael Franze, Citiq Prepaid Managing Director.

In 2010 the energy regulator, NERSA, recommended its inclining block tariffs (IBTs) in an effort to provide cross subsidies for low income domestic consumers and encourage energy efficiency. On its website it has published a study where it defends the efficacy of the solution. However, Franze says despite its obviously good intentions, the complexity of the tariffs is hindering energy saving efforts and the confusion can result in suboptimal consequences, exacerbated by the current economic climate.

"The better solution is to match the tariff structure to what people can understand and the capabilities of meters and systems. Most residential meters can only measure kWh and give users no tariff feedback," explains Franze.

He goes on to give an example: *"If a meter could signal to the user that they have now exceeded their allocation in the first block of an IBT and they are moving into the next, more expensive one, then this would help modify user behaviour, as Nersa intended."*

However, this is not the case and Franze continues: *"With a postpaid sub-meter the user will find out months after the fact with no opportunity to modify behaviour. And only when municipalities actually print the tariff blocks on their invoices, which many do not do. For prepaid sub-meters, meanwhile, people will buy credits for the month and the only indication of the tariff blocks will be on the receipt. And, when they buy for more than one month, they end up paying more than if they waited to buy again the following month. It is unrealistic to expect people to translate the IBT into something intelligible, even if they have access to the information and take the time to understand it."*

LANDLORDS HAVE ADDITIONAL HEADACHES

While the electricity end-users have their own challenges, Franze says these are exceeded by landlords who, he says, are faced with bills that are even more complicated.

"The landlord bill can be very complex

and almost impossible to translate into a tariff for their tenants. Maximum Demand Charges or Seasonal Tariffs might make sense for industrial users but residential tenants typically have no control over these variables."

Franze believes it unfair to expect a tenant to understand that, for three months of the year, their tariff jumps threefold. Rather, he believes it would be better to simply have a slightly higher tariff in low usage summer months to make up for the higher cost in winter.

Similarly, he points out that the Reactive Energy charge (a charge for 'non-working' power, or power that has to be made up due to inefficiencies at the customer's load source) is only measurable with industrial meters.

"These industry complexities cause huge headaches for the landlords and often result in tenants either over or underpaying. This leads to disputes and non-payment, the knock-on effect of both of these can even result in evictions."

KEEP IT SIMPLE

Franze believes that both Eskom and the municipalities would benefit from a simple, flat kWh tariff with lower rates for indigent users. What's more, additional billing items such as daily and flat charges should be avoided.

"Creating a tariff structure that people understand will improve confidence in tariffs overall, lower disputes and cut down on non-payment.

At the moment we are stuck with complex tariffs that can only be justified with user education. But this education is sorely lacking. A glaring example is that the Tariff increases would have gone live without being published on most municipal websites. For example, on the City of Joburg website, the tariff update was only published on 6 July. The City of Cape Town's publication of their updated tariffs are ok, but not that of the City of Ekurhuleni, which last published their tariffs in 2019 nor that of the City of Tshwane, which still reflects outdated tariffs.

And then we have some really poor municipalities. Buffalo City last shared their tariffs three years ago.

And then when the correct tariff is published it is almost unintelligible to somebody outside the industry. This example is from the published City of Cape Town tariffs (and the tariff is actually quite simple).

Unfortunately for both landlords and tenants very few municipalities will have the new 1 July tariff structure published anywhere for the next few weeks or even months. We can expect some confusion and anger from consumers, and, given our fragile power system, additional non-payment pressure is not ideal," Franze warns. wn

Finding our 'just transition' away from coal

On South Africa's energy landscape, a vision is taking shape – to not just a move away from burning coal for power, but to do so in a way that creates opportunities for those with the most to lose. SRK Consulting is focused on two key aspects of this process: the ongoing development and implementation of best practice in responsible coal mining; and contributing toward an understanding of needs to be met in a just transition to a less carbon-intensive future.

It has been over three years since Eskom announced the imminent closure of five of its coal-fired power stations. This was generally welcomed as one of the necessary steps on the road towards meeting the country's environmental commitments as a signatory to the Paris Accord.

At the same time, however, this announcement gave new vigour to the concerns about the fate of workers and communities whose livelihood was dependent on the coal economy. It was clear that a 'just transition' would be the ideal route from a coal-intensive energy system to a low-carbon future. Such as transition would also have to be fair to energy users, offering them affordable prices and access to electricity.

"The key argument behind a just transition is that our move away from coal must be a process that is well managed, with a phased approach and clear guidelines that are followed in a planned manner," said Andrew van Zyl, director and principal consultant at SRK Consulting. *"Importantly, this is an approach that the trade unions also support."*

The number of workers directly involved is significant; coal mining employs about 82,000 workers, and Eskom employs about 12,000 in its power stations.

Some regional and local economies are built on the coal industry, especially in the province of Mpumalanga. In the municipality of Emalahleni, for example, some 38% of gross value added (GVA) comes from coal mining. The impacts of mine closure on suppliers and industries such as retail and services are expected to be severe. Coal-powered generation will of course continue for decades to come, but is expected to include cleaner coal technologies.

COMMITTED

Eskom's current management has said it is committed to contributing to global efforts to address climate change, but it is equally keen not to desert employees and their communities. *"We cannot just leave them in the lurch, leaving ghost towns and communities behind as festering political, social and economic wounds,"* said Eskom CEO André de Ruyter in a recent interview. Aware that South Africa is *"not very well prepared for the energy transition that is underway globally"*, De Ruyter is nonetheless confident that the company will yet *"beat our coal shovels into wind turbines and solar panels"*.

That day is some way off, however, with coal generating 92% of South Africa's electricity. SRK Consulting principal mining engineer Noddy McGeorge noted that, in addition to new power stations Medupi and Kusile, Eskom has at least two other power stations with life-spans of another 35 to 40 years. With coal reserves for another 100 years, the latter two face little chance of being shut down earlier than that.

"The remaining life of many of the other generating facilities really depends on their mechanical costs," said McGeorge. *"If the investment is affordable, a number of facilities could still be run for another 20 years or more, taking us to 2040 or later for a 'final' transition date away from coal."*

SOCIAL AND ECONOMIC TRANSITION

The process towards trying to understand the social impacts of this transition, though, is already underway. *"For the past couple of years, Eskom has been requesting technical input on what the likely socio-economic impact will be when power stations are closed,"* said Jessica Edwards, senior social scientist at SRK Consulting. *"The closure process is likely to involve similar issues to the closure of the associated coal mines – such as re-skilling of employees, economic resilience of communities and diversification of local economies."*

There are certainly many lessons that can be learnt from countries who are travelling this path ahead of us, in spite of their stark socio-economic differences with South Africa. In the coal regions of Germany, Australia and Canada, researchers have identified which policies have been most successful in halting the production of coal without placing the economic burden on coal workers and communities.

While workers in extractive industries like mining are often presented as the main opposition to decarbonisation policies, the research shows that they are actually quite supportive of environmentally-friendly policies if their immediate interests are not threatened. Active and genuine dialogue with communities is key, followed by effective action such as developing re-employment opportunities in clean industries. Investing in people's future through training and business development, for example, is also vital. Experts in South Africa have considerable experience to offer the energy sector in terms of social engagement and facilitating economic resilience. Under currently constrained economic conditions – aggravated by the coronavirus lockdown – there is less certainty about the state's capacity to invest where it is required.

ENVIRONMENTAL LEGACY

The environmental impact of coal mining has historically been severe, with real efforts to reverse the damage coming only in the past couple of decades. The cost of rehabilitation and responsible closure of coal mines may be underestimated – especially by new entrants through mergers and acquisitions, according to Lisl Fair, principal consultant (social sciences) at SRK Consulting.

"As many of the larger coal mining companies in South Africa withdraw from this commodity and sell to smaller firms, a concern arises over the financial resources available for closure," said Fair. *"It is a particular worry when mines change hands just 5-10 years before their end-of-life. This timeframe is often not sufficient to provision for the considerable social and environmental costs of closure."*

Whatever the hurdles, the country has a unique opportunity to transition to renewable energy, said SRK Consulting senior environmental scientist Ashleigh Maritz.

"With our ageing fleet of coal-fired power stations, we have no choice but to build more renewable generation capacity," said Maritz. *"The country's Integrated Resource Plan commits us to a decarbonisation pathway hinging on the decommissioning of coal-fired power stations and the rapid uptake of renewable energy."*

Perhaps the coronavirus pandemic, ironically, could add momentum to this drive. As United Nations secretary-general António Guterres has urged, governments should ensure that taxpayers' money that is spent to rescue businesses should be directed at creating green jobs, as well as sustainable and inclusive growth. In South Africa, this could certainly contribute to a just transition from carbon-intensive industries towards a cleaner economic base. wn

5G is coming, but what does it mean for South African businesses?

The fifth-generation mobile network, also known as 5G, is the latest technology standard for mobile networks and the successor of 4G or LTE. This latest evolution will provide 100 times more bandwidth than 4G, which means more availability and far greater speeds.

BY I VISHAL BARAPATRE
CTO OF IN2IT TECHNOLOGIES

It has the potential to revolutionise the world for both consumers and business, although widespread implementation is not a simple matter, and the current global pandemic has caused further delays. However, while pervasive 5G may still be a number of years off, businesses need to begin gearing up to ensure they can leverage the benefits as soon as possible.

WHEN WILL IT BE HERE?

Traditionally South Africa has tended to lag behind the developed world in terms of technology, yet 5G is one area where we are not that far behind. There are service providers and networks already rolling out limited pockets of 5G, both locally and across the globe.

In South Africa we have the Rain network and similarly in Europe, Canada and the USA various service providers have deployed networks. However, all of these networks are siloed, many are still in testing phase, and we remain several years away from stable and pervasive 5G deployments.

One of the challenges with the rollout of pervasive 5G networks is the need for new standards, which have not as yet been developed completely or agreed upon. There is also a requirement from governments to make additional bands available and to license these bands, and questions remain around the security of the network. In addition, the 5G network will require more base stations, closer together, which dramatically increases the cost of deployment. It has also raised concerned about the long-term effects of exposure to the millimetre 5G waves on the human body, which need to be studied.

The global Covid-19 crisis has also caused delays with the deployment of 5G networks, not only because of its effects on commerce but also because it has put extreme strain on many budgets. Service providers have plans for deployment, but their timelines have been thrown off. So, while we know for a fact that 5G is coming, pinpointing exactly when it

will become widely available is an all but impossible task.

WHAT DOES IT MEAN FOR LOCAL BUSINESSES?

The pervasive availability of 5G will bring unprecedented network availability and speeds, giving us incredibly fast download speeds and the ability to move huge amounts of data fast. For example, a consumer would be able to download an entire high-definition movie in less than a minute. The rollout of 5G will also finally enable the Internet of Things (IoT) to be used to its full potential, which means real-time applications like autonomous vehicles will become a real possibility outside of specific and siloed areas.

Once we are able to leverage the full potential of 5G, we will see even more IoT and machine to machine data being leveraged. A while back, IDC predicted that by 2020 we would have 26 times more devices than people in the world, and whether or not this statistic is accurate, the sentiment is true. Harnessing the power of this data, businesses will be able to become more proactive, more agile, innovative and will be able to make decisions in real-time based on real data insights.

For South Africa, 5G enabling IoT could completely change the game. While our major cities are well-connected currently, much of the country lacks connectivity, particularly the rural areas. These areas are also where the farms and mines are located, and these businesses would benefit immensely from connected technology. In addition, connectivity will enable improved healthcare and educational prospects. Widespread deployment of 5G can help to improve health, safety and security in previously disconnected and underserved areas and bring the benefits of technology to all.

HOW DO WE PREPARE FOR ITS ARRIVAL?

Arguably the biggest challenge in the rollout of 5G is the budgets required to create these pervasive networks. The traditional approach of every service provider building its own infrastructure is no longer a financially viable solution and is in many cases an unnecessary duplication of effort, so cooperation is essential. It is also critical for government to prioritise the allocation of zones and licensing of bands, and to work with service providers to create more flexible regulations to overcome deployment challenges.

For businesses, it is important to begin planning for 5G now so that when it is available, the benefits can be harnessed immediately. This means bringing the right ICT partner on board with the necessary history, skill sets and experience. While the foundation technology behind 5G may differ to previous mobile network iterations, the underlying principles of service delivery remain the same. A partner with the skills to help create, develop, and implement new services on the 5G network will help businesses push their competitive advantage as we move into this new connectivity era. wn

Television Whitespace

SHARING CSIR'S EXPERIMENTAL RESEARCH EXPERIENCES ON A NEW WAY TO CONNECT PEOPLE AND BUSINESS

Television Whitespace (TVWS) can be described simply as unused space found between channels that are used in the ultra-high frequency (UHF) spectrum. TVWS frequencies span from 470 MHz - 694 MHz. With the TVWS, the Council for Scientific and Industrial Research (CSIR) and the Independent Communications Authority of South Africa (ICASA) have enabled a new way to do telecom in South Africa.

BY | DR ALBERT LYSKO
PROF FULUFHELO NELWAMONDO
DR LUZANGO MFUPE

This new exciting last-mile technology can offer 24 Mbps throughout, over 10 km range, handles propagation through vegetation and over obstacles better than traditional techniques, is cheaper than LTE and well suited for fixed links in traditionally challenging rural environments. This report includes some of the experiences from CSIR experimental work in TVWS.

INTRODUCTION

The digital transformation is happening, and the Covid-19 Pandemic has emphasised the need for this to be implemented quickly. The demand for connectivity has been growing exponentially[1,2], and the International Telecommunication Union (ITU) expects this trend to continue. Various operators indicate that Covid-19 has amplified the demand for broadband by around 50 per cent. Covid-19 has also highlighted a desperate need to connect schools and pupils and fulfil the targets of South Africa Connect, or broadband for all. What are the challenges in fulfilling this, and how to address them?

MOTIVATION FOR TVWS

ITU says[3] that, globally, an increase of 10 per cent in fixed broadband penetration yields an increase of 0.8 per cent in the gross domestic product (GDP), and an increase of 10 per cent in mobile broadband penetration produces a rise of 1.5 per cent. A study focusing specifically on the Africa region suggests that a 10 per cent increase in mobile broadband penetration in Africa would yield an increase of 2.5 per cent of GDP per capita[4].

In South Africa, ICASA reports[2] that the percentage of households with access to the Internet at home, or for which at least one member has access to or used the Internet, during 2018 was only 10.4% (although 64.7% of households had Internet access from somewhere). While the national 3G and 4G coverage are good, at 99.7% and 92.8%, respectively, the rural coverage for 4G/LTE is around 82%, and the cost of mobile data is still high.

Telecommunication services require investments in infrastructure. The most rapid and cost-efficient way to provide broadband is by using wireless[5] connectivity, which involves access to the radiofrequency spectrum and associated licensing. The investments are usually recovered by charging users for data. This works well in densely populated urban areas, but it is challenging to be profitable in sparsely populated rural areas.

Television WhiteSpaces (TVWS)

Television White Spaces (TVWS) is the term used to describe portions of unused radio spectrum; the gaps left between bands allocated for TV broadcasting in the **Ultra High Frequency (UHF) range (470 MHz to 694 MHz)**, excluding the **Radio Astronomy sub-band 606 MHz – 614 MHz**. The **Council for Scientific and Industrial Research (CSIR)** has been working on **Research, Development & Innovation (RD&I)** in the field of **Dynamic Spectrum Access** and **Spectrum Management (DSA/SM)** since 2009. This **RD&I** work has been taking place together with research addressing the cost to communicate and lack of broadband access in under-serviced and rural communities, hard-to-reach areas.

What are TVWS used for?

TVWS signals have the ability to **travel long distances** and penetrate both natural and man-made obstacles

DIGITAL TRANSFORMATION

Stronger societal use such as **studying at home or remote diagnosis**

Offer an approx. **24 Mbps broadband speed**, covering distances of more than **10 kilometres**

The various frequency bands offer multiple advantages. The frequencies used by television (TV) provide excellent coverage but limited bandwidth. The mm-wave-bands associated with frequencies between 10 300 GHz offer vast bandwidth but with minimal coverage. Access to the specific frequency band depends on the availability of the band and obtaining a license. Formally, most bands have already been allocated. Yet, most bands are usually only unavailable in a small percentage of locations. This is especially so for TV bands[6]. The traditional licensing process is very time-consuming, as a norm. Besides, the cost of spectrum licenses is often prohibitive for most entrepreneurs.

The ability of the signal to penetrate vegetation, walls and obstacles is another vital consideration. The peacefulness and beauty of trees, and other vegetation, often results in substantial and expensive-to-solve technical challenges when it comes to providing connectivity, especially at higher frequencies. Areas like this can be found in cities and particularly in rural areas.

Wireless entrepreneurs have also indicated[7] that there is an additional challenge arising from theft and vandalism, which place further

constraints on the locations of and ability to set up wireless links.

VARIETY OF TELECOM SOLUTION OPTIONS

There are many traditional technologies used for wireless, varying in suitability. The urban areas are the most advantaged, benefitting from access to high-speed fibre and latest cellular, now also starting to include 5G in selected places. The options quickly reduce to somewhat cheaper, older and more common cellular technologies, like 3G and 4G, in less dense areas with lower economic activity. The low-cost and high-power 5.8 GHz version of Wi-Fi is often used for fixed wireless links. In the most remote locations, satellite connectivity is the only viable option.

A 2019 techno-economic analysis[8,9], tells that nationwide broadband coverage is best achieved using an optimal combination of different technologies. This is illustrated in Fig 1.

