wattnow

POSSIBILITIES OF THE 5TH INDUSTRIAL REVOLUTION

RSA | R30.00 incl. VAT

RAILWAYS

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

SMART GRID FORUMS

IEC 61850 Global 2020

Driving the large-scale deployment of IEC 61850 across the substation, the wider smart grid, and distributed energy resources

26 - 30 October 2020
Brussels, Belgium

Event highlights

- ✓ **Tech Innovation Panels**
- ✓ **Live Demo Lab**
- ✓ **Solution Zone**
- ✓ **Power Networking**
- ✓ **Case-Study Programme**
- ✓ **Fundamentals Workshop**
- ✓ **DER Integration Seminar**
- ✓ **Roundtable Discussions**

Save 10% using discount code
IEC-20-MEDIA-SAIEE
when registering online!

Find out more and register at:
www.smartgrid-forums.com/

CONTENTS

FEATURES

GENERAL

REGULARS

SAIEE @saiee

wattnow

MANAGING EDITOR
M Avrabos | minx@saiee.org.za

TECHNICAL EDITOR
J Buisson-Street

CONTRIBUTORS
V Fouché
K Motupa
W Coetzee
S Sibande
P Croucamp
R Coetzee
D Basson

EVENTS
G Geyer | geyerg@saiee.org.za

CPD & COURSE ACCREDITATION
S Moseley | suem@saiee.org.za
www.trainingacademy.saiee.org.za

MEMBERSHIP & TECHNOLOGY LEADERSHIP
C Makhalemele Maseko | connie@saiee.org.za

ADVERTISING
Avenue Advertising
T 011 463 7940 | F 086 518 9936 | Barbara@avenue.co.za

SAIEE HEAD OFFICE
P.O. Box 751253 | Gardenview | 2047
T 011 487 3003
www.saiee.org.za
Office Hours: 8am - 4pm

ISSN: 1991-0452

2019 Q4 - 13 496

April has seen South Africa live through an unprecedented lockdown in a bid to ready the country for the pandemic that is spreading through the world. We, as South Africans, are truly amazing, as we have always had the mindset of "adapt or die"; we make the best of every situation.

During April, many industries have suffered severely, particularly the transport sector, which is not only due to the Covit-19 pandemic. This last month has seen the end of SA Express. In this issue we highlight a different aspect of transport, that being Railways.

Our first feature is an exclusive interview with William Dachs, the CEO of the Gautrain Management Agency. Read the interview on page 26.

On page 32, we have an article on how electricity is the enabler for heavy haul operations and how Transnet can give power back to the grid.

Page 36 features an article "Migration from the road to rail in South Africa" where the discussion tackles the age-old debate: road vs rail.

I took the liberty to publish, for you, the "Economic and Social Impact study of the Gautrain". Find this on page 40.

Dudley Basson did not disappoint with his in-depth historical article on Isambard Kingdom Brunel, who changed transporting for ages to come. Read more about Brunel on page 124.

Watch out for the invitation exclusively to SAIEE Members for the ST-Talk: Railways Webinar, taking place on 21 May at 1 pm CAT. Our presenters will be William Dachs, CEO GMA and Sguda Sibande, Chief Electrical Engineer, Transnet.

To get the best out of the on-line wattnow, this pdf is now 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 April issue,
enjoy the read, take care and stay safe!

Minx

AI&ML for the Smart Grid 2020

8 - 10 September 2020
Belgium, Brussels

Implementing AI&ML platforms and processes to enable the rapid scale-up of advanced smart grid analytics use-cases

12+ utility case studies including:

STEDIN
TenneT
50hertz
alliander
BKW
enel
Elektro Ljubljana
ENEDIS L'ELECTRICITE EN RESEAU
Eesti Energia
ESB INTERNATIONAL
innogy

Save 10% using discount code **AIM-20-MEDIA-SAIEE** when registering online!

In-depth insights on:

- ✓ Demystifying AI
- ✓ Forecasting
- ✓ Maintenance
- ✓ Implementing AI
- ✓ Latest Technologies
- ✓ Managing Data

Event highlights include:

- ✓ Case-Study Programme
- ✓ Roundtable Discussions
- ✓ Technology Innovation Panel
- ✓ Live Demo Lab
- ✓ Solution Zone
- ✓ Evening Networking Reception

Find out more and register at:
www.smartgrid-forums.com/AIML20SAIEEM

The Fifth Industrial Revolution

SY GOURRAH
2020 SAIEE PRESIDENT

Although the Fourth Industrial Revolution, along with its disruptive technologies, focusses on the digital economy which is evolving rapidly, the application of Artificial Intelligence (AI) and big data are triggering the explosion of better processing capabilities

Many industries are embedding AI into their products and services. The use of AI, robots, algorithms and other related technologies is increasing at a rapid pace. The speed and evolution of the current industrial revolution indicate that a possible Fifth Industrial Revolution might be on us sooner than we expect due to the convergence of technology and humans.

This article discusses the era of the Fifth Industrial Revolution - the possibilities in the age of Artificial Intelligence, machines performing human tasks (singularity), innovation and inclusivity.

The evolution of technologies and machines for use in the fields of health, electric cars, driverless cars (autonomous), education and 3D printing as well as the increase in the density of robot workers, are all exploding and evolving.

The article will also cover the current developments of solar cells, humanoids, drones, wearable internet, supercomputers, nanotechnologies, artificial intelligence, quantum computing, virtual power plants and the data explosion forecast.

The article provokes the endless possibilities for members of the SAIEE and the engineering sector as a whole with Artificial Intelligence, Robotics, IoT, Big Data, Automation, Smart systems, Machine learning (ML) and humans striving to achieve countless innovations into the future.

INTRODUCTION

The exponential growth of technology, along with the acceleration in AI, has integrated technology with humans at such a rapid pace that the fifth industrial revolution is imminent.

Looking at the history of the different industrial revolutions: the first took place between 1760 and 1850. During that time, the developments were mainly mechanisation. The second industrial revolution (1863 to 1947) that primarily covered electrification. Then came the third industrial revolution (approximately 1969 to 2000), which lasted almost 31 years and focused mainly on automation. The timeframes of each of the industrial revolutions reduced dramatically. Currently, we are in the fourth industrial revolution, which is primarily digitalisation. However, the speed of the evolution of technology along with the speed of the industrial revolutions does

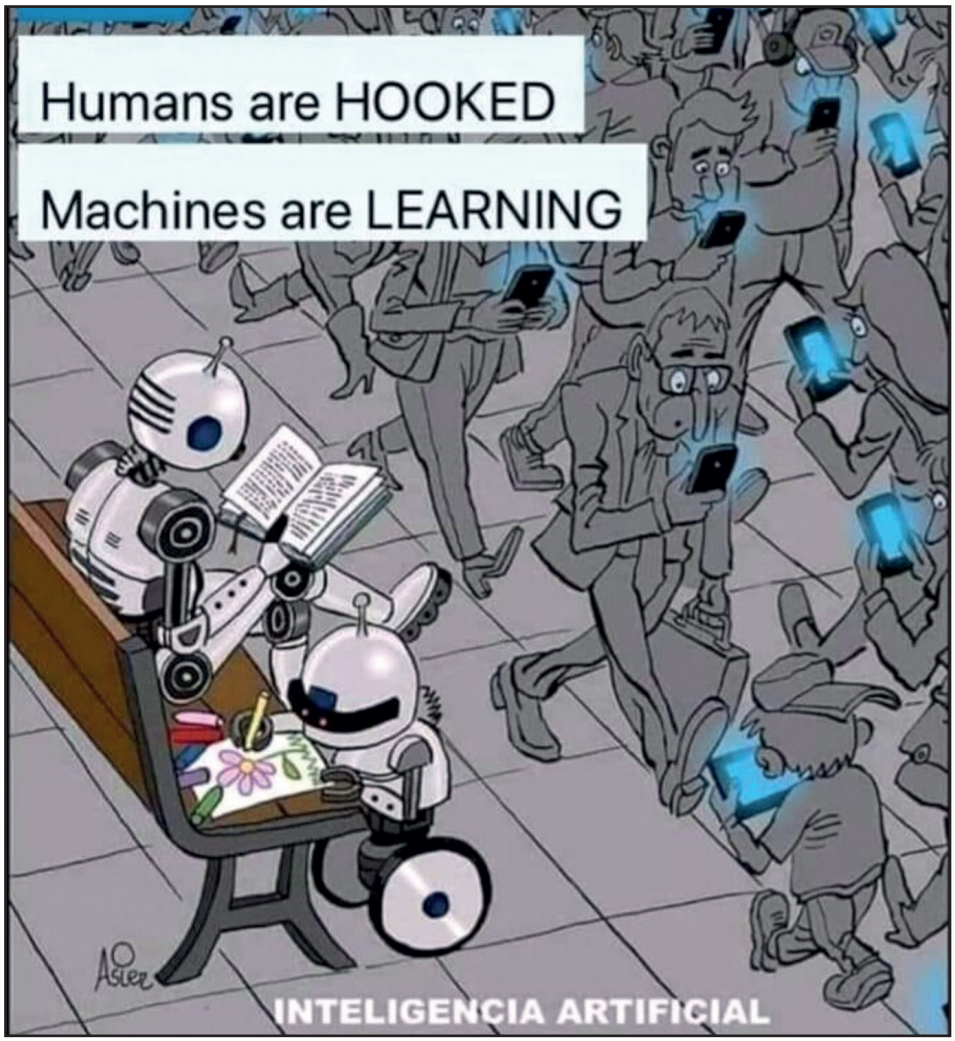
indicate that a possible fifth industrial revolution might come about sooner than we expect.

The Era of the Fifth Industrial Revolution
While the fourth industrial revolution is mostly about digital transformation and is thought to be transformational, the fifth industrial revolution, which is characterised by the steep exponential acceleration of technology, is rapidly propelling us into the era of artificial Intelligence. These will result in cyber systems, linked by networks, which will create smart autonomous plants, offices and homes, which will lead to smart cities with intelligent societies.

THE POSSIBILITIES IN THE AGE OF ARTIFICIAL INTELLIGENCE

Artificial Superintelligence (ASI) occurs when a machine's Intelligence far exceeds that of humans. Machines are taking over many tasks, previously performed by humans, and are improving the productivity, speed and accuracy of many of the functions. Machine Learning (ML) is currently cited as an essential modern business trend that may be a driver to success in several businesses.

According to a study conducted by PwC, 82% of South Africans are willing to engage with robotics and AI, unlike our counterparts in first world countries who have openly opposed the implementation of robots. This might be driven by the fear of robotics and AI taking over jobs and increasing unemployment. Interestingly, the ratio of industrial robots to employees in South Africa is amongst the Global top 40 where one would have expected South Africa to be lagging in the installation of robots; this is not the case - see Figure 1.



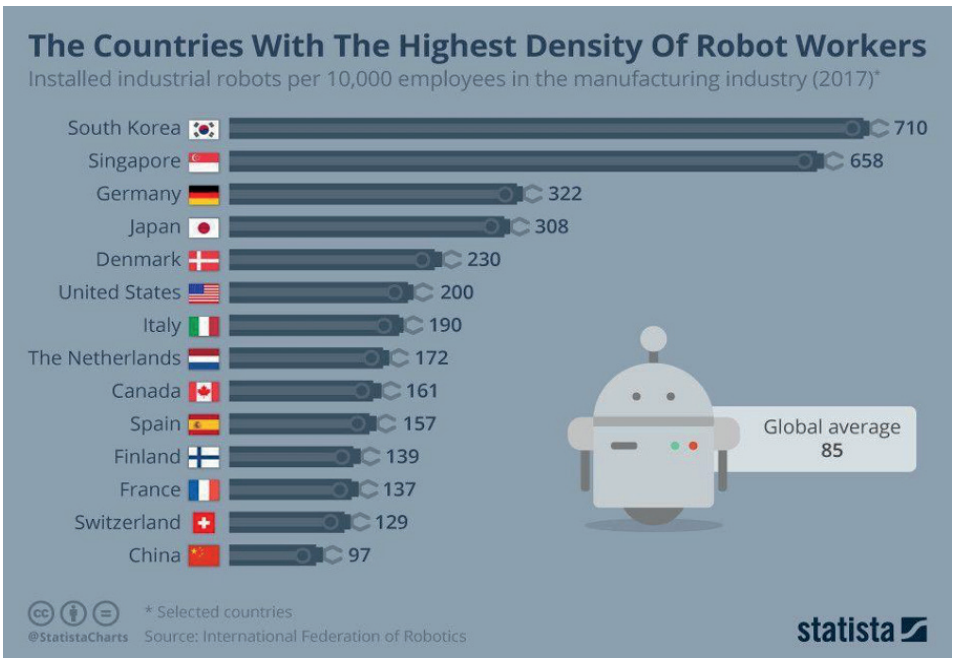


Figure 1: The countries with the highest density of robot workers

CURRENT ADVANCES

There are numerous advances in terms of the current technology available, such as the following:

Wearable internet already plays an essential role in many of our lives. Some watches answer calls, make calls, get messages, count your steps, heartbeats, blood pressure, oxygen levels and even ECG.

The newer technology works with the blood vessels carrying blood below the surface of one's skin. Advancements on this technology include rings, such as the Oura Ring, which obtains its information from blood vessels which are much closer on the finger than the wrist, thus providing a more accurate reading. Advancements on health apps are soon to be universal.