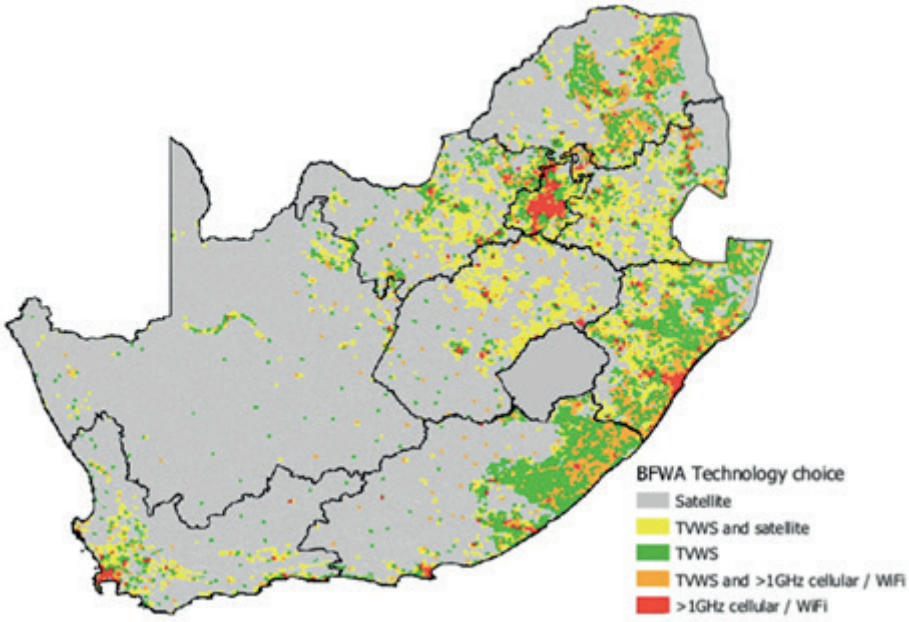

Fig 1: Matching population density to technology. Reproduced from "Assessment of current and future spectrum for WAPA, Report, Wireless Access Providers Association, 2019" with permission.

As per the same analysis, TVWS might be the most suited technology to address the broadband connectivity needs of 12.5% of the South African population. Furthermore, if taken slightly further, TVWS can be used to provide coverage for around 42% of the population.

TVWS BAND AND ASSOCIATED ADVANTAGES AND CONSTRAINTS

The CSIR and ICASA have recently identified additional frequencies that can be used for telecom in South Africa, called television white spaces (TVWS), which involves the sharing of the 470 – 694 MHz band with the TV broadcasting on a secondary basis.

This new exciting development uses a significantly simplified and automated spectrum licensing regime borrowing unused TV spectrum (called *white spaces*, a term derived from the empty spaces on the hardcopy printouts showing graphs with occupancy of the spectrum), and keeping to the traditional TV channel width of 8 MHz.

The modern TVWS technologies can offer 24 Mbps and cover distances over 10 kilometres. However, the latest devices and optimised configurations may offer even higher speeds, with 54/9.8 Mbps achieved over 4 km distance in urban conditions[10].

There are several advantages and constraints associated purely with the specific frequencies used, i.e. 470 – 694 MHz.

The TVWS handles propagation through vegetation and over obstacles much better than traditional technologies like long-range 5.8 GHz Wi-Fi and is well suited for fixed links in traditionally challenging rural environments.

To quantify this advantage, it is possible to compare the specific attenuation due to woodland [ITU-R P.833] for different frequencies associated with different communication technologies. For example, the particular attenuation for TVWS band is below 0.15 dB/m, while 1800 MHz LTE experiences 0.37 dB/m and 5.8 GHz Wi-Fi has to concur 1.15 dB/m. This means the TVWS can typically penetrate about eight times thicker bush or trees than Wi-Fi. An overview plot is shown in Fig 2.

The higher robustness to vegetation and great flexibility afforded by TVWS also help to reduce the challenge of vandalism. For one, the TVWS equipment can handle much thicker vegetation than Wi-Fi or 4G and can even go over limited blockages. This gives planners and installers more flexibility in designing the networks and locating the network nodes, thus reducing costs and minimising the need

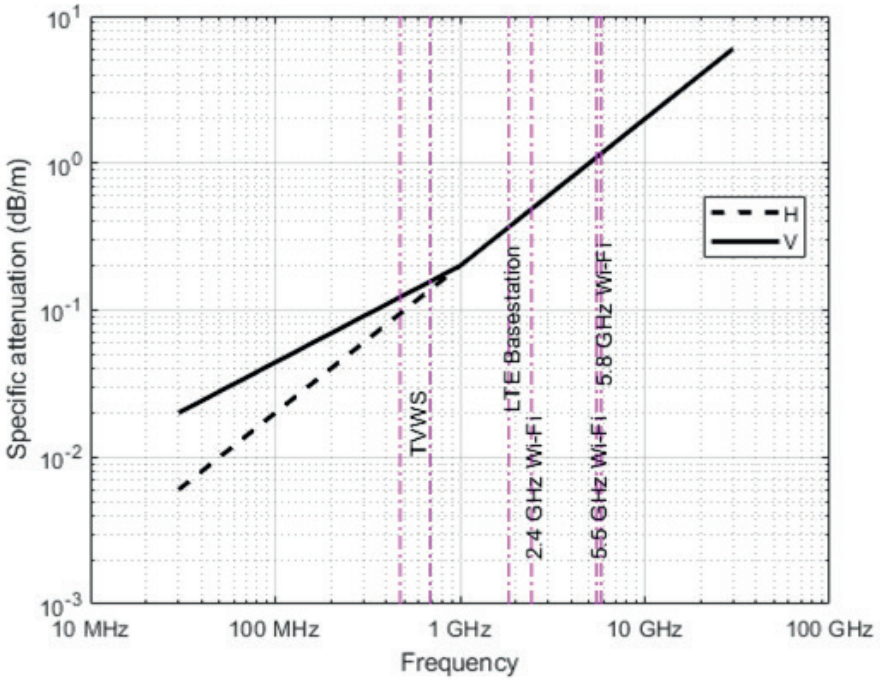

Fig 2: Specific attenuation due to woodland [Rec. ITU-R P.833-4]. "H" refers to the vertical polarisation and "V" refers to horizontal polarisation

to install in high-risk spots. Also, the devices themselves are more robust to theft, as they must identify themselves to a central database before the database allows them to transmit.

Usage of lower frequencies in the ultra-high frequency (UHF) TV band also brings a limitation. The gain for commercially available TVWS antennas is usually at most 14 dB[i], limited by the practically acceptable size of antennas. Also, if one wishes to avoid ground losses, TVWS antennas need to be installed 2-3 times higher than 5.8 GHz Wi-Fi counterparts. Furthermore, the regulations limit the transmit power to 41.2 dBm for fixed rural, as compared to 53 dBm being permitted for 5.8 GHz Wi-Fi.

Nevertheless, these restrictions are usually compensated for by the much lower propagation loss, which is about 20 dB lower as compared to Wi-Fi. Overall, a typical TVWS installation could be expected to have about a half the range of a long-distance Wi-Fi point-to-point link while offering several times wider area coverage[12] in the point-to-multipoint scenario.

It should be noted that, as the close frequency bands, such as the 700 MHz and 450 MHz bands, are assigned and being considered for cellular communications in South Africa, the 4G (LTE) and 5G technologies will be able to offer similar frequency-related advantages. Utilising this advantage will likely be limited by the high cost of LTE and 5G.

BASIC PRINCIPLES OF OPERATING IN TVWS

The general principle is relatively simple. A white space device (WSD) informs a central database (which in South African TVWS terminology is called a geolocation spectrum database (GLSD)) about its location and operational parameters, such as antenna height and transmit power[13]. The GLSD also knows the location and parameters of the primary transmitters (here: TV broadcasting transmitters), criteria for protecting reception of the TV broadcasting as well as the topology of the landscape. Based on this information, the GLSD calculates the availability of the spectrum for the location of WSD and informs WSD, which enables WSD to start using the spectrum for communications.

As the WSD requires frequent communications with the GLSD, and this connection is made over the Internet, the TVWS cannot be used for links isolated from the Internet. Also, the availability of TVWS spectrum, i.e. availability of TV channels is not guaranteed.

The actual realisation is more involved, as it includes different types of WSDs (Master and Client), two levels of GLSD (Reference and Secondary), a set of regulations to be adhered to, and technology-specific compliance testing. The specifics of the automated spectrum allocation in South African TVWS works are described here.

TVWS IN SOUTH AFRICA

Active introduction of TVWS in South Africa started with field trials. International examples and several large field trials were used to convince the national regulator, ICASA, to begin drafting the TVWS regulations. South African trials were held in the Tygerberg district of Cape Town[14] and Polokwane, Limpopo[15]. Together, these two trials demonstrated providing TVWS-based broadband connectivity to over 16,000 students and teachers, without causing any interference to the reception of TV. This was followed by ICASA starting a public consultation process to produce the national TVWS regulations.

FEATURE continues from page 27

ICASA published South African TVWS regulations[16] in 2018. TVWS relies on the availability of unused TV spectrum. This availability is automatically determined by a geolocation spectrum database (GLSD) developed by the CSIR. According to the regulations, South Africa has two GLSD levels. The reference GLSD (R-GLSD) is the leading automated authority controlled by ICASA. The secondary GLSD (S-GLSD) is qualified[17] by ICASA and serves the WSDs (users) as depicted in Fig 3.

TVWS MANUFACTURERS AND PRACTICAL MATTERS

There are a host of manufacturers of TVWS equipment. When selecting TVWS equipment, it is essential to determine whether this equipment is compatible with ICASA's Reference GLSD. The CSIR currently offers such testing.

One Master WSD can usually serve 8 to 50 Client WSDs. Some brands and models use tighter radio frequency (RF) filters and can operate near TV transmitters. This permits them to be used even in cities with the highest occupied spectrum, such as Pretoria and Cape Town. Other models use less sophisticated filters and may require a substantial-frequency and distance spacing to the nearest TV broadcasting transmitter. However, considering that rural areas typically have an abundance of TVWS, most equipment can work well there.

The influence of filters may be demonstrated with the results showing the effects of 1) being near TV broadcasting signal, and 2) of the TVWS receiver's channel width on the "noise" level received by a TVWS card and its effect on the throughput, as shown in Fig 4.

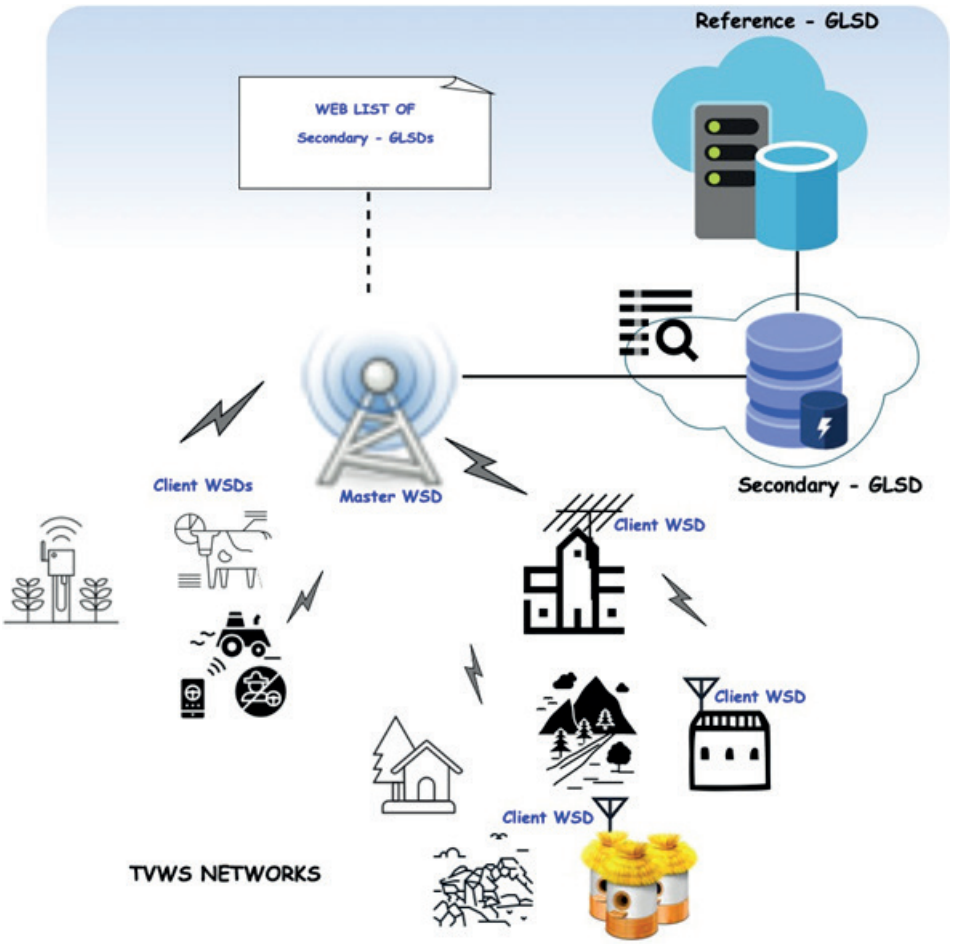

Fig 3: Illustration of TVWS network deployment under the South African regulatory framework

The upper plot shows the measured levels of signals versus frequency, with TV broadcasting transmissions visible around the carrier frequencies of 530 MHz and 610 MHz. The "Noise 1" and "Noise 2" plots show the levels of noise measured by the TVWS card when it was configured at specific frequencies closer and further away from the TV-signals mentioned above. It is clear that the measured level of noise increases, as the card is configured to operate closer to the TV signal.

The last plot shows how the configuration affects the throughput achievable with the TVWS card. The best performance is achieved for the configuration corresponding to the lowest level of noise.

These explain the following practical observations applicable for some (not all) TVWS devices based on Wi Fi-like hardware:

1. drastic reduction of throughput from being too close to an operational TV channel;
2. when near an active TV broadcasting, lowering channel bandwidth may improve performance.

CHANNEL AGGREGATION AND MULTI-DEVICE OPERATION

Some TVWS equipment allows aggregating several TV channels, usually up to 24 MHz, to increase speed.

When one installs multiple WSDs on the same or a nearby mast, one needs

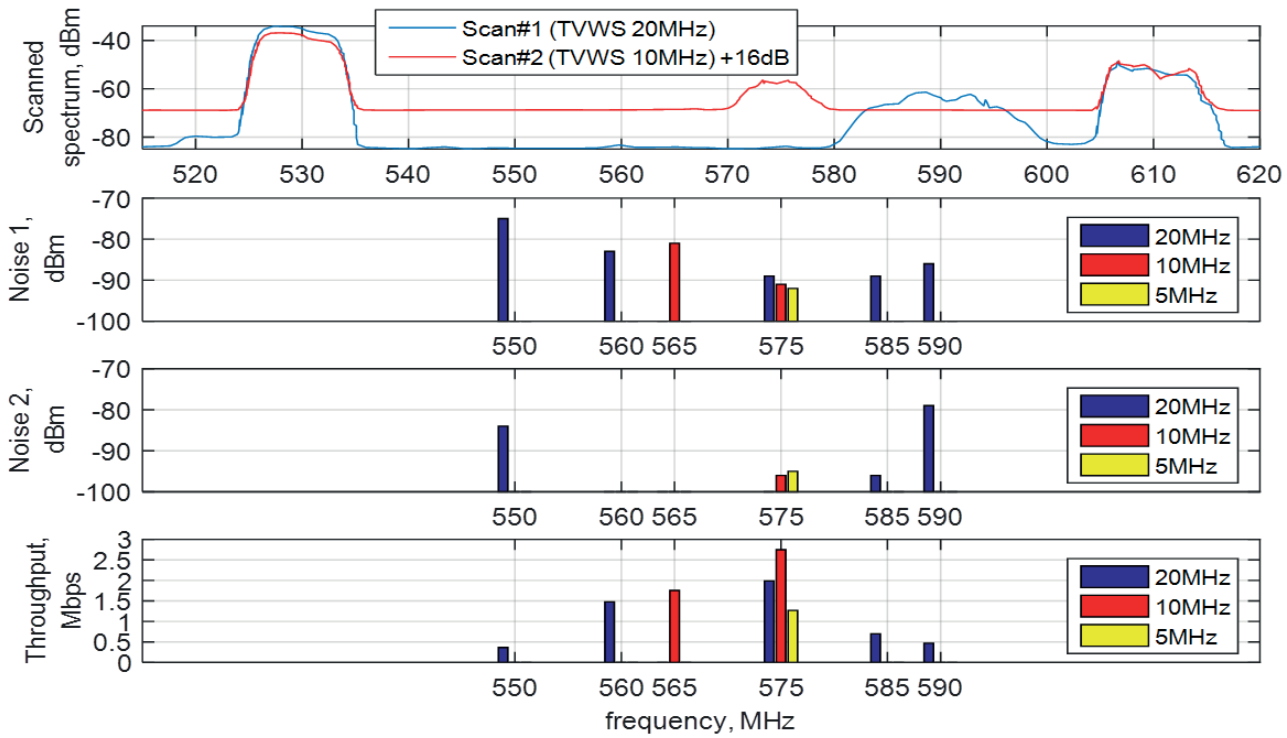

Fig 4: Effects of channel width and being near TV broadcasting channels. Based on CSIR/UCT research lead by Dr D. Johnson, 2016.

to consider the saturating effects of near-field coupling between antennas and devices. Many WSD units have dedicated connectors to allow for synchronising the transmissions between multiple devices and thus avoid losing sensitivity and range. Using such a synchronisation feature may lead to a minor, of the order of 10 per cent, loss in the throughput.

TVWS operates on a secondary basis avoiding interference to the primary users, i.e. TV receivers receiving TV broadcasting. The study *[A.A. Lysko and G. Dludla, Considerations for coexistence: DVB-T2 broadcasting and LTE base stations in 700/800 MHz bands in South Africa, IEEE GEMCON, 2018]* considered the mutual location of primary and secondary users of the spectrum (transmitters) and concluded that the optimum configuration involves co-locating primary (here: TV) and secondary (here: TVWS) equipment on the same tower. It should be noted that this optimal configuration may,

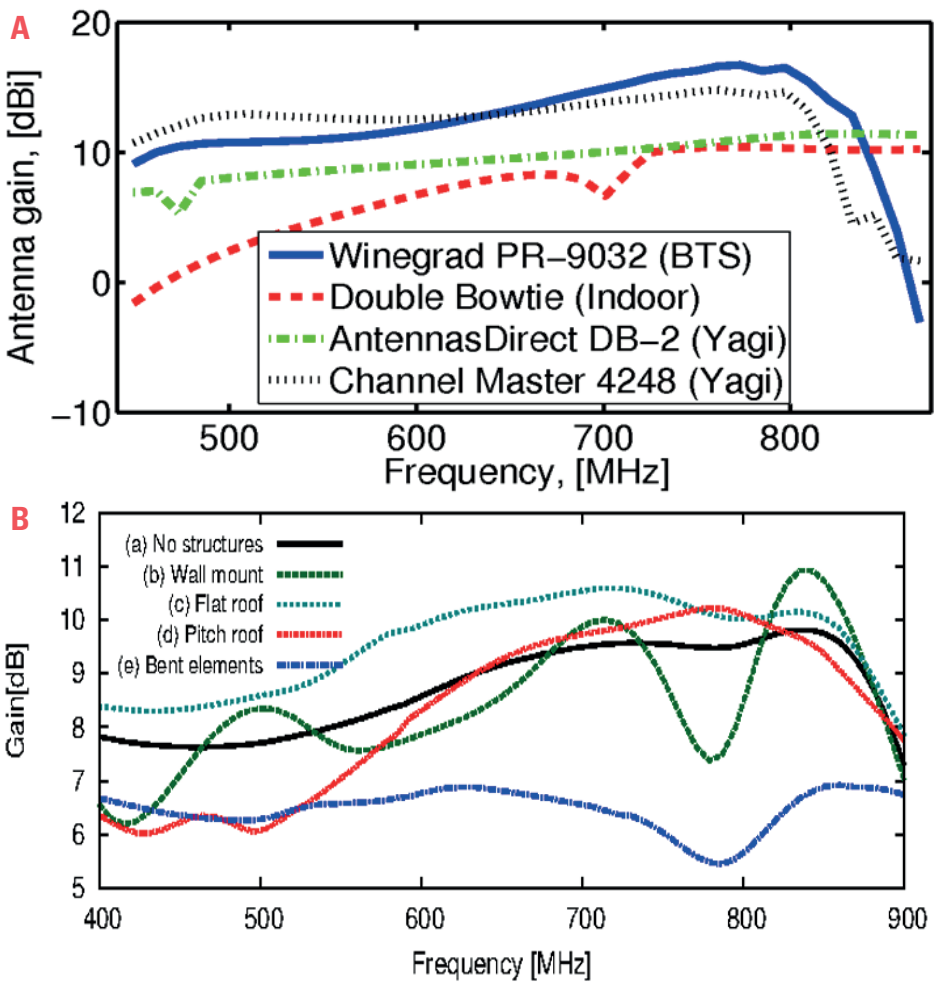

Fig 5: a) Influence of frequency dependence and b) influence of antenna mounting environment, simulated for several TV antennas.

however, not always be possible and that in rural areas with an abundance of the spectrum, not necessary.

SELECTION OF ANTENNAS

TVWS can use readily available TV antennas and cables. As a TVWS antenna must cover a comprehensive range of frequencies, its performance varies typically with frequency and may also depend on the nearby environment. These effects are illustrated with Fig 5 based on numerical simulations.

TVWS: PROS AND CONS

TVWS is an order of magnitude better in penetrating vegetation and trees than 5.8 GHz Wi-Fi, and somewhat better in handling obstacles, as well as having several times wider coverage area than Wi-Fi. The cost of TVWS equipment is between that of LTE and Wi-Fi equipment.

On the other hand, TVWS does have its limitations. TVWS installations require the Internet to access the database periodically. TVWS channels are not guaranteed in environments with significant usage of the TV spectrum. Some TVWS devices may be sensitive to TV broadcasting transmitters and require frequency or spatial separation from these transmitters. wn

For information regarding the CSIR secondary geolocation spectrum database (S-GLSD), please contact Dr Luzango Mfupe, CSIR (lmfupe@csir.co.za).

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AI and ML in Telecommunication Systems:

THE CASE OF INTELLIGENT AND DYNAMIC SPECTRUM MANAGEMENT IN WIRELESS COMMUNICATIONS

Globalisation, and the growing scale of industrialisation, have led to the formation of complex nexus environments. Demanding countries, such as South Africa, approach sustainable growth in a transdisciplinary manner. The problems affecting the nexus issues are diverse and practically challenging to experiment, as the interrelations between various industrial sectors, or critical economic actors, have become too complicated with multiple response vectors to consider.

BY | PROF F. NELWAMONDO
PROF F. MEKURIA, CSIR NGEI

Accordingly, South Africa needs to stay relevant in a complex world of exponential growth in smart integrated technologies, while trading off between economic growth, social development and environmental sustainability.

Understanding these nexus issues and how actions in one sector are likely to impact other areas is critical to ensure sustainable development. Accordingly, emerging technologies such as Artificial Intelligence (AI) and Machine Learning (ML) techniques are opening a plethora of possibilities to improve the way technological and natural resources are being optimally utilised.

The definition of artificial intelligence (AI) varies, however, for this article, we will adopt that AI is defined as a collection of Cyber-Physical Systems, which can perceive or sense their environment, share-data, analyse and process the accumulated sensor data, generate actionable insights and finally take a set of reasoned actions to maximise the likelihood of achieving a particular goal. Artificial Intelligence (AI) and ML techniques have been applied in many telecommunications scenarios which support other technologies such as self-driving cars and self-healing network-controllers, amongst many others.

The emergence of the digital society requires the use of techniques to build wireless networks that are optimally operated, with network resources that are optimally utilised for the provision of improved quality of service. Apart from this, and specifically for emerging economies, AI-enabled network automation combined with green and self-healing networks can help in extending digital connectivity to underserved rural communities by allowing remote network management. The recent International Telecommunications Union (ITU) and the United Nations (UN) organised multi-stakeholder world forum on

the subject of 'Artificial Intelligence for Good' (AI4Good): ai4good.org, identified and gave directions on how to get a profitable and ethical use of AI and associated technologies.

There is now a strong belief these can bring a new wave of beneficial applications and rejuvenate the concept of intelligent, green and resource-effective wireless communications systems. Exciting opportunities are seemingly emerging when one realises that telecommunications systems generate large amounts of data, every minute of the day. If these data are made available and are harnessed adequately, it would be possible to generate actionable insights to improve wireless systems planning, network operations, efficient and quality of service (QoS) provisioning of network services.

The telecommunications industry has warmed up to AI and associated technologies, and this is expected to result in significant breakthroughs with applications for improved wireless communication network operations, radio resource utilisation, business process and QoS based end-user services. Wireless industry leaders recently gathered at the IEEE world forum on the 5th generation wireless ICT standards, in Germany. It was predicted that AI and ML techniques would achieve significant breakthroughs in applications for wireless communications networks, in the operational, business and QoS based end-user services[3-4].

The predictions were that in the short term (1 to 3 years) and long-term (4 to 10 years), AI/ML applications would flourish in all layers of the wireless network design and operational levels. The vast quantities of data will fuel what the existing and future wireless systems generate.

As billions of customers are added every year to the networked society, and the demand for high bandwidth applications increases, wireless networks will become so complicated that managing existing network operations will become crucial for the survival of mobile network operators. The need to derive desired 'intelligent' outcomes and actionable insights based on data analytics by applying AI is expected to untangle the enormous complexities associated with emerging wireless systems such as 5G and beyond. The possibilities related to AI for reliable, automated and self-optimising networks, where real-time and intelligent optimisation of network resources, green network operation and control with improved quality of service provision for any wireless service is now within reach of all network operators. Dynamic and intelligent management of spectrum resources for wireless communications is already becoming a big challenge. Essential applications of AI and ML algorithms are expected to be in the multi-variable resource optimisation problems, such as in smart cities and wireless digital connectivity. **Picture X** shows the complexity of integrated optimisation for an application of AI/ML in a city's resources and activities optimisation using AI tools and techniques. The AI/ML is based on extensive multi-variable data derived from smart sensing devices placed in diverse sectors involving health, transport, power supply, water resource and ICT wireless infrastructure management.

As cities and metros become more densely populated, several sectors will be equipped with smart sensors to collect relevant and accurate data, for the ML algorithms to work on, and build interrelated systems and models to optimise the multi-variable resource utilisation. Smart sensors will play an essential role in guaranteeing the data accuracy and integrity, which shall be crucial to the operation and the resultant actionable insights of AI/ML algorithms. Questions such as the ones below would need to be answered to get reasonable solutions through the use of AI tools and ML algorithms:

How do we:

(1) avoid traffic congestion in big metros with the optimal routing of traffic throughout the city?

(2) predict power supply demand and avoid high-cost to consumers?

(3) predict network bandwidth demand and re-route network bandwidth resources where it is most needed, without affecting the quality of service to other customers?'

DIGITAL CONNECTIVITY AND COMPLEXITY AND AI/ML APPLICATION

As presented in Picture X, digital connectivity and secure transfer of information between the different infrastructure components, ubiquitous

Picture X: Smart City application of AI/ML.

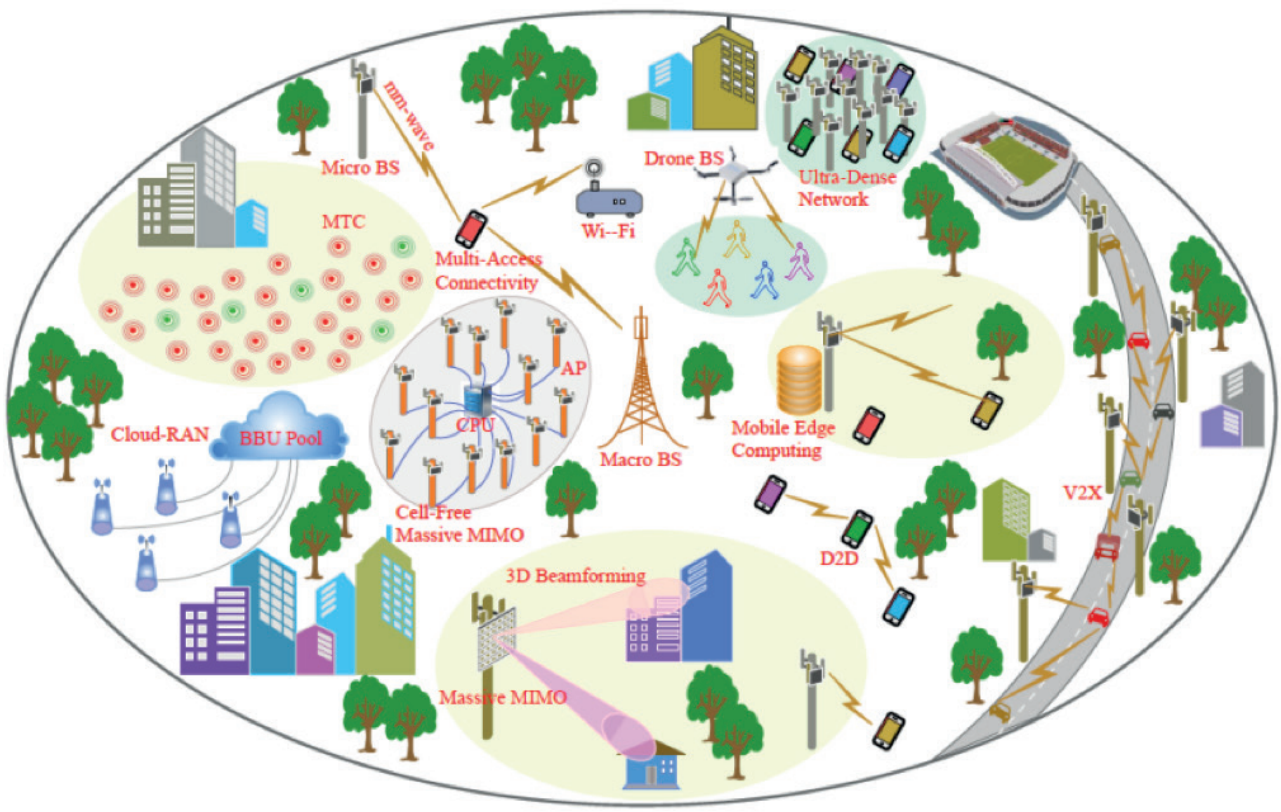
sensors, and datacentres storing the relevant information for data processing and analytics, play an essential role. Due to the flexibility associated with wireless connectivity, most of these communications are going to happen over the wireless interface.

AI and ML are expected to transform wireless digital connectivity, from the current semi-automatic networks and their management systems into a self-healing, self-learning, intelligent data-steered and fully automatic resource optimisation networks. Therefore, the need to derive desired 'intelligent' outcomes from wireless network data and performing ML-based analytics to produce actionable insights becomes a crucial differentiator and the tool to address the enormous complexities associated with future wireless systems. The demand for supporting different connectivity applications to private personal customers, industry applications and provide public societal services has resulted in various wireless technologies addressing different sectors as shown in **Picture Y.**

AI and ML, with reasonable data integrity and ethical considerations, can be applied to improve wireless network operations and management, network resource optimisation, business and service provision layers, in future wireless networks. Wireless communications industry players have several pilot RD, and I projects involving AI and ML for Radio Access Network Data analytics, autonomous network orchestration and network slicing. Real-time data analytics based on network operations data, to produce business insight for end-user applications and QoS improvement for networked services are now possible using AI/ML techniques. The application of the same tools has been proven to predict, accurately, network latency, backhaul status, data-plane traffic flow statistics, usage and pattern data, amongst others. AI and new applications of Data Science have shown the enormous benefit of deriving insights from these wireless infrastructure generated data sources. Finally, one of the essential uses of AI in telecoms is an improvement in the reliability and security of wireless networks. Intelligently identifying vulnerable nodes in the complex network infrastructure, as shown in Picture Y, and providing the necessary dynamic protection is one of the essential applications of AI which mobile operator industry is expected to deploy in the upcoming 5G and future wireless networks.

AI IN DYNAMIC SPECTRUM SHARING AND SENSING

AI applications for dynamic spectrum sharing (DSS) with re-enforcement learning methods are expected to improve the implementation of dynamic spectrum management in future wireless networks for all bands



Picture Y: A composite picture of future wireless communications network infrastructure.

of interest. The current activity of spectrum sharing based on Television White Spaces (TVWSs) is just the beginnings of a wave of applications for AI-enabled spectrum sharing and sensing. Several spectrum sensing algorithms such as estimator-correlator (EC) detector, the semi-blind energy detector and the blindly combined energy detection (BCED) have been developed recently, all aimed at improving Dynamic Spectrum Management (DSM) for emerging network technologies. All of these tools have their shortcomings, for example, they depend heavily on the accurate knowledge of noise power, which is usually uncertain, and this makes some of these algorithms unsuitable for the practical environment. The lack of prior knowledge would result in performance degradation. ML techniques have been adopted to develop cooperative spectrum sensing (CSS) framework. Compared with traditional CSS techniques, an ML framework brings the following two advantages: (1) it is robust to the changes in the radio environment; and (2) it can achieve a better performance in terms of device classification accuracy and spectrum assignment[1-2].

Traditional Dynamic Spectrum Access (DSA) mechanisms require a centralised control node responsible for allocating the spectrum resources to network devices. A central node would collect the global network information, such as the position information of customer-premise devices, base station power levels, and channel state information, amongst others. Such comprehensive network information is, however, necessary to avoid interference, although it presents significant signalling overhead on the system. Interference avoidance in the presence of a large number of users can result in very high data-intensive process delaying network operations. An intelligent DSA framework with deep reinforcement learning and re-configurable network devices is expected to provide superior performance on sequential decision-making tasks, enabling more flexible and smart DSA mechanisms[1-2]. Furthermore, the combination of software-defined radios (SDRs), artificial intelligence and cognitive radio technologies5, will open the way for brilliant network technologies[5], with ubiquitous and instant responses to reconfigure wireless networks, cognitive customer devices and on-demand quality of service provision anywhere and anytime.