3D Printing was previously pricey but has reduced in price considerably. This is used for the manufacture of jet engines, apartments buildings, circuit boards, prosthetics etc. One of the most expensive supply chains in the world was to send spares or replacement for parts into space. This was resolved through 3D printing which can produce alternatives faster. The latest technology combined with computation can deliver any complex component, including possible body organs.

The Internet of Everything has many exciting developments such as super-intelligent societies, especially the children of today who can google or YouTube anything and everything. Countries such as Japan are already preparing for the fifth industrial revolution by creating super-intelligent societies and changing their business models to suit the fifth industrial revolution. They are not waiting for it to happen but rather preparing for the inevitable.

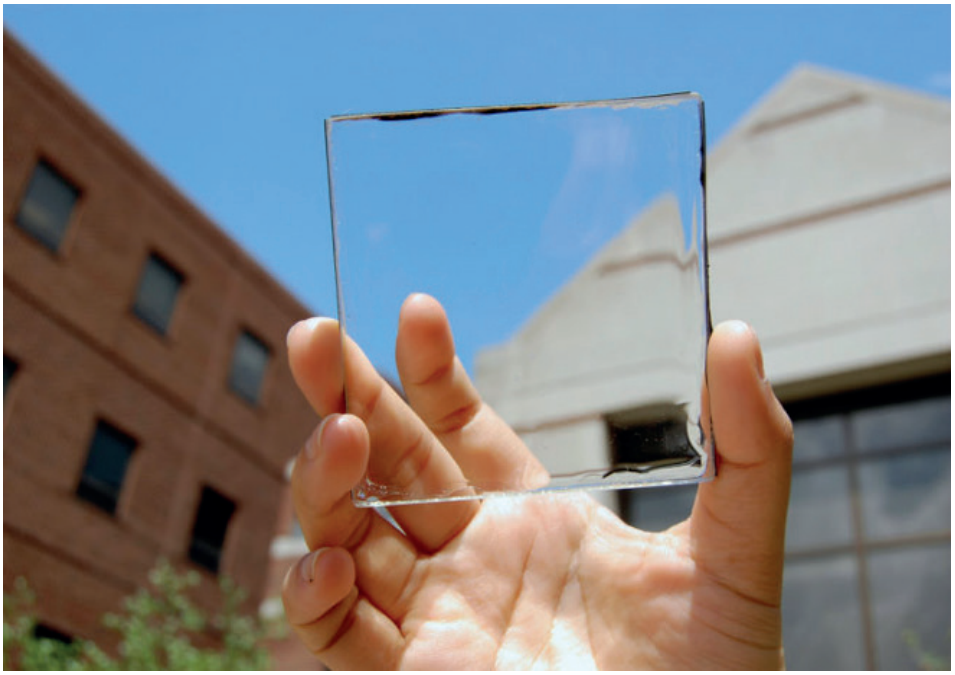


Figure 2: Solar Cells

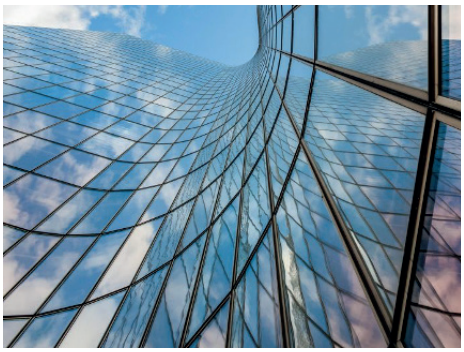


Figure 3: The visible light is let through while ultraviolet and infrared rays are redirected to small solar panels on the side of the glass.

There are memory mirrors that can video, for example, different outfits that can send to friends to advise on which is the most suitable best outfit. Or fit your clothes digitally and order online through body scans.

The advances I would like to elaborate on are as follows:

SOLAR CELLS: This solar glass is coated with materials such as Phosphorous which can absorb ultraviolet radiation and convert it to visible light. The visible light is let through while ultraviolet and infrared rays are redirected to small solar panels on the side of the glass. This technology could have lots of high-rise buildings converted using solar panes, as in Figure 3 a & b.

DRONES: Drones make use of technologies such as machine learning, 3D printing and material science breakthroughs with multiple purposes, especially in the agricultural and health fields. There are three different drone applications discussed here, namely **Zipline**, a USA company that has

Figure 4: The Zipline Drone

Figure 6: Drone Weaponry

developed a drone delivery system used in Rwanda and Tanzania. It is primarily responsible for the delivery of critical lifesaving products, such as blood and vaccines, to exactly where it is needed in areas especially where the road infrastructure is not adequate. This is a complete transformation in the traditional logistics, which consists of autonomous navigation systems. Avoiding delays of drones connecting to a Global Positioning System (GPS), a GPS unit is placed inside the battery unit of the drone so that it is continuously connected and does not delay take-off which is often scheduled for a few minutes after receiving an order. The drone is launched using a rail, a pulley, and an electric motor to achieve approximately 100 km/hr in 0.3 secs.

Another drone application is the **Aurora Odysseus** which is a solar-powered plane that flies at a high altitude, mainly in the stratosphere and is primarily used for surveillance and Intelligence.

The last possible application of drones considered here is **drone weaponry.** Facial recognition and GPS location are already in use and but could also be used to trace or track people. Further, and if required using a small amount of explosive could be added to the payload. A possible application would be in defence and military weaponry. This could also be a potential misapplication of the drone technology and where governments need to ensure such inventions are ethical and authorised to be implemented, to avoid it being used for wrong reasons. Regulations on drone flights and usages should be developed, legislated and implemented in each country.

DATA EXPLOSION: Large amounts and volumes of data and storage have created a data explosion. Big Data