WAY FORWARD

In conclusion, AI is here to stay, and it will shape and transform the telecommunication space for good. It is therefore essential for all of us to embrace it as it will address the emerging issues in communications and networking. The benefits of AI are already visible in many applications, including dynamic network resource access, intelligent QoS control, wireless caching, network reliability and cyber-security, which are all crucial to next-generation networks, such as 5G and beyond. Deducting from the discussions above, the future of telecommunications is intertwined with Artificial Intelligence, and network operators and service providers are better prepared for the new intelligent paradigm. wn

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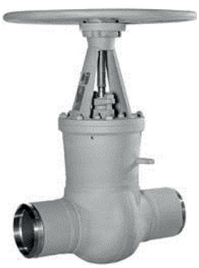

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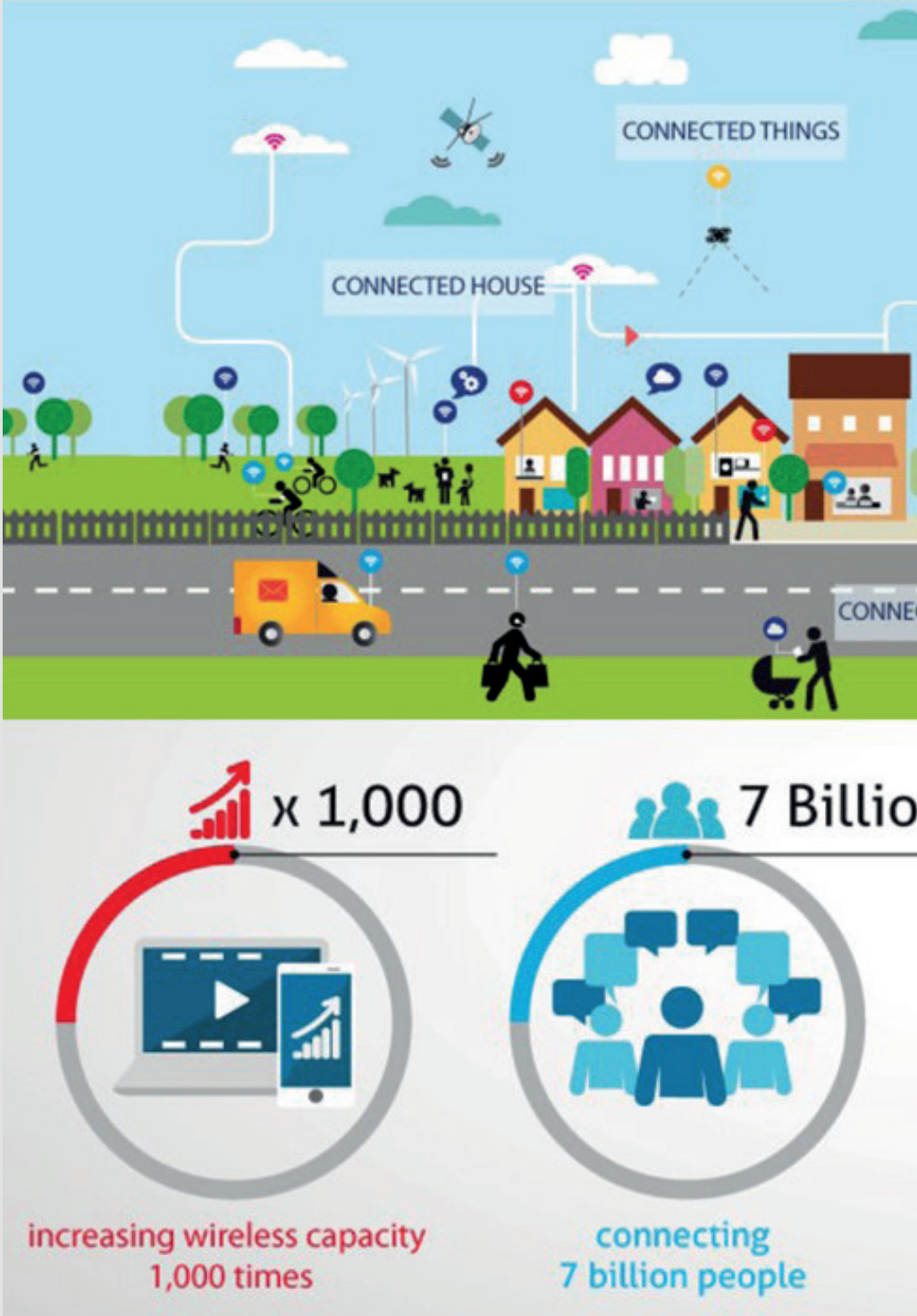
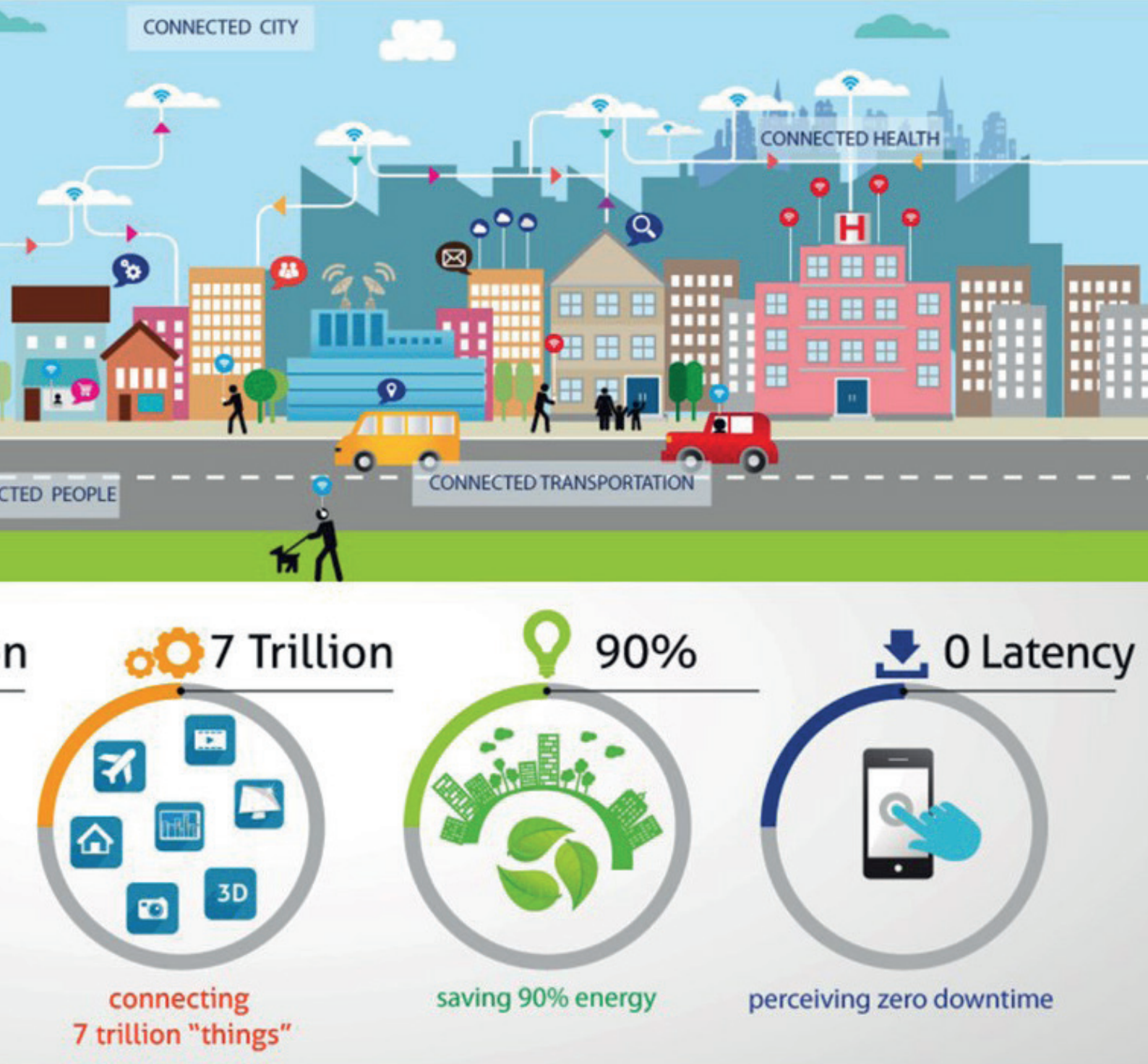
Expectations are high for 5G, as it promises many benefits and new business opportunities for all stakeholders engaged in the creation and use of future networks and services. The 5G Infrastructure Public Private Partnership (PPP) continues to invest considerable resources into researching and developing the technological side of 5G systems. A relatively recent development is the additional challenge to EU research projects to validate claims about business opportunities through business validation analysis.



Business Validation in 5G PPP vertical use cases



The problems for business validation involve using an appropriate analytic approach, as well as the identification of the critical ingredients used for the study. Business validation must encompass value propositions for vertical industries, the identification of stakeholders, the new roles in the value system, as well as the identification and visualisation of the complex ecosystems that are expected to emerge.

In the late fall of 2019, the Working Group "Visions and Societal Challenges" of 5G Infrastructure Association (5G IA) took the initiative to establish the "Business Validation, Models, and Ecosystems" Sub-Group (BVME-SG). On the 25h February 2020, BVME-SG was formally constituted and started a series of meetings to refine the scope and processes of the group.

This positioning paper has been collaboratively developed by BVME-SG participants to summarise the findings of those initial meetings. It formally establishes the scope of the group and key working processes. We draw on some example projects in the 5G PPP portfolio of projects; however, the BVME-SG welcomes new participants from any of the 5G-PPP projects to share knowledge on their project approaches, the

challenges, insights and findings so a view on the diversity of strategies can be formed. Future work of the BVME-WG will systematically capture and characterise the methods used for business-related considerations of the 5G PPP projects and eventually also capture market estimates, business models and business cases.

1. INTRODUCTION

The BVME-SG focus is aligned to the European 5G Vision of ***"5G empowering vertical industries"*** which also encompasses public sector users. A consequence of framing benefit analysis in terms of the vertical is that the supply side of the telecoms sector and its traditional supply chain is not the predominant focus. A great deal of business validation is to understand what enables verticals, and how this is articulated through market expansion models, business and social benefits. Once the BVME-SG has established an understanding regarding how vertical value propositions and business models can be enabled, a secondary supply-side beneficiary in terms of the designing, building, maintaining and operation of a network may be apparent and could be identified. However, supply side-oriented thinking regarding mobile network operator product and service is not to be the primary focus.

The BVME-SG carried out an initial survey of various 5G PPP projects to find conventional approaches and processes to business validation. This information helped form an initial view on the purpose of business validation and helped to identify challenges that appear to be standard across a number of the 5G-PPP projects. While it is not the intention of the group to form a view on the "best" solutions, and it was certainly not the objective to do so in the time frame of this paper development, the expectation is that as we progress further, we may find commonality amongst projects that focus on common verticals or technology layers.

Section 2 is a short introduction to the purpose of business validation for 5G PPP vertical use- cases and the importance of embracing some coherent approach to the process. Four critical stages to the business validation process are discussed; customer validation, solution alignment, business model selection and financial analysis and projections.

Section 3 summarises many challenges that have been discovered by several of the projects as they have developed and executed their approaches to business validation. The list that has been created is not thought by the group to be an exhaustive list; indeed, it is highly likely that the list of challenges will grow.

In Section 4, we provide concluding remarks and next steps. While developing the initial views of the group has proved invaluable to create common terminology, we capture an initial list of terms used by the group as this also helps with establishing the scope of the group in Section 5.

2. THE PURPOSE OF BUSINESS VALIDATION

Turning brilliant research into successful commercial products is a complex task with many failures. Most failures occur because there is a lack of Product/Market [1] fit or to put it simply, the product or solution that is built is not what the customer

Figure 1 Approach to business validation for H2020 vertical use-cases

wants to buy in sufficiently large amounts to sustain a business. This is a particularly significant risk in the fledgeling 5G verticals market where so much has already been invested and committed to the infrastructure. This raises the chance that solution providers may propel towards creating solutions for a problem that does not exist in sufficient scale, or can be more cost-effectively solved with alternative solutions. To help avoid this, many early ventures in new markets use a Lean Start-up Methodology [2] as the preferred method to guide their journey to initial viability. The Lean Start-up paradigm envisions a unique proposition being created based on a new product or service that will be embraced by a market [3] because ***it solves the customer's urgent problem.***

While a Lean Start-up Methodology is the accepted option for creating founder-driven, investor-oriented start-ups, there is strong evidence [4] that adopting a similar approach in the research domain can lead a project to enable better: i) the commercialisation of better products and services, ii) while being faster to the market, and iii) with sustainable business models.

Figure 1 illustrates four phases that are almost always present in some form of the business validation process. The first phase, customer validation, is arguably the most important as it helps to establish the specific business problems that a potential customer wants to solve and is willing to invest money to gain the benefit they need. Development of business models, technology roadmaps and revenue plans are essential activities in later phases. Still, they have a higher likelihood of failure if not consciously and continuously grounded in support of specific customer pains. The figure also illustrates that technological validation, the other pillar of validation in 5G PPP projects, is a parallel activity to business validation, and the processes are intertwined and complementary. We shall see in the next section that 5G PPP projects report challenges in all business validation phases. However, there appears to be a consistent view that if vertical customers' real pain points are not adequately understood and placed at the centre of the validation process, the future uptake of 5G amongst verticals will be significantly retarded.

Regardless of whether the business validation process follows a strict Lean Methodology or some variations thereof, the general approach is the same as with all research methods – create a hypothesis that can be tested, and allow for agile re-adjustment before investing time and effort in outcomes that cannot be successful. This is a fundamental underpinning for the technical research process, and a comprehensive business validation process should encompass a similarly disciplined approach to assessing if a viable business can be created that delivers value to the stakeholders involved.

Business validation, therefore, is much more than desk-based research that estimates potential revenues and market sizes. The process must always be grounded with an objective and detailed understanding of customer needs (Customer Validation) and develop robust assumptions about solutions that future customers will use.

It should be noted that business validation is better carried out iteratively with openings for feed-back and learning loops. Aspects such as willingness to pay, market size, routes to market and business model calibration can be addressed in subsequent phases of business validation while constantly revisiting and recalibrating that the business is creating a solution that sufficient customers will want to buy. There are many challenges also in later phases of business validation, as noted by 5G PPP projects (see section 3 and Annex A). Later BVME-SG white papers will also explore appropriate approaches to challenges with complexity in value systems, ecosystems, roles and stakeholders, and business models for both verticals and 5G providers.

3. 5GPPP PROJECTS AND BUSINESS VALIDATION: STATUS AND CHALLENGES

The BVME-SG has carried out an initial examination of an indicative set of 5G PPP projects starting from more mature Phase II and Phase III projects to projects conducting advanced 5G validation trials across multiple vertical industries (see Annex A). In summary, all projects put significant efforts into business validation with a varied set of approaches. They form a group of domain-specific insight and experience, with massive potential for knowledge sharing and development for innovating with 5G.

The projects use classical methods to business aspects such as providing exploitation plans and less frequently, techno-economic analysis of costs, revenues, and market evolution. The business model canvas (BMC) recurs in most projects as a basis for identification of provisioning roles and stakeholders, business opportunities, and market estimates.

The projects typically examine hypotheses related to the value of

services and business models through peer group exploration, small sample surveys or workshops. Additional notable approaches use tools to explore the problems customers and users need to solve, and the use of design thinking tools such as customer journeys and storyboards.

On this basis, some key challenges are consistently emerging, mainly associated with the identification of customer/vertical "pain points", the benefit analysis of 5G enabled products and services, and the usage of ecosystem driven approaches to the definition and creation of sustainable solutions. As illustrated in Figure 2, some of these challenges are emerging in early business validation phases and may affect the success of the subsequent process. Thus, addressing them is vital and has been the main driving force for the creation of BVME-SG.

VERTICAL INDUSTRY VALUE PROPOSITION ENHANCEMENT VS DEPENDABILITY:

Today, many vertical industries rely totally on Mobile Network Operators (MNOs) for their internal telecommunication needs. However, some large industry sectors, such as the railways, have come to regard the network as part of their business infrastructure. 5G can bring together traditionally separated industries with typical value chains.

In contrast, the market position of many vertical industries can be empowered by including 5G enabled enhancements in their core business unique proposition(s). However, no matter the promised improvements and business viability, vertical industries can be strategically reluctant to rely on MNOs for their core business propositions (and engage them in their value chains) or hesitant to include additional network operations in their business processes.

THE GAP IN DEMAND AND SUPPLY:

A collective challenge encountered is bridging the communication and knowledge gap between potential customer demand and provider solutions. Specialists in the telecommunications industry may have an only partial understanding of vertical industry requirements and the limitations imposed in their business activities; specialists in the vertical sectors have an incomplete understanding of what 5G can bring in their domain.

Both domains have even less knowledge of the required transformations in respective business processes. At a certain level, this stems from the fact that stakeholders do not share common vocabulary, concepts, visions and missions. Thus, appropriate tools for business validation purposes may also serve as a translation layer between stakeholders.

NEW ROLES IN THE VALUE CHAIN AND CANDIDATE STAKEHOLDERS:

5G advancements in network deployment, operation and services provisioning can accelerate the transformation of the complete value system of the telecom and vertical industries business, both in terms of new emerging roles and in terms of functions shared between existing and emerging stakeholders.

For instance: network deployment and telecom services provisioning is currently the core business role of telecom operators; in future value

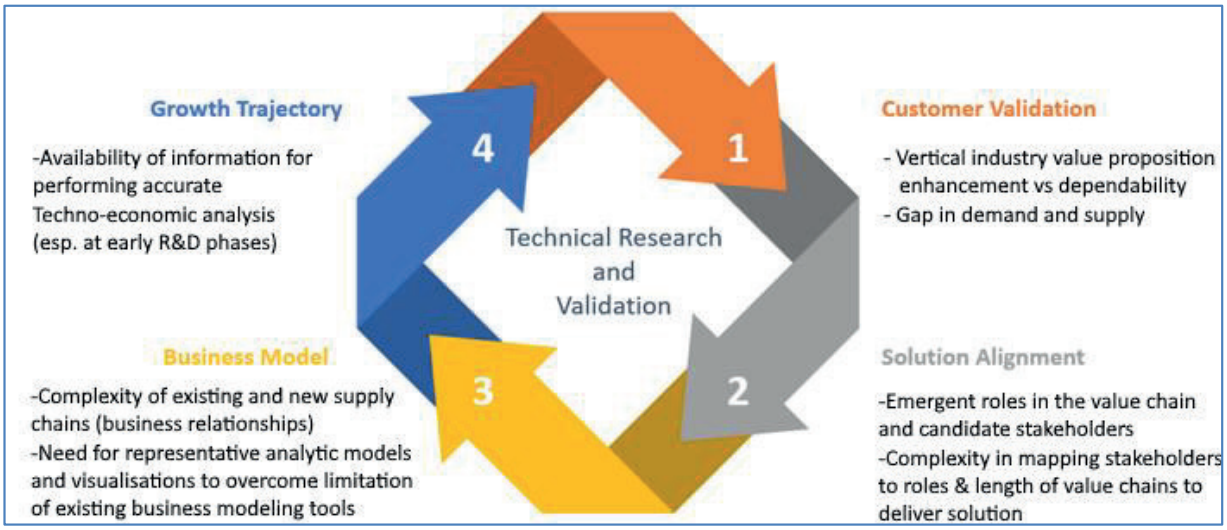


Figure 2 Typical challenges with business validation of vertical use-cases

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systems, stakeholders from vertical industries may emerge as small scale telecom service providers or non-public network (NPN) providers. They could develop from a different starting point in the value system, taking advantage of 5G capabilities to rapidly overtake traditional providers.

An indicative case could be the Railways, specifically concerning the advent of Future Railway Mobile Communications Systems. Therefore, mapping of a business role with stakeholders will become less straightforward; several of the 5G PPP projects have responded by employing tools to analyse and visualise new value chains and ecosystems.

COMPLEXITY IN MAPPING STAKEHOLDERS TO ROLES:

Considering the value as mentioned earlier system transformations, while the beneficiary stakeholder/vertical and their need may be easy to identify, the mapping of contributing stakeholders to deliver a potential solution can be more complicated.

For the latter, a mapping between required roles in the value chain and stakeholders to undertake them depends on the market environment and the stakeholders' associations in it. It can be a burden, no matter the business benefit and validation of the solution from the beneficiary side. Thus, business validation would require methods of analysing these relationships in a holistic way.

THE COMPLEXITY OF EXISTING AND NEW SUPPLY CHAINS:

The complexity in mapping stakeholders to roles for the delivery of a solution increases in markets with multiple stakeholders, as a considerably high number of business relationships/ associations could be required, along with a proportionally high number of complex contractual arrangements between them; constituting a hurdle to the evolution of the market. This complexity of supply chains is not easily depicted with current business modelling tools and can be a challenge from the vertical industries side.

REPRESENTATIVE ANALYTIC MODELS AND VISUALISATIONS:

The Business Model Canvas (BMC) is a commonly used method presenting a business model of a value proposition for a specific customer segment. However, in early business validation phases, it is beneficial also to capture aspects related to the role(s) and the level of transformation of their current business activities that the beneficiary stakeholder/vertical is willing to perform plus elements that are specific to the stakeholder and market environment.

Also, aspects related to the market environment (e.g. regulatory or competition-specific), to potential social impact and acceptance, may severely impact the sustainability of a solution even if the innovation/product economic viability is validated. For these purposes, tools mapping the whole socio-technical system could be valuable.

AVAILABILITY OF INFORMATION FOR ACCURATE TECHNO-ECONOMIC ANALYSIS:

Although experts in the 5G community conduct technical studies and accurately define suitable solutions/ deployments for specific verticals, the economic evaluation of solutions is challenging and adds to uncertainty in evaluating the overall hypotheses.

This is because the parties developing the technology cannot disclose economic data at early R&D stages. Thus, key financial metrics like volume vs price, price decreases over time, and many others are not available to support accurate financial modelling for the verticals.

4. CONCLUDING REMARKS AND NEXT STEPS

Starting from this white paper, the BVME-SG will systematically review how 5G PPP projects address business validation. The group will facilitate and promote the sharing of practices through regular meetings and documentation. Eventually, this will lead to a full cycle of business validation beyond customer pains, into business models and ecosystems. The ultimate goal of the BVME-SG is to establish guidelines on best practice and approaches for business validation across all 5G-PPP projects to facilitate a sustainable evolution of the 5G market.

In this white paper, we introduce, and direct our fellow 5G PPP projects, to well-known business validation approaches such as the Lean Start-up method. Pivotal to this and similar procedures is the emphasis on solving the customer's urgent problem.

Translated into the context of 5G and verticals, it is essential to explore and validate vertical customers' real problem early. This lays the ground for finding out if and how 5G capabilities can solve the issues identified and facilitate the development of sustainable business models, ecosystems, and business cases.

An analysis of a subset of 5G-PPP projects indicated that most employ some methods for examining the customer pains and value propositions. Nonetheless, the plans also reported

that some challenges had emerged in the process of business validation, spanning from the initial customer validation and value proposition identification to the definition of suitable win-win business models for all stakeholders in the value system.

Typical challenges in the early phases of validation were associated with the alignment between the customer expectations, the technology, and value proposition capabilities.

In later stages of business validation, challenges concern (i) the identification and distribution of roles in the complex value system of the future 5G ecosystem, and (ii) the associated complexity of existing and new supply chains. These challenges call for the development of representative analytic models and visualisations to overcome limitations of existing business modelling tools.

To summarise, 5G PPP projects share some standard views on business validation challenges and which methods are more appropriate to support the business validation process. While these methods are easy to describe, it is still demanding to put them into practice in the 5G community.

This white paper suggests with confidence that 5G PPP projects exploring vertical use cases should cater to customer problems in the early stages of business validation. Beyond that, the projects will benefit from sharing and learning between them and forming new and best practises for business validation for 5G technology and markets.

This white paper is a standing invitation to all experts whose subject of work is the business validation in their respective 5G PPP projects. Please join the effort of the BVME-SG in systematically reviewing, analysing, and sharing best practices towards the development of sustainable business models for all stakeholders in the 5G ecosystem. wn

Download full paper here.

Managed services augment cybersecurity as imminent risks during COVID

According to a Mimecast analysis of the first 100 days of the pandemic, cybercriminal activity increased. Between January and March, spam and opportunistic detections rose by at least 26%, impersonation was up over 30%, malware by over 35% and the blocking of URL clicks rose nearly 56%. Across all detection categories, volumes increased 33%. Online criminals are at least a third more active since the pandemic started and remote working has become the Achilles heel of the business.

BY I SIMEON TASSEV
MANAGING DIRECTOR AND
QUALIFIED SECURITY ASSESSOR
AT GALIX

For years, companies have fine-tuned their security systems that include policies and resources calibrated for the internal workplace. Even though those systems can provide remote access, nobody anticipated that everyone in the company would work remotely, and need to do so quickly. This created a need for managed security services to bolster the organisations cyber security –as fast as possible.

GOING REMOTE IS STRAINING IT AND SECURITY

You can't just flip a switch and enable a comprehensive and secure remote-working environment. Instead, you need to revisit policies and strategies to 'tighten' them up, and conversely, relax some of them to ensure people can log in. This drop in capability has been attracting criminals. We know for a fact that a majority of incidents in the past have been triggered from known vulnerabilities and unpatched machines. All those loopholes are now potentially creeping in and the bad guys are ready to strike. It's as simple as that.

Exacerbating the issue is the fact that IT and security resources are more strained than ever before. They have many plates spinning at the moment and security demands threaten to bring those crashing down. This is why now is the perfect time to weigh managed security service options.

A managed security service provides both the people and the infrastructure to create and maintain dynamic

security. Unlike an outsource arrangement, managed services focus on critical and even core systems, closely aligned with the customer's strategy and business requirements.

Managed security services frees the business, including its IT professionals, to focus on operational aspects of the organisation, without having to worry about an area that they don't necessarily specialise in. This logic made healthy sense prior to COVID-19, and the current crunch on company resources has elevated its benefits even more.

IMPROVING YOUR INTERNAL CAPACITY

Even if a company has a strong internal capacity, it's nonetheless under tremendous pressure. As I noted earlier, the rules have changed. Companies have gone from a mass of internal users with a few remote logins to practically everyone working from the outside in. Managed security services can help manage that transition, giving the company space to evolve its policies and resources.

Managed security services are not off-the-shelf solutions. Its benefits come from four areas: specialisation in security best practice and intelligence, pooling of top skills, control and management of security infrastructure, and a generous capability to scale.

A good service provider will align these elements to what a customer environment needs. The customer gets peace of mind without giving up strategic control.

It also results in savings. Under the guidance and expertise of managed security services, a customer spends money for the right things and achieves as much as possible, rather than just going in without knowing where to start or without understanding necessarily the risks.

COVID-19's many disruptions has been a shot in the arm for cybercriminals. One silver lining is that these changes have also created much more awareness around security. The next step is to act, and with the help of a reliable and experienced managed security service provider, we can stay ahead of the bad guys. wn

Help-notes for experiencing better quality video conferences

I have been working with computers for a long and have found the following to be helpful to achieve the best video conferencing experience.

BY | PETER TOLSMA | SMSAIEE

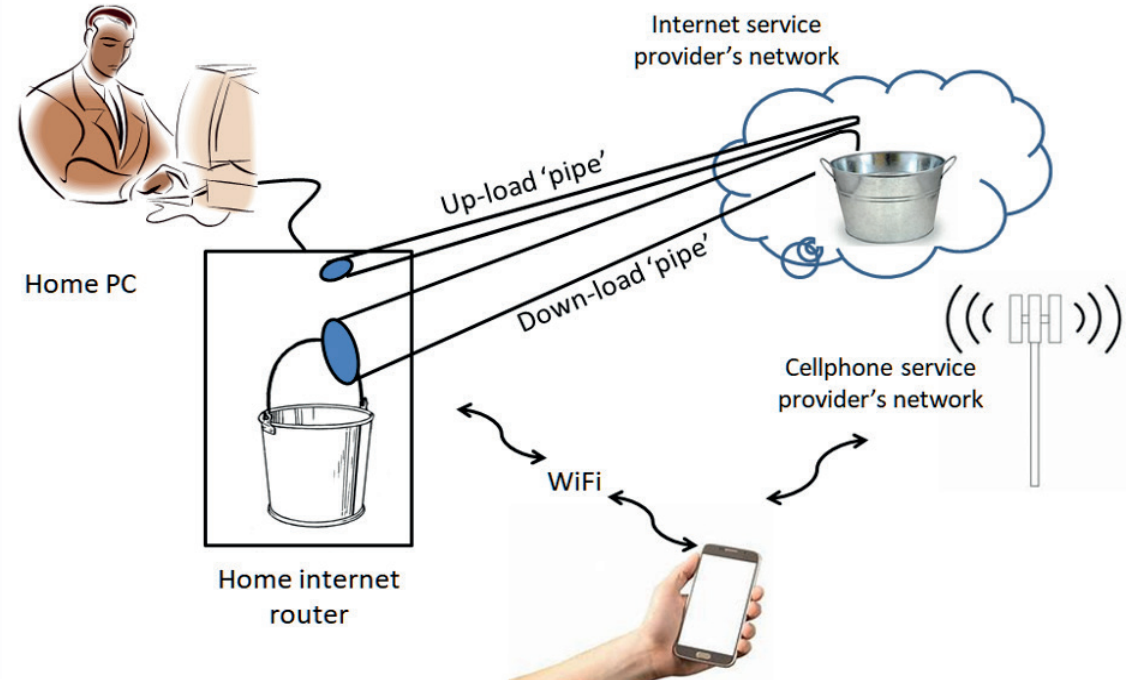
There are two factors to consider: (1) The speed of moving data to and from your computing device and (2) the data consumed by your devices. It's similar to running water through pipes into buckets. How fast can I fill the buckets through the pipes and how big is the tank that is filling the buckets. One bucket is with you and one at the service provider. See pic.

Be wary of what contract (for the 'pipe') you sign up for with the internet service provider. If you contract for a low maximum speed rate (MBps (Mega Bits per second)), then do not expect more than that. We call this your household maximum data-throughput. The "cap" that you sign up for is the maximum amount of data ('water') that you are allowed to 'flow' up- and down between you and the service provider.

Remember that you are also sending data back into the telecommunications network. When you Zoom or use WhatsApp video or talk, you send and receive data all the time. Let's take a video-conference: your picture and speech are thrown into the service provider's network, and you receive all the other attendees' videos, voice streams and the presentation pictures back to your device. It is thus essential to check that you have upload and download speed available in the 'pipes' that you rent form the service provider (filling the buckets of water – you pay for 'moving' water up and down).

OK, how does one get a good quality video-conference (video-con)?

1) It is assumed that you have up-to-date internet security software with anti-virus protection on your PC (Personal Computer).
2) Buy the correct contract from a service provider that you have good speed and a data-cap that can support the number of conferences that you will have every month.
3) If you can, attend the video-con on a PC that is connected via a cable between the service provider's router (internet terminating equipment) and your PC.
4) Restart your router (Internet terminating equipment) by switching the power off for 30 seconds and then on again. Do this 30 minutes before the video-con starts.
5) Start your PC at least 30 minutes before the conference is set to begin. This allows time for the PC to do its start-up and house-keeping before you have the video-con.
6) Check that you are familiar with sound and video settings a few days before the scheduled video-con. Test it on the program that you will be using (Zoom, Skype, Remo, etc.). Schedule a one-on-one video-con meeting with a friend and play with all the features until you are comfortable.
7) Remember that other devices in your house like cellular phones that are also connected via Wi-Fi to your router can contend for your household data-throughput. A cellular phone is always active and can download video's and voice-clips that are sent to you, even if you are not working on the mobile device. If your household data-throughput is not right, switch these cellular phones to flight mode. A second person in the house watching a YouTube video can degrade you video-con experience completely.
8) Before the video-con starts, close all other programs on your computer (Word, Excel, games, email boxes, etc.) These programs can down-load data in the background (affecting the 'flow' of the 'water'



in the pipes) that could influence your video-con negatively.

9) For the technical brave-users, one can upgrade your router's software to the latest version. Do this well in advance of a meeting, once every six months.
10) If you have a wireless router (3G, 4G or 5G), test the internet speed. Move the router closer to a window or the other side of the house. Re-do the speed test. Find the best place for the router. Remember that brick/concrete walls or even dense trees can weaken the signals. If you have an outdoor-unit, move it around. Height could improve reception for outdoor units.
11) If you will be attending the video-con on your cellphone and you are connecting via your router, switch off other PC's and switch other cellular phones to flight mode.
12) If you and your spouse will be attending the same video-con meeting, do not sign on separately. Use one device to connect. Remember, you only have one connection. The 'pipe' will only allow a certain amount of data ('water') to flow at any given point in time.
13) Never have two separate video-cons in one household on a single internet data connection. If two video-cons need to be done in the same timeslot, then one must be on the router connection and one on a cellphone that is linking via the cellular network and not via its Wi-Fi connection. Switch Wi-Fi off on that cellphone.
14) Once you are on the video-con, you have options regarding your microphone (mic) and video camera. After greeting everyone on the meeting-platform (e.g. Zoom), switch off your mic and video. This will reduce your data-throughput, will enhance the viewing quality and limit your data consumption.
15) After the video-con meeting, switch back all cellphones to normal mode, away from flight mode.
16) If you view/attend directly on your cellular device and do not use a separate router, go to a spot in the house or neighbourhood where you know there is a strong signal and stay there for the duration of the video-con meeting.
17) There are programs available (e.g. www.Speedtest.net or speedtest.mybroadband.co.za) to measure your data throughput rate. Check this against what your service provider has promised you. If it is well below what is on your contract, log a fault with the service provider. If needed, upgrade the contract to obtain more bandwidth (bigger diameter 'pipe'). In extreme cases, change to a provider that can supply you with a router that connects to a fibre connection, which is the most reliable and can easily be upgraded to very high throughput speeds.
18) Check the specifications of your equipment. I had a 10/100MB network switch in my home network between the service provider router (internet terminating equipment) and my PC, which capped my incoming speed at 96 MBps. After realising that this could be a bottle-neck, I replaced the network switch with a gigabit switch (R350) which increased my internet connection speed to 130 MBps.

I trust that this guideline will help you to have a better video-con experience. If you want to contribute, please send me an email at tolsmap@gmail.com

What to keep in mind when choosing the right data management partner

The vast array of providers and data management solutions that organisations are faced with can be daunting – from outright ownership models, to a combination of ownership and subscription models to pure service provider offerings – and the market is continuously evolving.

BY I GERHARD FOURIE
DISTRICT CHANNEL MANAGER
COMMVAULT IN SOUTH AFRICA

Deciding on the right data management partner can be extremely tricky, and in order to make the right choice, there are a number of important considerations for organisations to consider before making a commitment.

At the same time, partners are also struggling to choose the right vendor, based on the sheer volume of offerings in the market. The landscape was much less complex five years ago, when most partners had their preferred vendor, worked quite closely with them and it was fairly easy to position their technology.

However, the pace at which technology and data management solutions are evolving has made it difficult for partners to keep up with all the new offerings, especially in terms of skills.

Additionally, customers are becoming more informed about new offerings in the market, forcing traditional partners, that used to focus on a specific product, to start skilling up on other vendor offerings or platforms to ensure that their customers are not left behind.

MARGIN EROSION

The sheer volume of data management offerings that is flooding the market has also led to some margin erosion, forcing partners to pick their battles very carefully.

Essentially, they are all chasing the same accounts and each one is trying to show different value to the customers, so the products that partners in the channel space tend to stick to are typically those that still fall within a healthy margin spectrum.

For data management vendors, choosing the right partners for their product offerings can be as complicated, but any vendor-partner

relationship must be underpinned by absolute trust. Vendors share their business models with the partner, and in turn they trust that the partner will not share this with their competitors.

Reputation is key. Successful data management partners – those that been around for a while – usually build up an extremely good reputation with their customers, and data management is all about trust. Customers must rest assured that if they have an outage, the partner will be there for them.

ASPECTS TO CONSIDER

On the other hand, as a vendor, the last thing you want is to be seen supporting a fly-by-night partner who leaves behind a mess for you to clean up. So, it is crucial that you make sure you are aligned with a partner that is reputable and has a good understanding of the data management market.

When onboarding a partner, vendors should look at these five aspects:

- What is their influence in the market?
- Do they have a broad reach in their relevant region?
- Do they have the capacity to get skilled on new products and the motivation to build a pipeline and business model around a product?
- Do they have competent staff within their team?
- What is their level of commitment?

Also, agile management is important. A good partner must be able to adapt quickly to new circumstances within an account, be able to make clear decisions, and demonstrate strong execution.

If you are going to invest money into a partner's environment through business development funds, you want to see the execution.

Ultimately though, make sure that you have a proper exit strategy in place that ensures that both partner and vendor understand that, should either one become unhappy with the other, there is the option to break ties and walk away. wn

South Africans Work the Hardest and Are the Least Happy

BY | LUCY DESAI
CONTENT WRITER
QUICKBOOKS SOUTH AFRICA.

Many of us have stayed later at work to meet a tight deadline or finish a large project — but would we work frequent unpaid hours? Have you considered the toll this can have on your mental health and wellbeing? It is well established and commonly known across the world that work-related stress is a huge contributor to work absence.

Therefore, it's incredibly important that companies are aware of the effects of mental health and the cost this could have in regard to employee satisfaction and productivity. Evidence suggests that long work hours can be detrimental to personal health, with workers having less time to spend on personal care, leisure, and with friends and family.

Mental wellbeing and happiness often derive from a good work life balance — the best way to achieve this is by encouraging flexible and supportive working practices. Tokyo may be one of the most overworked cities. A reporter for Japan's national broadcaster NHK passed away from 'karoshi', a term to describe 'death from overwork', which has led to calls for the government to impose a cap on overtime. Meanwhile, in February 2018, millions of Germans won the right to work a 28-hour work week to help them achieve a good work life balance and spend more time with their families.

Here, we'll take a look at data regarding which countries work the most overtime comparing with world happiness statistics.