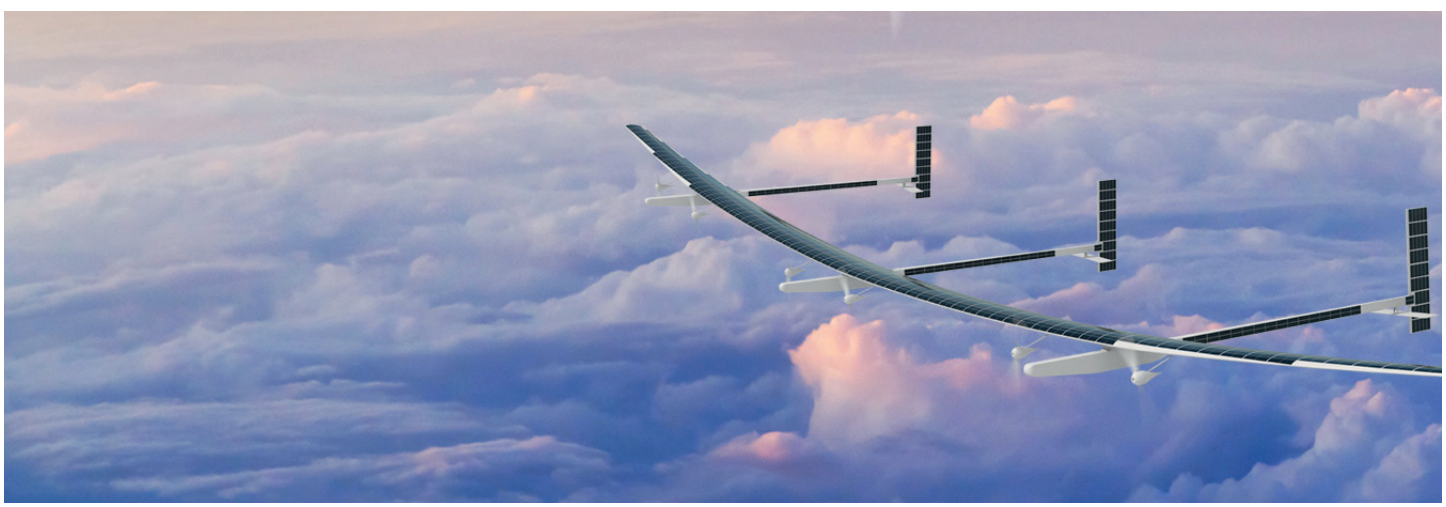


Figure 5: The Aurora Odysseus Drone

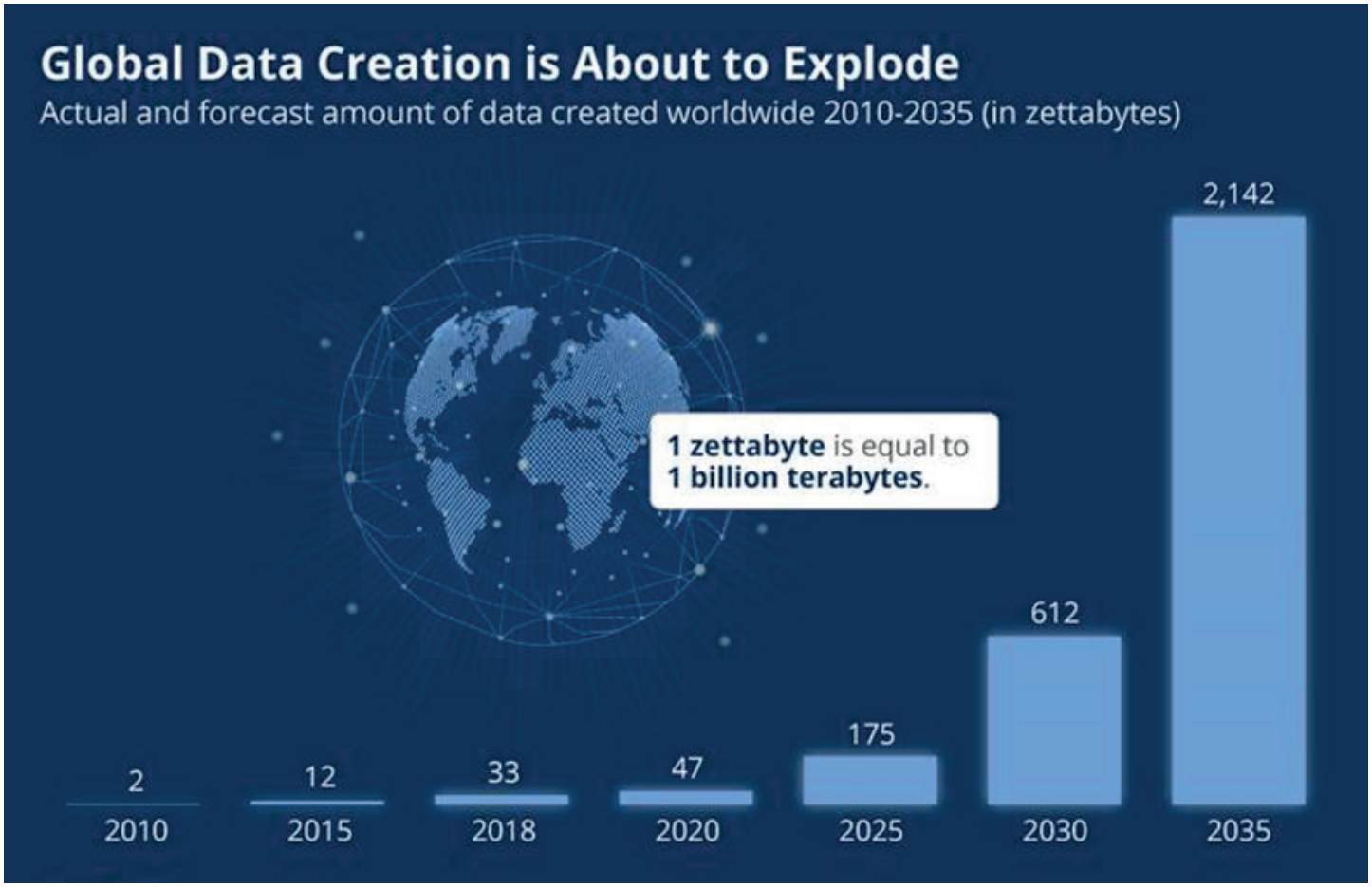


Figure 7

and the Internet of Things (IoT) with devices and sensors are the creators of large quantities of data. IoT devices alone could create over 90 ZB of data by 2025. It is expected that by 2035 we would have close to 500 billion sensors globally. AI and ML are essential for tackling the data explosion by sorting the databases and finding the relevant information for a particular application. Blockchain, virtual reality, Cloud-based computing and storage all increase data explosion.

The Zettabyte Era, which began in sometime between 2012 (when the amount of digital data exceeded 1 ZB) and in 2016 (when global IP traffic exceeded 1 ZB), would fill 500 million x 2 terabyte hard drives at a current cost of R575 billion. It took approximately 40 years to reach a global Zettabyte, but it will not take that long to reach 2 ZB. The USA, in anticipation of a further data explosion, has set aside approximately $260 billion for 2022 to tackle data explosions and its applications.

NANOTECHNOLOGIES: This technology has a significant market share with the top applications being that of electronics, the energy sector and in the biomedical field. The US alone has a market value of approximately $49 billion in 2017 and is projected to increase to $79 billion by 2020.

To illustrate the size of a nanometre, consider that the size of a COVID-19 virus molecule is 80 nm. This means that approximately 750 COVID-19 virus molecules would fit into the cross-section of one human hair. Nanotechnology is the science of manipulation of materials at atomic, molecular and macromolecular scales. It is also the production & application of structures, devices and systems by controlling the shape and size at nanometre dimensions. Imaging techniques have increased the ability to control structure sizes or shapes.

Au (Gold) & Ag (Silver) nanoparticles are used as coloured pigments in stained glass and ceramics. Some of the applications of nanotechnologies are polymers, chemical processes, computer chips, DVD drives, enhanced data storage, nano-engineered membranes are used for energy-efficient water purification or desalination processes. Specific self-cleaning windows use a 15nm thick coating of activated titanium oxide

engineered to be highly water repellent, so that rainwater runs off the surface, washing away the dirt. Nanoparticles are also used in some sunscreens to reflect and absorb ultraviolet light.