WHO ARE THE HARDEST WORKING COUNTRIES IN THE WORLD?

The hours workers spend at the office is largely dependent on the industry in which they work. For example, hours per week would be different for online accounting developers and retailers. That, and the worker's location can impact working hours. In richer countries, the average work week for

full-time employees is considerably lower than 40 hours, whereas it is close to 50 in others.

In an analysis of 37 affluent countries, the Organisation for Economic Co-operation and Development (OECD) found which countries are working the longest hours, and what percent of the population is working very long hours at 50 or more a week.

The country which was found to work the most hours was South Africa at 2,209 hours a year, which was also the fourth highest country for employees working 50 hours or more at 18.1%. Mexico worked the second longest (2,148) with 28.7% working 50 hours or more. Costa Rica came third, (2,121) however there wasn't data available for the percentage of employees working very long work weeks. Fourth was Korea (1,993) at 25.2%, and surprisingly, fifth was Russia (1,972) with 0.1%.

Different cultural attitudes and socio-economic factors contribute to the number of hours workers are expected to work. South Africans have been labelled some of the hardest working in the world and are three times more likely to work a 60-hour work week than Americans, although South African's labour law prohibits being asked to work more than 45 hours a week. Mexico's long working weeks are attributed to internalised fears of unemployment and lenient labour laws which means the maximum 48-hour workweek isn't often imposed. South Korea's long hours were introduced as an initiative to boost economic growth. However, with falling birth rates and stagnating productivity the country's working hours have been reduced to allow workers to rest.

ARE THE HARDEST WORKING THE LEAST HAPPY?

The World Happiness Index is an annual publication of the United Nations rankings of national happiness based on responses from residents in that country. Of the 2019 data reviewed in this article, South Africa unsurprisingly came in at the lowest with a happiness index of 4.72, likely due to being overworked and not having much free time. Mexico scored 6.6, Costa Rica 7.17, Korea 5.9, and Russia 5.65. It would appear that these countries have a relatively low happiness score, suggesting a link between happiness and hours worked per week. Russia's

happiness score is at a three-year low, explained by no apparent life improvement. It would seem that as countries develop, we want to work less to become happier — Russia's Labour Ministry reported that a four day work week would be beneficial, however workers are opposed to this over fear they'd earn less money.

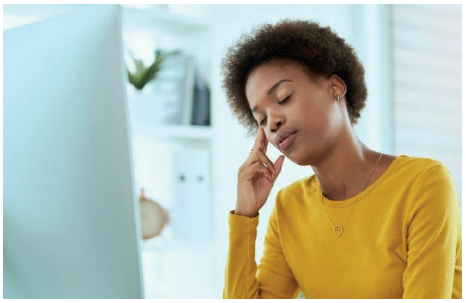
WHICH COUNTRIES WORK THE LEAST HOURS?

The country which was found to work the least hours was Germany at 1,362 hours a year, which was also one of the lowest countries for employees working 50 hours or more at 4.3%. Second place was Denmark (1,392) with 2.3% working 50 hours or more, third was Norway (1,416) with 2.9% working very long weeks, fourth was Netherlands (1,433) at 0.4%, and fifth was Iceland (1,469) at a higher 15.1%.

It seems that countries don't need to work long hours to get more work done — Germany has been recognised as one of the most productive countries, striking the ideal work life balance while being 27% more productive than their UK counterparts. When considering the number of hours worked a week with low overtime rates, they scored relatively low in terms of happiness at 6.92, close to the average.

It isn't surprising that the Scandinavian countries are the happiest in the world, with Finland first at 7.77, followed closely by Denmark 7.6, Norway 7.55, and Iceland 7.49. These countries work lower work weeks with less overtime, however Iceland's percentage of employees working very long hours is higher than anticipated. With these countries prioritising life over work, their employees and economies are benefiting.

Employers across the world seem to ignore the overwhelming evidence that long working hours don't mean consistent good performance. Happy workers mean productive days. It's important to achieve a good work life balance and enjoy time with those who matter. wn



Country	Hours worked	Employees working very long hours	World happiness index
South Africa	2,209	18.1%	4.72
Mexico	2,148	28.7%	6.60
Costa Rica	2,121	-	7.17
Korea	1,993	25.2%	5.90
Russia	1,972	0.1%	5.65
Turkey	1,832	32.6%	5.37
Poland	1,792	6.0%	6.18
United States	1,786	11.1%	6.89
New Zealand	1,756	15.1%	7.31
Hungary	1,741	3.0%	5.76
Italy	1,722	4.1%	6.22
Canada	1,708	3.7%	7.28
Spain	1,701	4.0%	6.35
Latvia	1,699	1.3%	5.94
Slovak Republic	1,698	4.1%	6.20
Japan	1,680	17.9%	5.89
Australia	1,665	13.0%	7.23
Switzerland	1,561	0.4%	7.48
Finland	1,555	3.8%	7.77
Belgium	1,545	4.8%	6.92
United Kingdom	1,538	12.2%	7.05
France	1,520	7.7%	6.59
Luxembourg	1,506	3.8%	7.09
Sweden	1,474	1.1%	7.34
Iceland	1,469	15.1%	7.49
Netherlands	1,433	0.4%	7.49
Norway	1,416	2.9%	7.55
Denmark	1,392	2.3%	7.60
Germany	1,362	4.3%	6.92

Happiness and hours worked by country

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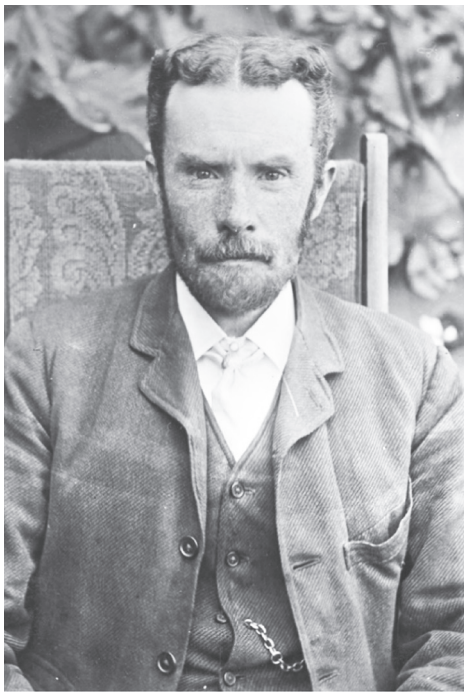
Heaviside and Gibbs

Two scientists, Oliver Heaviside (1850-1925) and Josiah Willard Gibbs (1839-1903), made major original contributions to mathematics, physics and engineering as well as major advances based on the ground breaking work of James Clerk Maxwell (1831-1879).

BY | DUDLEY BASSON



Oliver Heaviside
1850 - 1925

Oliver Heaviside was born on 18 May 1850 in Camden Town, London. At a young age he contracted scarlet fever which left him with a permanent hearing impairment which caused him to avoid social gatherings and meetings.

A small legacy enabled the family to move to a better part of Camden when he was thirteen and he was sent to Camden House Grammar School, but his parents could not keep him at school after he was 16, so he continued studying for a year by himself and had no further formal education.

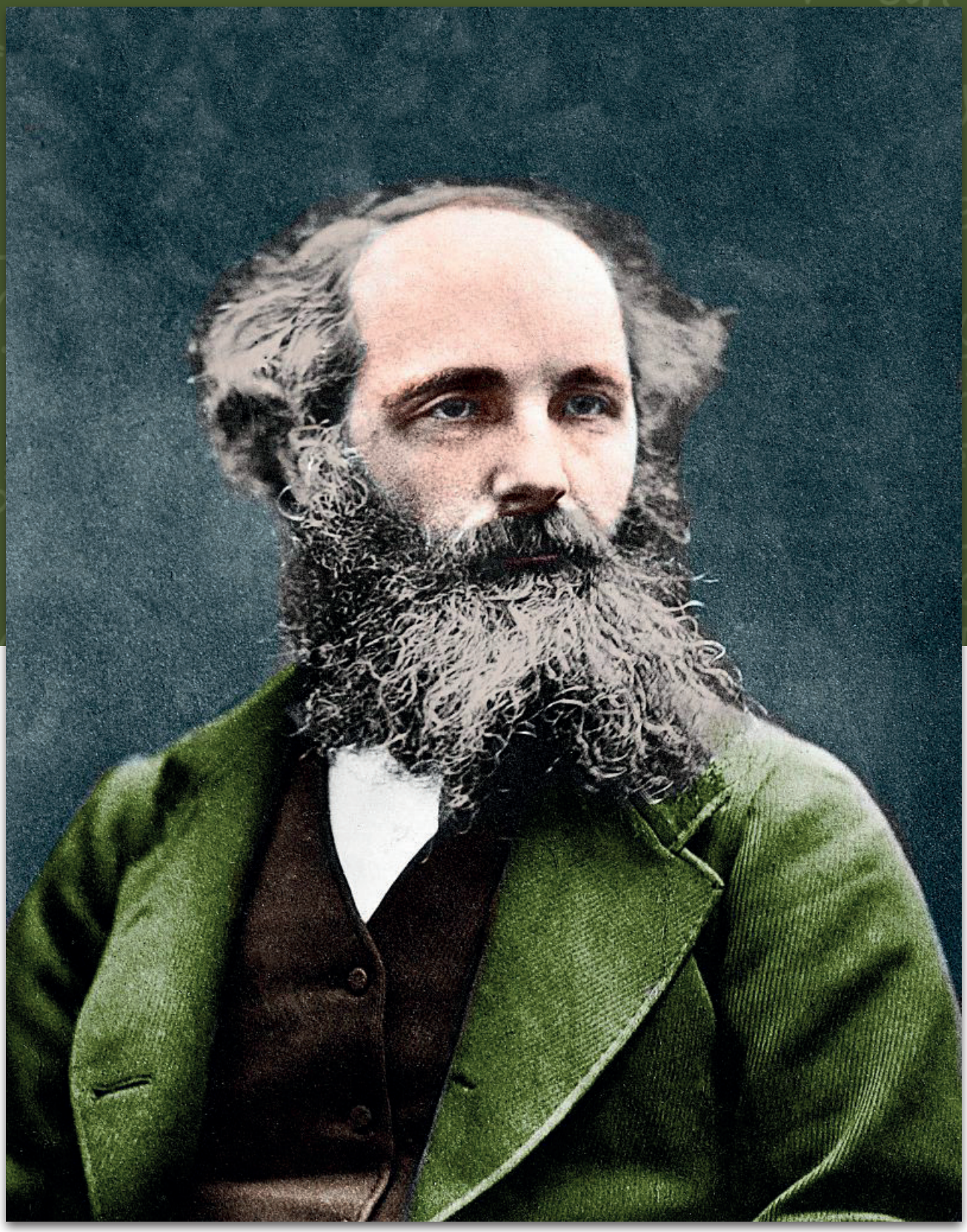
Sir Charles Wheatstone (1802–1875) was Heaviside's uncle by marriage. He was an internationally renowned expert in telegraphy and electromagnetism, and the original co-inventor of the first commercially successful telegraph in the mid-1830s.

Wheatstone took a strong interest in his nephew's education and in 1867 sent him to work with his own older brother Arthur. He became an electrician and continued to study while working. By the age of 22 he published an article in the prestigious Philosophical Magazine on *'The Best Arrangement of Wheatstone's Bridge for measuring a Given Resistance.'*

From humble beginnings, he was able to make very many significant scientific achievements to rival the most revered of his university-educated peers in the great Victorian era of scientific discovery.

As a self-taught electrical engineer, physicist and mathematician, he changed the face of telecommunications, broadcasting, mathematics and science for years to come.

He adapted complex numbers to the study of electrical circuits, coining such terms as inductance, conductance, permeability, reactance, impedance and reluctance, all in common use today. Heaviside used the term 'elastance' as the inverse of capacitance which he disliked as it suggested a container.



James Clerk Maxwell
1831 - 1879

Heaviside made many improvements in practical telegraphic and telephonic systems over his lifetime.

He was elected a Fellow of the Royal Society in 1891 for his contributions to the mathematical description of electromagnetic phenomena. In 1905 he was conferred an honorary doctorate from the University of Göttingen and in 1908 an honorary Fellowship of the Institution of Electrical Engineers, from which he received the first Faraday Medal in 1921.

WATCH

Heaviside formulated his mathematical unit step function in 1880. An introduction to Heaviside's step function can be watched here.

WATCH

Heaviside did much work on differential operators. For a lecture (11 mins) of Heaviside's operator applied to electric capacitive and inductive circuits watch here.

A differential operator is an operator defined as a function of the differentiation operator. It is helpful, as a matter of notation first, to consider differentiation as an abstract operation that accepts a function and returns another function. These go back to the time of Leibniz. Differential operators greatly simplify the writing and printing of mathematical notation.

For a fuller treatment of differential operators including the Laplace operator, click here.

Differential operators

Hamilton introduced the nabla or del operator which has come into frequent use. Here shown in three dimensions and using quaternion unit vectors. The nabla was used by Heaviside in the re-formulation of Maxwell's electromagnetic equations.

$$\nabla = \mathbf{i}\frac{\partial}{\partial x} + \mathbf{j}\frac{\partial}{\partial y} + \mathbf{k}\frac{\partial}{\partial z}$$

The D notation's use and creation is credited to Heaviside who considered a differential operator of the form:

$$\sum_{k=0}^{n} c_k D^k$$

One of the most frequently seen differential operators is the Laplacian operator, which, using a dot product with the nabla, and n dimensions, is defined by:

$$\Delta = \nabla^2 = \sum_{k=1}^{n} \frac{\partial^2}{\partial x_k^2}$$

In three dimensional Cartesian coordinates:

$$\Delta f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2}.$$

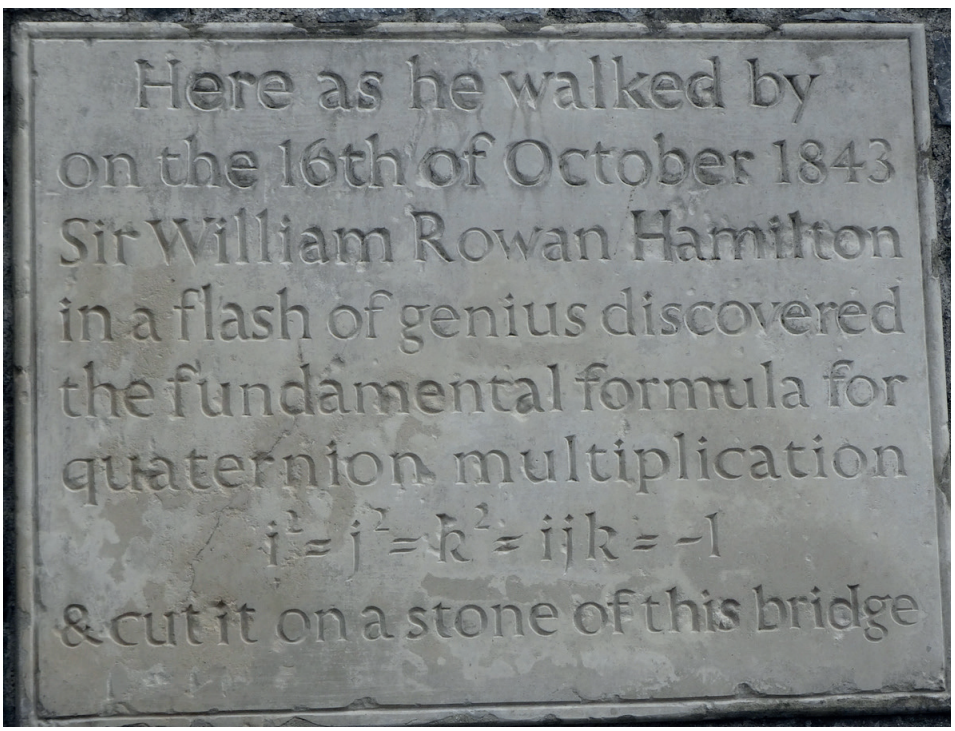
In cylindrical coordinates:

$$\Delta f = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho \frac{\partial f}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 f}{\partial \varphi^2} + \frac{\partial^2 f}{\partial z^2},$$

In spherical coordinates:

$$\Delta f = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \frac{\partial f}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta \frac{\partial f}{\partial \theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 f}{\partial \varphi^2}$$

Differential operators greatly simplify the writing and printing of mathematical notation.



Plaque commemorating Hamilton's Discovery on Broom (Brougham) Bridge

The discovery of quaternions came to Sir William Rowan Hamilton (1805-1865) in 1843 while walking along the Royal Canal in Dublin. This was an extension of two dimensional complex numbers defined by $i^2 = -1$ to four dimensional quaternions defined by the identity $i^2 = j^2 = k^2 = ijk = -1$.

He was so pleased with his discovery that he scratched the identity on a stone of Brougham bridge. No trace of Hamilton's graffito remains but a plaque has been affixed to the bridge commemorating his famous discovery. Quaternions were later extended to eight dimensional octonions by Cayley. Quaternions currently find frequent use

Peter Guthrie Tait
(1831-1901)

in three dimensional movie animations.

Maxwell's life-long friend Peter Guthrie Tait (1831-1901) co-wrote a physics text book with Kelvin and also became a leading exponent on quaternions, writing two books on the subject. Tait also did much work on mathematical knots which would become a branch of mathematical topology theory.

Clifford algebra is an algebra generated by a vector space with a quadratic form, and is a unital associative algebra. As K-algebras, they generalize the real numbers, complex numbers, quaternions and several other hypercomplex number systems. The theory of Clifford algebras is intimately connected with the theory of quadratic forms and orthogonal transformations. Clifford algebra has important applications in a variety of fields including geometry, theoretical physics and digital image processing. Clifford algebra has largely supplanted quaternion algebra. This algebra is named after the English mathematician William Kingdon Clifford (1845-1879).

Maxwell moved with his wife to London in 1856 on being appointed to the Chair of Natural Philosophy at King's College. This period was probably the most productive of his career. He would attend lectures at the Royal Institution where he regularly made contact with the now ageing Michael Faraday. In 1857 Maxwell wrote an elegant paper giving convincing mathematical grounds for accepting Faraday's lines of force and went on to develop his electromagnetic theory in the conditions of space.