Molybdenum disulphide (MoS2) and titanium dioxide (TiO2) (also known as titanium (IV) oxide or titania) are catalysts used for applications in clean energy storage, primarily when used in Lithium-Ion Batteries (which have superior storage capabilities and cycling performances). This is achieved when nanocomposites of lithium titanium oxide nanosheets are infused with molybdenum disulphide by a hydrothermal approach during the manufacturing process.

QUANTUM COMPUTING: A brief history of the origins of Quantum Computing and the great discoveries leading up to its development: In the early 1960s, Stephen Wiesner discovered conjugate coding. He had started off trying to figure out a way to make banknotes that could not be counterfeited but later attempted to find a way of secretly communicate Quantum Cryptography.

During the 1970s Alexander Holevo developed the Holevo Theorem concerning n-qubits. A qubit comprises of electrons, or the nucleus of a single phosphorus atom, and is created inside a layer of silicon. A qubit physical device behaves as a two-state quantum system.

Although quantum cryptography is in its infancy, a worldwide quantum cryptographic network is achievable with current technology and will be a satellite-based implementation. Sometime during the 1980s, Paul Benioff discovered the Laws of Quantum Mechanics and Yuri Manin linked quantum computing to Stephen Wiesner's Conjugate Coding. In 1989 the first secret quantum transmission was completed, then in 1993, quantum teleportation was invented, and quantum information was transmitted from one location to another. During the 1990s Quantum computers were solving oracle and computational problems by building Quantum databases using 2 to 3 qubits, and a nuclear magnetic resonance (NMR) computer was built.

Throughout the 2000s, there were numerous discoveries in quantum theories. A few worthwhile to mention is the no-cloning and deleting theorems; Single-photon emitter for optic fibres and six photon one-way quantum computer; nitrogen in a buckyball molecule used in Quantum computing. D-wave systems were used in NASA quantum computers, and IBM built a 17 qubit. Later in 2019 a 53 qubits quantum computer was built.

ARTIFICIAL INTELLIGENCE: All Tesla cars are being built with the hardware required for self-driving, which includes eight vision cameras, 12 ultrasonic sensors, radars to be used by a full self-driving computer. Data and computing are already having a significant impact on disciplines like humanities, machine learning and artificial Intelligence. MIT has previously announced a $1billion plan to create a new college for Artificial Intelligence. Many leaders at various universities are emphasising that AI be taught to all students from the first principles.

Uber Elevate/Aerial Ride is currently looking at being implemented in Dallas, California and Los Angeles (in the USA) by 2023. Billions of dollars have already been invested into this concept, and are awaiting approvals from Federal Aviation Administration to go ahead with the implementation. Elon Musk's Boring Company and Tesla are expanding their rocket and electric car companies and developing their concept of transportation networks which use magnetic levitation to propel passenger pods down vacuum tubes travelling in Hyperloop.

The UK manufacturing sector is investing £455 billion in AI. Ford Motor Company, in collaboration with Dominos, are looking at providing pizza delivery services using self-driven cars. Another development in robotics is the BionicCobot which is an arm with seven degrees of freedom and

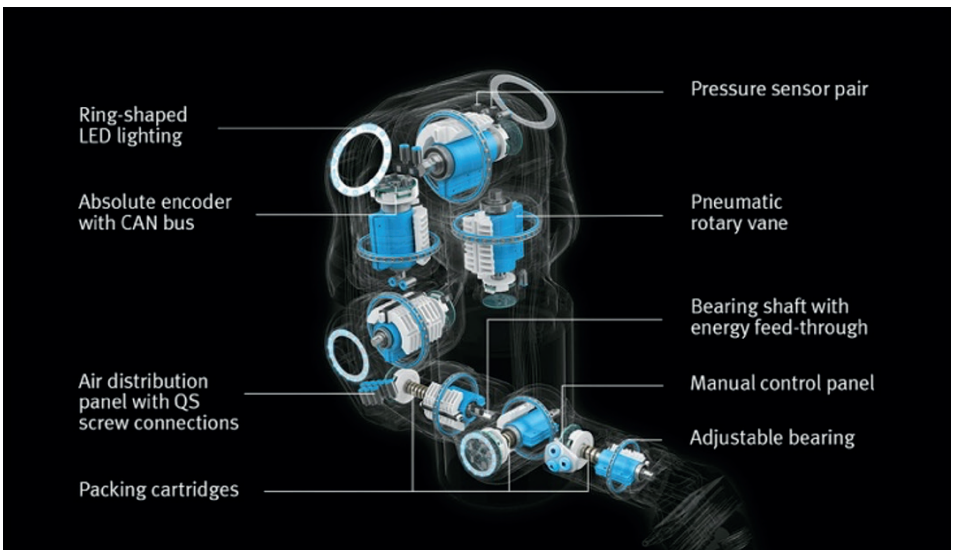


Figure 8

Figure 9: A Vegbot

allows customers to customise what they require. It is currently used as a replacement for a human arm. The fifth industrial revolution is all about personalisation.

There have also been significant advancements in the use of AI in agriculture; Vegbots have been developed and are used to harvest or fruit picking robots. These are proven to be dexterous robots with cameras that are used by the AI embedded in their control systems.

Mercedes Benz has released a concept car that makes use of a photographic technique that records how light is scattered from an object thus giving an option to customise the exterior, interior and specific functions of the car. These cars even have thirty-three bionic flaps or moveable scales which are meant to communicate with the driver.

SUPERCOMPUTERS: These are used for scientific and engineering applications dealing with large databases or/and a significant amount of computation.

With the COVID-19 crisis, the speed of data analysis is of the essence, and this is where Supercomputers can help. NASA and IBM have lent a hand with their supercomputer to complete computational studies, frameworks and Investigations to stop the virus.

IBM has a supercomputer, called Summit, which was commissioned in 2014 by the Department of Energy in the US. It is housed in Oak Ridge at the National Laboratories in Tennessee.

Supercomputers, one of which is Summit, have been enlisted to assist with stopping COVID-19. To do this, it is necessary to understand how the virus affects host cells. The spike protein is what merges with our cells and causes the infections so if we can develop a vaccine or compound that binds with the spike protein to render the protein ineffective we can stop the spread of the virus.

The supercomputers have used simulations of the infected cells being combined with numerous drugs to assist in the identification of possible cures. Summit has to find drug components that can bind

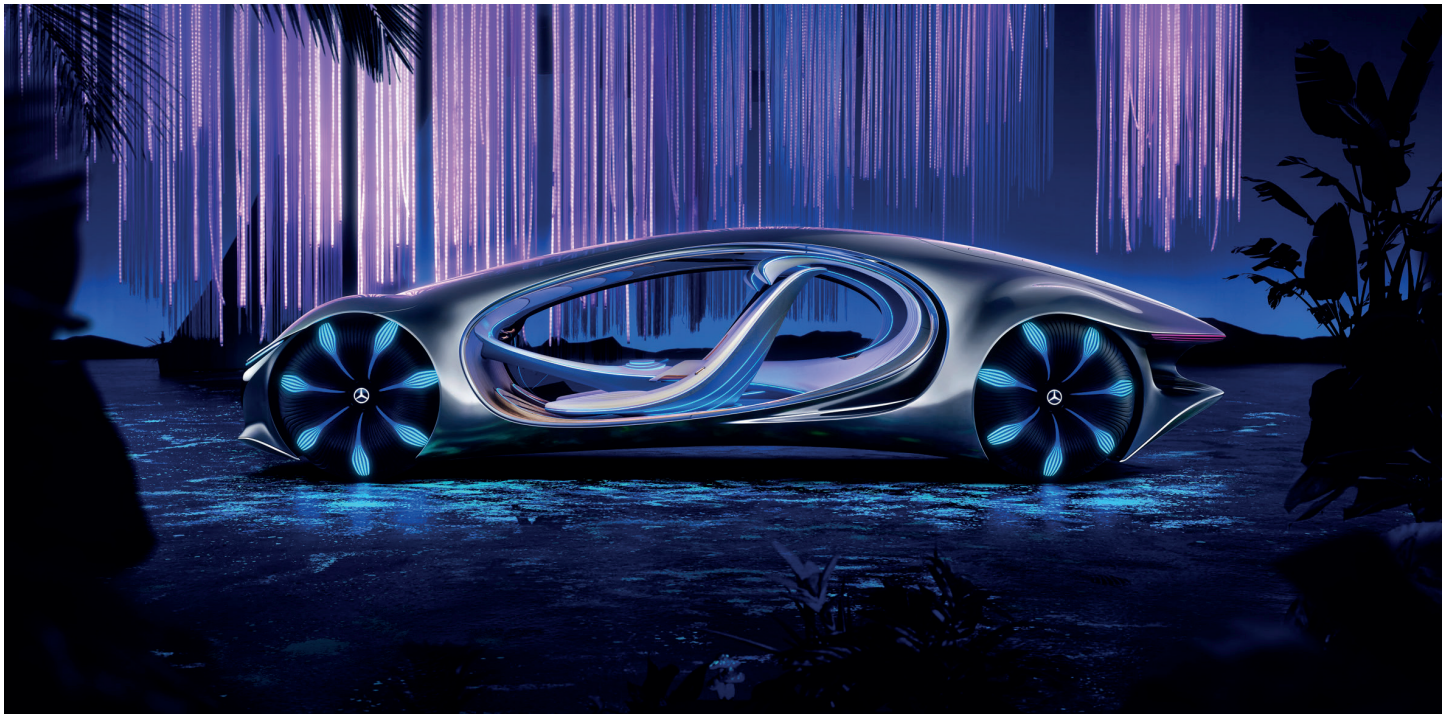


Figure 10: Mercedes Benz Concept Car

with the spike protein, rendering the protein ineffective. Summit models the coronavirus spike and simulates how the atoms and particles in the viral protein would react to different compounds. It ran simulations of over 8 000 compounds and identified 77 of which were ranked in order of priority.

Other applications of supercomputers include detection of patterns in a molecular, cellular system that may precede Alzheimer's, analysis of genes that may contribute to opioid addiction, climate simulations that may predict extreme weather.

The speed of supercomputers is measured in petaflops which is a measure of computers processing speed. A supercomputer's rate is in the range of 220 to 330 petaflops (floating-point operations per second) of speed.

AI PAVES THE WAY FOR VIRTUAL POWER PLANTS: Countries such as Dubai, Australia and South Africa are all investigating and implementing Virtual

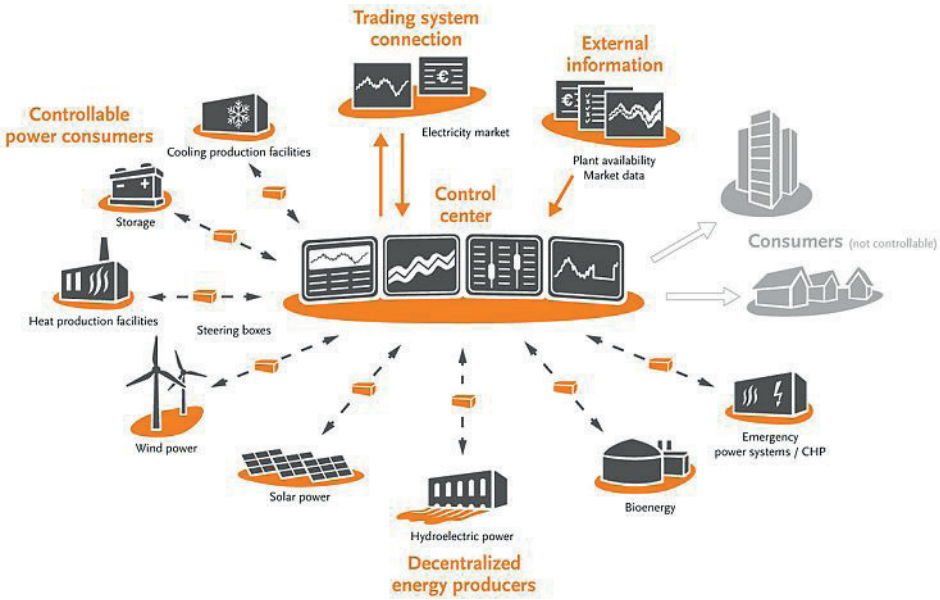


Figure 11: AI paves the way for Virtual Power Plants.

Power Plants (VPP). A VPP is a smart network consisting of decentralised medium scale generation units such as solar photovoltaic, battery storage, wind farms, flexible loads and controllable loads which are linked and operated as a single centralised system. To run a VPP requires a unique algorithm which is processed by an intelligent network (i.e. using AI) to enable the integration of various types of energy into the smart system. This allows the digitalisation of the energy sector through VPPs. See figure 11.

RISKS: With any advancement of technology and the innovation of related products, there are numerous risks and challenges. Some of these risks are:

- The surge of smart technologies could severely impact global economies. There is already a shortage of skills for the fourth industrial revolution; there is a significant risk that there will not be sufficient staff equipped and skilled to deal with the fifth industrial revolution. The increased use of robots and the advancement in technology will affect the unemployment rates.

  Android robots are doing a lot of the routine and repetitive work that we are currently doing. The risk of losing jobs to robots can be countered by people skilling themselves for jobs of the future. We cannot stick with traditional job descriptions but instead evolving roles suitable for the Fifth Industrial Revolution. With the volumes of data and use of robots exploding, productivity could be increased; would humans be required to do these jobs that can be done by robots?