Maxwell needed a four dimensional algebra for his electromagnetic theory and was able to use quaternions discovered earlier by Hamilton.

Maxwell expressed his electromagnetic theory as twenty quaternion equations in twenty variables using:

GAUSS'S LAW:
Electric charges produce electric fields.
AMPERE'S LAW:
Electric currents produce magnetic fields.
FARADAY'S LAW:
Changing magnetic fields produce electric fields.

Maxwell completed the last key pieces of his electromagnetic theory in 1864, at age 33. In his 1864 talk and the paper that followed, he left the mechanical model behind but kept the concept of displacement current. Focusing on the mathematics, he described how electricity and magnetism are linked and how, once properly generated, they move in concert to make an electromagnetic wave.

Maxwell's equations were not at first widely accepted and Thomson (later Lord Kelvin) objected to the idea of displacement current. The mathematics of the twenty quaternion equations was not widely understood at the time.

In 1873 Heaviside had encountered Maxwell's newly published, and later famous, two-volume Treatise on Electricity and Magnetism. In his old age Heaviside recalled:

"I remember my first look at the great treatise of Maxwell's when I was a young man… I saw that it was great, greater and greatest, with prodigious possibilities in its power… I was determined to master the book and set to work. I was very ignorant. I had no knowledge of mathematical analysis (having learned only school algebra and trigonometry which I had largely forgotten) and thus my work was laid out for me. It took me several years before I could understand as much as I possibly could. Then I set Maxwell aside and followed my own course. And I progressed much more quickly".

Hermann von Helmholtz commented in 1881:

"Now that the mathematical interpretations of Faraday's conceptions regarding the nature of electric and magnetic force have been given by Clerk Maxwell, we see how great a degree of exactness and precision was really hidden behind Faraday's words…it is astonishing in the highest to see what a large number of general theories, the mechanical deduction of which requires the highest powers of mathematical analysis, he has found by a kind of intuition, with the security of instinct, without the help of a single mathematical formula".

In 1885 Heaviside reformulated James Clerk Maxwell's field equations in terms of the electric and magnetic forces (deleting Maxwell's potentials

along the way, due to their non-observability) while independently co-formulating vector analysis and Prof. Henry Poynting's energy-flux theorem. The Poynting vector represents the directional energy flux (the energy transfer per unit area per unit time) of an electromagnetic field. It is named after its discoverer John Henry Poynting who first derived it in 1884. Heaviside also discovered it independently in the more general form that recognises the freedom of adding the curl of an arbitrary vector field to the definition. For info on the poynting vector click here.

Heaviside used twelve of Maxwell's quaternion equations to reformulate electromagnetic theory using vector calculus. Heaviside and Gibbs developed the dot and cross products of vector algebra which were important to the equations. The very concise form of the equations was achieved by using the vector dot and cross products and the nabla differential operator of vector calculus.

For the definitions of vector dot and cross products click here.

MAXWELL'S ELECTROMAGNETIC EQUATIONS AS REVISED BY HEAVISIDE

Although the equations of Heaviside could reasonably be called the 'Heaviside Equations', Heaviside was adamant that they should be known as the Maxwell Equations.

For two fascinating videos showing how vector gradient and curl are associated with the dot and cross products with the nabla operator:

WATCH

WATCH

The Maxwell equations can of course also be written in the abstruse mathematics of tensors. To see how this can be done click here.

Name	Differential form	Integral form
Gauss's Law	$\nabla \cdot \mathbf{D} = \rho_f$	$\oiint_{\partial V} \mathbf{D} \cdot \mathrm{d}\mathbf{A} = Q_f(V)$
Gauss's Law for magnetism	$\nabla \cdot \mathbf{B} = 0$	$\oiint_{\partial V} \mathbf{B} \cdot \mathrm{d}\mathbf{A} = 0$
Faraday's law of induction	$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	$\oint_{\partial S} \mathbf{E} \cdot \mathrm{d}\mathbf{l} = -\frac{\partial \Phi_{B,S}}{\partial t}$
Ampere's law (with Maxwell's correction)	$\nabla \times \mathbf{H} = \mathbf{J}_f + \frac{\partial \mathbf{D}}{\partial t}$	$\oint_{\partial S} \mathbf{H} \cdot \mathrm{d}\mathbf{l} = I_{f,S} + \frac{\partial \Phi_{D,S}}{\partial t}$

Maxwell's Electromagnetic Equations as revised by Heaviside

Einstein's theory of General Relativity was written completely in the language of tensors.

For an introduction to the mathematics of tensors click here.

Pseudo-science writers have complained about the eight Maxwell quaternion equations disregarded by Heaviside, claiming that this has removed the electro-gravitational component of Maxwell's theory. It is also claimed that the full functionality of quaternions has been lost by using vector calculus.

If Maxwell's equations did indeed have an electro-gravitational component, then this would have constituted the long sought-after 'Theory of everything' which in turn would have given the theory for obtaining unlimited gravitational energy from empty space, making all current sources of energy redundant. Interestingly, Nikola Tesla remarked that it would only be a matter of time before unlimited energy could be obtained from empty space allowing "machines to be attached to the wheelwork of nature".

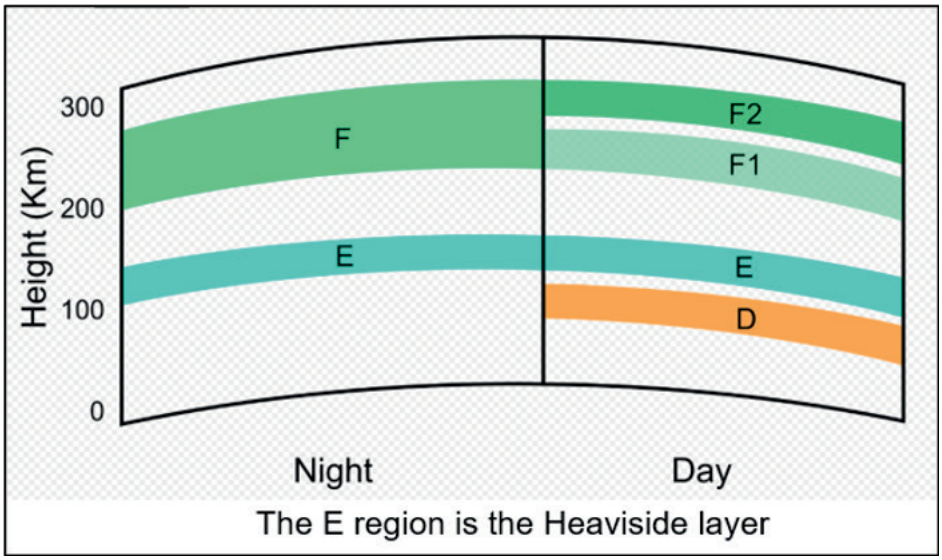
Gravitational energy from empty space has not been observed.

The Kennelly-Heaviside layer was predicted in 1902 by Heaviside and American electrical engineer Arthur Edwin Kennelly (1861-1939). This was proposed as an explanation for the propagation of radio waves beyond the horizon, observed by Marconi in 1901, who had received signals in Newfoundland that had been broadcast in England. The existence of the layer was shown by British scientist Edward Appleton in 1924 for which he received the 1947 Nobel Prize in Physics.

The Heaviside layer of ionised gas occurs roughly between 90 and 150 km above the ground and is one of several layers in the ionosphere and is also known as the E-region.

The layer is affected by the time of day, seasons and sunspot activity. This has been used since 1920 for reflecting medium frequency (shortwave) radio waves for long distances up to transcontinental distances. The F2 Appleton layer can reflect radio signals multiple times to reach around the Earth. Radio signals can be reflected from the Earth back to the ionosphere in much the same way as RADAR signals are reflected by solid objects.

How the Heaviside layer reflection worked presented a problem, as for reflection to take place the speed of the waves would need to be greater in



the ionosphere than in the atmosphere below, where the waves moved at the speed of light "c" which cannot be exceeded.

The paradox was resolved by the discovery that there are two velocities of light – the phase velocity and the group velocity. The phase velocity can in fact be greater than "c", but the group velocity, being capable of transmitting information cannot, by special relativity, be greater than "c". The phase velocity for radio waves in the ionosphere is indeed greater than "c", and that makes total internal reflection of radio waves possible. The geometric mean of the phase velocity and the group velocity cannot exceed "c", so when the phase velocity goes above "c" the group velocity must go below it.

WATCH

For a video illustrating group and phase, wave velocities.

The private Radio Clube de Moçambique, also known as Lorenço Marques Radio was founded in 1931, and would become a popular shortwave English radio service in South Africa, especially amongst teenage listeners. Shortwave listeners would sometimes, when searching for broadcast stations, hear the noise of encrypted messages between ships at sea.

Coaxial cable was used in the 1858 transatlantic cable but its theory was not described and patented until 1880 by Heaviside.

Coaxial cable is widely used to carry high frequency electrical signals with low losses. It is used in such applications as telephone trunk lines, broadband internet networking cables, high speed computer data busses, cable television signals, and connecting radio transmitters and receivers to their antennae. Every dish-TV user will have a coaxial cable connecting the dish to the decoder. The dimensions of the cable and connectors are controlled to give a precise, constant conductor spacing, which is needed for it to function efficiently as a signal transmission line.

The Heaviside condition is the condition that an electrical transmission line must meet in order for there to be no distortion of a transmitted signal. Also known as the distortionless condition, it can be used to improve the performance of a transmission line by adding loading to the cable.

A signal on a transmission line can become distorted even if the line constants, and the resulting transmission function, are all perfectly linear. There are two mechanisms: firstly, the attenuation of the line can vary with frequency which results in a change to the shape of a pulse transmitted down the line.

Secondly, and usually more problematically, distortion is caused by a frequency dependence on phase velocity of the transmitted signal frequency components. If different frequency components of the signal are transmitted at different velocities the signal becomes "smeared out" in space and time, a form of distortion called dispersion.

This was a major problem on the first transatlantic telegraph cable and led to the theory of the causes of dispersion being investigated, first by Lord Kelvin and then by Heaviside who discovered how it could be countered.

For more information on the Heaviside condition click here.

Ethernet cables are a modern development in ultra-high-speed cabling. These come in several grades and have very specific minimum and maximum lengths of up to a few hundred metres. These cables are capable of data transmission well into the Gbps range and are widely used in Ethernet local area networks. Ethernet cables are in many cases a viable alternative to Wi-Fi.

Heaviside's Telegrapher's equations are a pair of coupled linear partial differential equations that describe the voltage and current on an electrical transmission line with distance and time.

The equations come from Heaviside's paper of 1876 which demonstrates that the electromagnetic waves can be reflected on the wire, and that wave patterns can form along the line. The theory applies to transmission lines of all frequencies including direct current and high frequency current. It can also be used to electrically model wire radio antennae as truncated single conductor transmission lines.

For more information on Heaviside's Telegrapher's Equations click here.

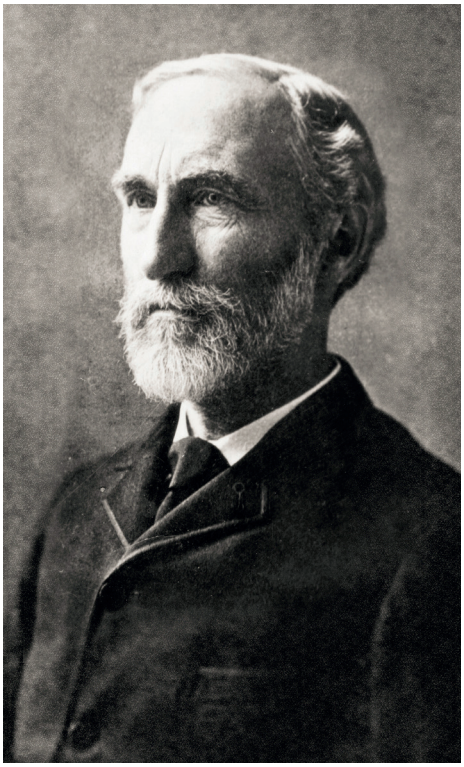
Heaviside died on 3 February 1925, at Torquay in Devon after falling from a ladder, and is buried near the eastern corner of Paignton cemetery. He is buried with his father, Thomas Heaviside (1813–1896) and his mother, Rachel Elizabeth Heaviside.

Josiah Willard Gibbs was born on 11 February 1839 in New Haven, Connecticut, USA.

His father, also named Josiah Willard Gibbs, was professor of sacred literature at Yale University. The Gibbs family originated in Warwickshire, England and moved from there to Boston in 1658.

Gibbs enrolled at the local Hopkins Grammar School where he was described as friendly but withdrawn. His total commitment to academic work together with rather delicate health meant that he was little involved with the social life of the school. In 1854, aged 15 he entered Yale College where he won prizes for excellence in Latin and Mathematics.

After his father died in 1861, Gibbs and his two sisters inherited the family house and sufficient savings to make them financially independent.



Josiah Willard Gibbs
1839 - 1903

Remaining at Yale, Gibbs began to undertake research in engineering, writing a thesis "On the Forms of the Teeth of Wheels in Spur Gearing" in which he used geometrical methods to study the design of gear wheel teeth. The involute tooth design provides smooth velocity transmission from one gear wheel to another and is ubiquitously used by the automotive industry and engineering worldwide. Cycloidal and harmonic gearing provide compact high ratio gearing with few moving parts for special purposes. Worm drive gearing provides high ratio gearing with orthogonal shafts.

When he was awarded a PhD from Yale in 1863 it was the first doctorate of engineering to be conferred in the United States. Gibbs also held significant patents for railway brakes and couplings and also a steam-engine governor. He served as a tutor at Yale for three years, teaching Latin for the first two years and then Natural Philosophy (Physics) in the third year.

Gibbs went with his sisters Anna and Julia to Europe in 1866 where he would spend academic years in turn at the Sorbonne in Paris and the Universities of Berlin and Heidelberg. His single-minded purpose was to continue expanding and refining his scientific knowledge.

Like his father, he seems to have had a considerable gift for languages, so working in French and German caused him no problems. In Heidelberg he was influenced by Kirchhoff and Helmholtz. At that time France, Germany, and the United Kingdom lay at the heart of the scientific world.

In Europe, Gibbs' health was a concern – tuberculosis was suspected – and he and his sisters moved to the French Riviera, hoping the warm, dry Mediterranean climate would help him. Thankfully, after a few months on the Riviera, he was pronounced free of tuberculosis.

On his return to New Haven, Gibbs taught French for a time at Yale, and worked privately on some of his engineering ideas.

In 1871, he was appointed Yale's first professor of Mathematical Physics. The role was unpaid. Gibbs was happy with this situation – he was a man of modest needs and his inheritance provided him with more than enough money. Furthermore, he was happy that the role required little teaching work, allowing him more thinking and research time.

As his scientific reputation grew, he was head-hunted by other universities. Gibbs chose to stay at Yale, because he

was happy in the familiar surroundings of his hometown. Moreover, Yale's other scientists told him how much they valued his presence at the university. He stayed at Yale for the whole of his career and the University started paying him a salary to counterbalance offers he received from other institutions.

In 1873, two years into his professorship, the 34-year-old Gibbs began publishing work that revolutionized the understanding of thermodynamics. His first major paper was *"Graphical Methods in the Thermodynamics of Fluids"*. He began by noting that the first two laws of thermodynamics could be combined into a single equation of state – the Gibbs Equation of State – now a basic equation of thermodynamics. In the following two links the Δ represents 'difference' and not a differential operator.

For a treatment of Gibbs free energy click here.

For the Gibbs-Helmholtz equation click here.

His second paper, also published in 1873 was *"A Method of Geometrical Representation of the Thermodynamic Properties of Substances by means of surfaces"*.

In the two ground-breaking papers he showed how expressing thermodynamic quantities on graphs he had constructed led to entirely new conclusions about the behaviour of matter. These graphs were in three dimensions, with x, y, and z axes.

Gibbs sent copies of his work to 75 notable scientists in Europe. One of these was James Clerk Maxwell at the University of Cambridge.

Maxwell, one of the world's foremost authorities on thermodynamics, devoured Gibbs work, realizing that it solved a conceptual problem he had been wrestling with in vain for over two years. Furthermore, Gibbs' new interpretation of thermodynamics improved Maxwell's personal understanding of the field.

In 1874-1875 Gibbs proposed a thought experiment which is known as the Gibbs Paradox. The paradox allows for the entropy of closed systems to decrease, violating the second law of thermodynamics. A related paradox is the "mixing paradox".

If one takes the perspective that the definition of entropy must be changed so as to ignore particle permutation, the paradox is averted. The paradox can be illustrated by means of a set of pendulums of different lengths as a closed system. When set in motion the pendulums will swing with increasing disorder and then gradually become realigned lowering the entropy.

WATCH the video of the Gibbs Paradox.

WATCH the following video of pendulums starting with low entropy, going to disordered higher entropy and then lower again.

Maxwell shared Gibbs' work enthusiastically with other British scientists. He made three 3-dimensional plaster models of a surface in one of Gibbs' graphs and sent one to Gibbs as a token of his appreciation and respect.

Maxwell and Gibbs were on the same mental wavelength – they understood each other's work, which few other people did at the time.

A copy of the plaster model sent by Maxwell to Gibbs, held by Yale's Peabody Museum of Natural History. The model represents the behaviour of a water-like substance plotted on axes of volume (x-axis), entropy (y-axis) and energy (z-axis). The dark lines on the model are lines of equal pressure and equal temperature. (This was a time before 3-D computer graphics)

Unfortunately, Maxwell's untimely death in 1879 deprived the scientific world of what could have become a very fruitful, if long-distance, partnership between two great intellects.

In 1878, Gibbs published a third thermodynamics paper, the most revolutionary of them all: *"On the Equilibrium of Heterogeneous Substances Part II"*.

In this paper Gibbs founded the science of chemical thermodynamics, entirely shaping our modern understanding of the field. This work lies at the heart of physical chemistry, telling us which chemical reactions are feasible.