- 3D printers have made it easy for anyone to create parts and objects; how will these be regulated? There are numerous ethical concerns and legal implications of these technological advances. Once robots/machines are made to be self-aware, what limitations should be placed on them? There could be Societal problems and challenges.

- Another risk is, how will one stop a machine in time if something goes wrong? Further, the risk of not offering a trained labour force to the economy. The risk of guaranteeing a minimum income when the labour requirements decrease considerably.

THE FUTURE

Artificial Intelligence brings different disciplines together - from researchers in cognitive science to those in neuroscience as well as those in computer science and engineering.

It is predicted that by 2021 robots and automation will be everywhere, and hat AI will be trained to create conversation and not just obey commands. By 2022, robot dexterity should have matured enough to anticipate human needs, and by 2023, we could have supercomputers in our pockets. Uber Aerial, vacuum pods and Hyperloop travel will be a possibility. It is predicted that the global robotics market will reach $500 billion by 2025. The most significant expansion of this technology will be in the Agricultural sector, with the drones market predicted to reach $2.5 while robotics market would reach $23 billion in 2028.

By 2030, computers could become more intelligent than humans and ML could become commonplace.

CONCLUSION

The fourth industrial revolution might be here, but the fifth industrial revolution will rapidly gaining traction as the exponential growth curves of technology steepens.

The FUTURE is approaching faster than any of us can comprehend. The rapid evolution in AI and its use in areas such as the health sectors, autonomous and electric cars, education, 3D printing and the way that we do agriculture in this modern age will all require evolving jobs.

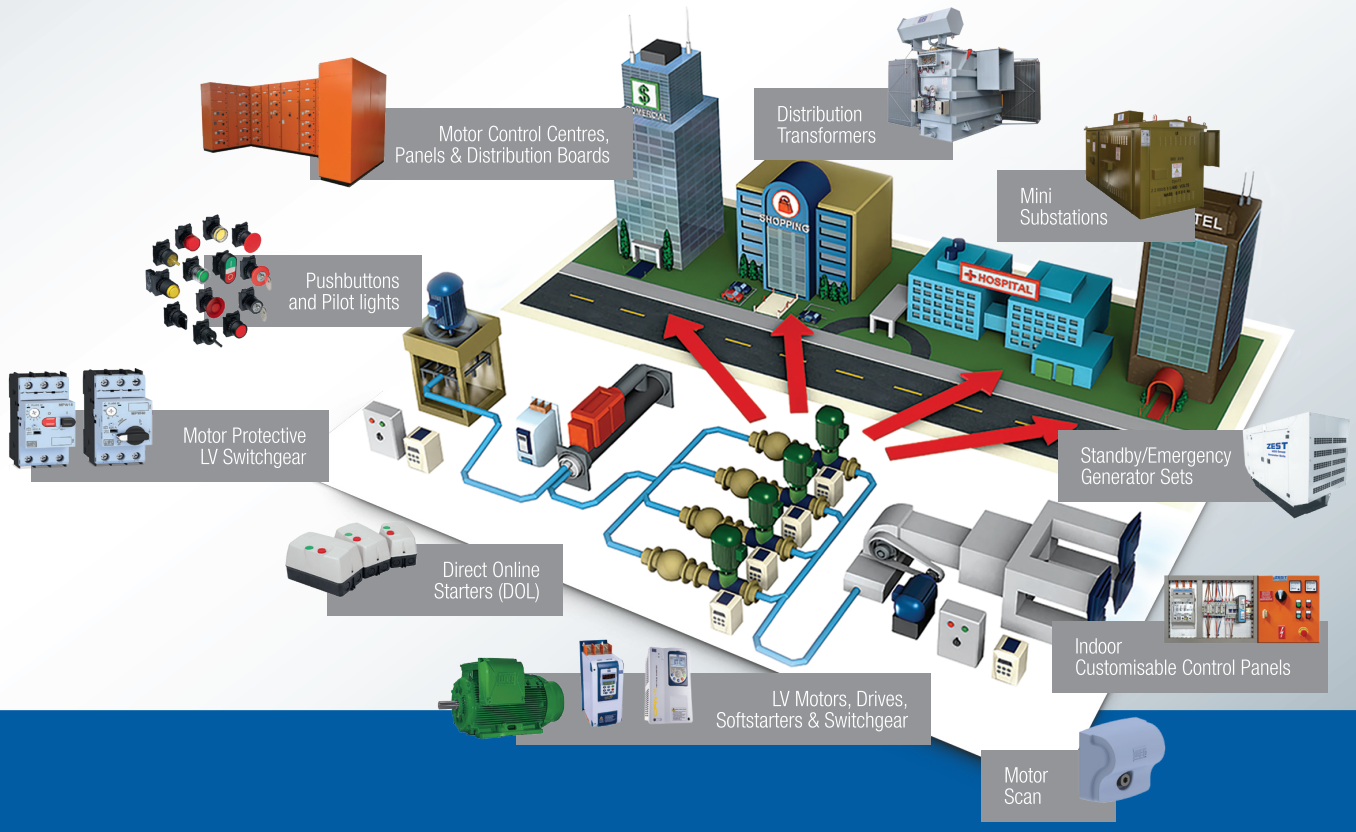
Software has disrupted and will continue to disrupt, most traditional industries in the future. The SAIEE encourage entrepreneurship, innovation and the development of the skills to address the fifth industrial revolution.

With the endless possibilities the SAIEE together with the engineering sector as a whole, need to apply AI, Robotics, IoT, Big Data, Automation, Smart systems, machine learning, supercomputers, nanotechnologies, quantum computing, data explosion etc. towards a better world for all in the future. wn

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

MORE THAN JUST PRODUCTS...
COMPREHENSIVE SOLUTIONS

for the heating, ventilation and air conditioning industry.



An in-depth understanding of the requirements for HVAC applications, access to quality product solutions and years of experience have ensured that the Zest WEG service offering is fit-for-purpose. From single product installations to individually customised solutions, our latest technology ensures optimal performance, increased reliability and the highest levels of energy efficiency. Reduced maintenance and ease of serviceability assist in lowering the total cost of ownership for operations.

All our products are engineered to guarantee a safe and reliable environment.

Zest WEG is proud to celebrate 40 years of innovation in Africa.

40 YEARS OF INNOVATION IN AFRICA

Level 1 BBBEE | CIDB Grades 9EP & 6EB | ISO 9001:2015 | African Distribution

ZEST
WEG Group

0861 009378 | www.zestweg.com | info@zestweg.com

The SAIEE is proud to announce the

2020 Office Bearers

DEPUTY PRESIDENT
PROF SUNIL MAHARAJ

Prof Sunil Maharaj became an SAIEE member in 1996.