Unfortunately, Gibbs' work was so highly mathematical that it took many years before its message was fully understood.

Gibbs commented: *"In the thirty years of my professorship of mathematical physics, I've had but half-a-dozen students adequately prepared to follow my lectures"*.

In 1880 Gibbs was awarded the Rumford prize for *"Founding the field of chemical thermodynamics"*. The Rumford prize was founded in 1796 and awarded to scientists for contributions in the fields of heat and light, which would include discoveries in thermodynamics and improvements in the construction of steam boilers.

Gibbs' work on vector analysis was also of major importance in pure mathematics.

He first produced printed notes for the use of his own students in 1881 and 1884 and it was not until 1901 that a properly published version appeared prepared for publication by one of his students. Using ideas of Hermann Grassmann, Gibbs produced a system much more easily applied to physics than that of Hamilton.

He applied his vector methods to give a method of finding the orbit of a comet from three observations. The method was applied to find the orbit of Swift's comet of 1880 and involved less computation than Gauss's method.

In 1897 Gibbs was awarded a Foreign Membership of the Royal Society of London.

The Royal Society was founded in 1660.

In mathematics, the Gibbs phenomenon, discovered by Henry Wilbraham (1848) and rediscovered by Gibbs (1899), is the peculiar manner in which the Fourier Series of a piecewise continuously differentiable periodic function behaves at a jump discontinuity.

For more info on the Gibbs phenomenon click here.

In 1901 Gibbs received what was then considered his highest honour awarded by the international community, the Copley Medal of the Royal Society of London.

The medal was awarded *"For his contributions to mathematical physics"*.

Gibbs was praised by Einstein as *"the greatest mind in American history"*.

Some quotes:
Willard Gibbs:
"A mathematician may say anything he pleases, but a physicist must be at least partially sane."

"One of the principal objects of theoretical research is to find the point of view from which the subject appears in the greatest simplicity."

"If I have had any success in mathematical physics, it is, I think, because I have been able to dodge mathematical difficulties."

Werner Heisenberg:
"When I entered Niels Bohr's institute in Copenhagen in 1924, the first thing that Bohr demanded was that I should read the book of Gibbs on thermodynamics, and he added that Gibbs had been the only physicist who really understood statistical thermodynamics."

Robert Millikan
"Gibbs did for statistical mechanics and for thermodynamics what Laplace did for celestial mechanics and Maxwell did for electrodynamics, namely, made his field a well-nigh finished theoretical structure."

Gibbs was perceived by people who knew him as kind, sympathetic, and happy. He never married. He shared the family home with his sisters: Anna, who remained unmarried; and Julia, her husband and children.

Gibbs attended church regularly and left New Haven only during his summer vacations, which he liked to spend in the mountains.

He had none of the idiosyncrasies that one may come to expect from men of genius - he remained a dignified and respectable gentleman. wn

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July in History

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1 JULY

1944 Although World War 2 was still raging on, representatives of all forty-four Allied Nations met in order to prepare to rebuild the international economic system. The result the Bretton Woods system of monetary management which lead to the establishment of the International Monetary Fund (IMF) and the International Bank of Reconstruction and Development (Ibrd0, which today is part of the World Bank Group.

2 JULY

2001 59-year old American Robert L. Tools became the first person to receive a self-contained artificial heart transplant called the AbioCor. This was made possible due to advancements in miniaturization, biosensors, plastics and transcutaneous energy transfer.

3 JULY

1962 After 132 years of French rule, Algeria gained its independence after the signing of the Évian Accords in the spa town of Évian-les-Bains, France. Independence was achieved after the result of the 1st July 1962 Referendum was for complete Algerian independence.

4 JULY

1865 Alice's Adventures in Wonderland was published for the first time. It's a novel by English author Lewis Carroll, which tells of a young girl named Alice, who falls through a rabbit hole into a subterranean fantasy world populated by peculiar, anthropomorphic creatures. It is considered to be one of the best examples of the literary nonsense genre.

5 JULY

1687 Isaac Newton's great work Principia published by Royal Society in England, outlining his laws of motion and universal gravitation

6 JULY

1964 Malawi gained its independence from Britain. Between 1953 and 1963, the Southeast African country had been part of the British controlled Federation of Rhodesia and Nyasaland. After dissolution of the federation and independence, Nyasaland changed its name to Malawi.

7 JULY

1959 Venus occulted Regulus. Data obtained from this event was used to determine Venus's diameter as well as the structure of its atmosphere. Occultations (when one planet passes in front of another) of bright stars are rare. The next one will be in 2044, and will be Venus and Regulus again.

8 JULY

2011 Space Shuttle Atlantis was launched for the last time, and was also the last flight of NASA's 30-year long and successful Space Shuttle program. STS-135, as this final mission was called, was the program's 135th flight.

9 JULY

2011 South Sudan, previously known as the Republic of South Sudan, peacefully seceded from Sudan after an independence referendum. Sadly, since then the country has been wrecked by violence.

10 JULY

1913 According to the Weather and Climate Extremes archive, the hottest temperature ever recorded on earth was in Furnace Creek, Death Valley, California at 56.7°C on this day.

11 JULY

2010 The first FIFA World Cup Final was held in Johannesburg, South Africa.

12 JULY

1975 São Tomé and Príncipe gained independence from Portuguese rule that had begun in 1470, until 1975. Manuel Pinto da Costa became the first president of the newly independent country.

13 JULY

1937 The now international (including South Africa) Krispy Kreme Doughnuts was founded by American Vernon Rudolph.

14 JULY

1850 1st public demonstration of ice made by refrigeration by Florida physician John Gorrie.

15 JULY

1988 "Die Hard" directed by John McTiernan and starring Bruce Willis and Alan Rickman is released in the US.

16 JULY

1953 Lieutenant Colonel William F. Barns, United States Air Force, set a Fédération Aéronautique Internationale (FAI) absolute World Record for speed over a 3 Kilometre Straight Course at the low-altitude course at the Salton Sea, California, USA.

17 JULY

709 BC "The sun was eclipsed and it was total." This is the earliest record of a confirmed total solar eclipse and was written about in the Ch'un-ch'iu, book I (Chinese). Further reference to this eclipse is found in the Han-shu ('History of the Former Han Dynasty') (Chinese, 1st century AD): "...the eclipse threaded centrally through the Sun; above and below it was yellow."

18 JULY

1976 14-year-old Romanian gymnast Nadia Comåneci performed in the uneven bars event, and was awarded a score of 10.

19 JULY

1837 English civil and mechanical engineer, Isambard Kingdom Brunel's S.S. Great Western, an oak-hulled steamship propelled by paddle wheels powered by a two-cylinder steam engine, was launched at Bristol, England.

20 JULY

1960 Mrs Sirimavo Bandaranaike became the world's first non-hereditary female head of government in modern history, when she was appointed as Prime Minister of Sri Lanka in 1960. She served three terms: 1960–1965, 1970–1977 and 1994–2000.

21 JULY

1982 The first closed-circuit video inspection of the upper reactor core region was performed on Three Mile Island's Unit 2's partial core meltdown. The camera had a diameter of 3.81 cm and was 30.48 cm long that was inserted through the empty leadscrew support pipe, and then into a central control rod guide tube. Nothing was observed until 1.52 m, and that was a pile of rubble.

LOOKING BACK continues from page 67

22 JULY

1895 The first true car race, from Paris to Bordeaux, France and back, was held. The total distance was 1,178 km, and the winner made an average speed of 24.15 kph.

23 JULY

2000 Tiger Woods, aged 24, became the youngest player to win a career Grand Slam after winning the British Open at St. Andrews.

24 JULY

1991 India's finance minister, Manmohan Singh, presented a budget to parliament. Singh said, "the room for manoeuvre, to live on borrowed money or time, does not exist anymore." His speech marked India's entry into global capitalism.

25 JULY

1837 *English inventors, Charles Wheatstone and William Fothergill Cooke, demonstrated their five-needle telegraph. They ran a six-wire telegraph line for 2.4 km, between Euston to Camden Town, along the Great Western Railway Company railway track.*

They successfully transmitted and received messages. Wheatstone provided the technological skill and is better remembered in the history of the telegraph while Cooke had the business acumen.

26 JULY

1989 Robert Tappan Morris, a graduate student from Cornell University, was indicted on a felony charge for releasing a computer virus, the Morris worm, that disrupted thousands of computers throughout the United States in 1988. He is now a professor at Massachusetts Institute of Technology.

27 JULY

2018 The longest total lunar eclipse of the 21st century coloured the moon reddish orange in parts of Africa, Asia and Europe for about one hour and 42 minutes.

28 JULY

1851 The earliest scientifically useful photograph of a total solar eclipse was taken by Julius Berkowski at the Royal Observatory in Königsberg, Prussia.

29 JULY

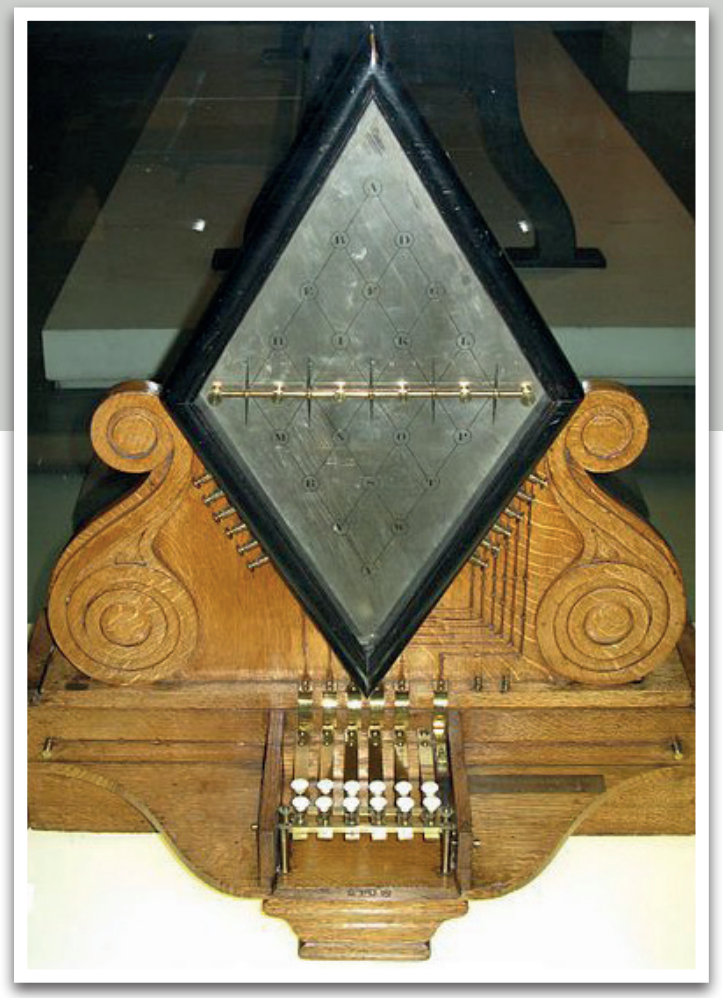
2008 The U.S. House of Representatives publicly apologized for the institution of slavery and Jim Crow laws that discriminated against African Americans.

30 JULY

2002 The Pretoria Accord was signed between the Democratic Republic of the Congo (DRC) and Rwanda as an attempt to end the Second Congo War. Sadly, it was not successful.

31 JULY

1865 The first narrow-gauge mainline railway in the world opened at Grandchester, Queensland, Australia. wn



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AUGUST 2020

4	**SAIEE Training Academy - Online CPD Course:** Photovoltaic Solar Systems - Day 1
5	**SAIEE Women in Engineering - Webinar** "Celebrating Women"
	SAIEE Training Academy - Online CPD Course: Photovoltaic Solar Systems - Day 2
6	**SAIEE Training Academy - Online CPD Course:** Photovoltaic Solar Systems - Day 3
7	**SAIEE Training Academy - Online CPD Course:** Photovoltaic Solar Systems - Day 4
12	**SAIEE Training Academy - Online CPD Course:** Fundamentals of Power Distribution - Day 1
13	**Power & Energy Section - Webinar:** "Role of the Smart Grid in Facilitating the Integration of Renewables"
	SAIEE Training Academy - Online CPD Course: Fundamentals of Power Distribution - Day 2
17	**SAIEE Training Academy - Online CPD Course:** Transformer Construction, Opersyion, Maintenance, Testing and Protection - Day 1
18	**Load Research Chapter - Webinar** Distribution Networks for Renewables
	SAIEE Training Academy - Online CPD Course: Transformer Construction, Opersyion, Maintenance, Testing and Protection - Day 2
19	**Power & Energy Section - Webinar** The Internet of Things
	SAIEE Training Academy - Online CPD Course: Transformer Construction, Opersyion, Maintenance, Testing and Protection - Day 3

To organize a webinar on the SAIEE Platform, please complete the **Webinar Booking form**.

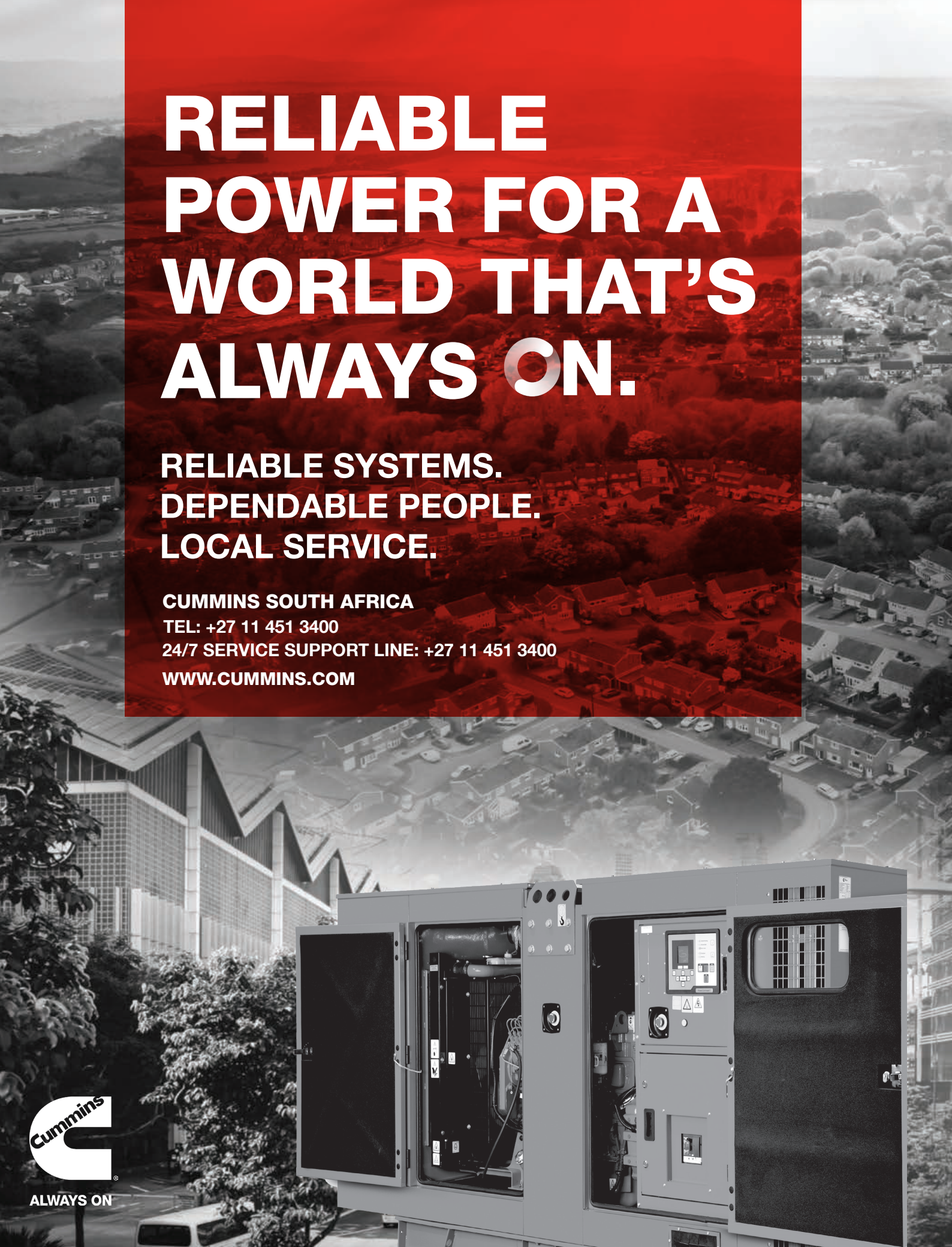
AUGUST 2020 (CONT)

20	**WATTNOW ST-TALK - Communications**
	SAIEE Training Academy - Online CPD Course: Transformer Construction, Opersyion, Maintenance, Testing and Protection - Day 4
27	**Power & Energy Section Webinar:** "Lightning Protection, Insulation Coordination for HV Power Lines"
	SAIEE Training Academy - Online CPD Course: HV Testing and Measurement - Day 1
28	**SAIEE Training Academy - Online CPD Course:** HV Testing and Measurement - Day 2

SEPTEMBER 2020

2	**SAIEE Training Academy - Online CPD Course:** Fundamentals of Practical Lightning Design for Commercial and Industrial Applications - Day 1
3	**SAIEE Training Academy - Online CPD Course:** Fundamentals of Practical Lightning Design for Commercial and Industrial Applications - Day 2
10	**SAIEE Training Academy - Online CPD Course:** Design of Economical Earthing Systems for Utility Electrical Installations - Day 1
11	**SAIEE Training Academy - Online CPD Course:** Design of Economical Earthing Systems for Utility Electrical Installations - Day 2
17	**Bernard Price Memorial Lecture - Webinar** Presenter: Roger Price
	SAIEE Training Academy - Online CPD Course: LV/MV & HV Switchgear Operation, Safety, Maintenance and Management - Day 1
18	**SAIEE Training Academy - Online CPD Course:** LV/MV & HV Switchgear Operation, Safety, Maintenance and Management - Day 2

Section & Chapter, Centre Webinars wattnow Webinars SAIEE Academy Online Training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