He completed his Bachelor of Science: Engineering (Electronic) and Master of Science Engineering (Electronic) at the University of Natal. In 2005 he was instrumental in establishing the Sentech Chair in Broadband Wireless Multimedia Communications at the University of Pretoria. He has supervised and mentored many students from Honours, Masters, Doctor of Philosophy to Post-Doctoral level. Since May 2011, Sunil has been the Head of Department of Electrical, Electronic and Computer Engineering at the University of Pretoria and has served on various national and international technical committees related to the ICT arena. Sunil is currently the Dean of the Faculty of Engineering, Built Environment and IT (EBIT) at the University of Pretoria.

SENIOR VICE PRESIDENT
PRINCE MOYO

Prince Moyo (FSAIEE) joined the SAIEE in 1996.

His academic qualifications include an MBL, 2015 (Unisa); MSc Eng (2001), GDE (2000) [Wits]; BSc Eng Hons (1993) (Univ Zimbabwe) and has 24 years work experience.

Prince specialises in the specification of all low voltage and high voltage AC and DC equipment up to 765 kV. His team comprises of ± 420 engineers, technologists and technicians. His key experiences include rural electrification designs, distribution project portfolio of R1,7 BN annually and reviewing maintenance strategies for all asset classes.

Prince is actively involved as an SAIEE Council Member and is the Chairman for the Cigre SANC.

JUNIOR VICE PRESIDENT
PROF JAN DE KOCK

Prof de Kock (FSAIEE) has served on council for the last four years. He became an SAIEE Member in 1986.

Jan de Kock received his B Eng, M Eng and PhD in electrical engineering from Stellenbosch University. He is a registered Professional Engineer in the South Africa. In 2001 he was appointed Professor in Electrical Engineering at North-West University. From 2005 to 2015 he was the Director of the School of Electrical Engineering and has previously acted as Dean of Engineering for 14 months. He has taught power electronics, electrical machines and final year project to undergraduate students, and advanced protection and power system dynamics courses to postgraduate students. Since January 2016 he has returned to being a lecturer and researcher within the School of Electrical Engineering.

IMMEDIATE PAST PRESIDENT GEORGE DEBBO

George Debbo (FSAIEE) became a member of the SAIEE in 1975.

Debbo has a BSc (Elec.Eng) and an MSc (Elec.Eng) degree, both obtained from the University of the Witwatersrand and is a registered Professional Engineer with the Engineering Council of South Africa (ECSA).

Debbo has been an integral part of the telecommunication industry in South Africa for over four decades. He started his career in the South African Post Office (SAPO), which later transformed into Telkom SA on commercialisation in 1991.

As a pupil technician, he progressively rose through the ranks to Executive level before he left in 1999 to further pursue his career in the vendor community.

TREASURER STAN BRIDGENS

Stan Bridgens (FSAIEE) became a member in 1963 and served as SAIEE President in 1998. He served the SAIEE as CEO from 2007 - 2018.

He started his career as an Apprentice at the Johannesburg City Council in 1958. He worked his way up to Director: Technical Service for Johannesburg Electricity. From 1995 to 2000 he worked as Executive Officer: Technical Support at the Metropolitan Electricity. From June 2000 to 2005 he managed the Khanya Project at City Power as Programme Manager. During this time he continued to represent the Engineering Council of SA in the forums created by the Department of Minerals and Energy regarding the National Restructuring of the Electricity Distribution Industry. In 2019 Stan received the SAIEE President's Award for his excellent service and contribution to the Engineering Fraternity.

HONORARY VICE PRESIDENT ROGER CORMACK

Roger Cormack (FSAIEE) became a member of the SAIEE in 2009.

He started his career in 1977 at Eskom. He was responsible for electrical protection commission, operations and maintenance of all generators and HV Yard and all auxiliary high voltage protection equipment at Eskom Power Station (Duvha). From 2002 - 2004 he was a Regional Engineering Consultant at Eskom when he was promoted to High Voltage Engineering Manager in 2010. He retired from Eskom in 2014 and started his own consulting business where he focuses on training engineers.

He is a professional member of ECSA and Director of the SA Cigre National Committee.

SAIEE LIBRARY FUND - Letter from the Historical Section

Dear Colleague,

You will be aware that the Historical Section (HS) of the SAIEE comprises a small group of members and friends of the Institute. They endeavour to fulfil the needs of the HS mission to, amongst other things, preserve items of importance to the history of electrical engineering in South Africa. We serve voluntarily on a part-time basis, are mainly retired persons, and carry out regular "work sessions" at the SAIEE Observatory facilities.

To this end, we have been able to develop the Innes House Museum, wherein valuable items are preserved and displayed. It is visited by Institute members, friends, and interested members of the public and schools from time to time. Furthermore, a large number of additional artefacts are stored in a safe environment and are available for inspection by interested parties.

We also have a collection of between 3000 and 4000 books, and a large number of journals, magazines and unique documents specific to electrical engineering that are held in a "Library" on the Observatory site. These are added to from time to time by donations, mainly from the estates of deceased members.

Over the years, we, the Historical Section, have created and maintained a record system to facilitate the selection and location of these books and other material as and when required by interested persons. During 2019 it became apparent that our efforts were no longer sustainable and that a drastic re-organisation was needed. A "proper" cataloguing system required to be installed that would facilitate international awareness of, and access to, this invaluable asset if the valuable work is done so far was not to be wasted.

After extensive investigations which included discussions with a librarian and other interested persons, it was decided that we should approach the Institute's Council to obtain funding for the temporary appointment of a person experienced in this field to assist us. This was duly authorised, and for the past three months, a retired librarian has guided and supported us in introducing a formal system of recording, labelling/numbering of each book and their orderly, systematic relocation.

The initial work has included selecting an appropriate system for our conditions, setting up computer facilities and starting with the process of cataloguing books in the required format, acquiring a tape-marker and carrying out labelling procedures. This is an ongoing task, and we find that our group's capacity to continue this work is limited by our circumstances, and we, therefore, for-see problems arising to complete the project without "outside" assistance.

We are acutely aware of the budget constraints faced by the Institute in the current economic climate and have received our President's and Executive Committee's blessing to make a direct approach to you as a member.

Quite simply, we ask if you are willing to make a once-off donation of R100 - or more if you are able - to a special SAIEE "Library Fund" to enable us to pay for the continued service of the current part-time assistance. If you can assist, please hand the amount in at the offices, or EFT it to the Institute's a/c (details below), marked "Library Fund."

Name: SA Institute of Electrical
Account number: 201547066
Bank: Standard Bank

I would appreciate hearing from you if you would like any further details.

Many thanks,

Max Clarke
Chairman, SAIEE Historical Section

5 kW Multi-Range Programmable DC Power Supplies

COMTEST is pleased to announce B&K Precision's new MR Series of 5 kW multi-ranging, single-output programmable DC power supplies, offering up to 1000 V or 80 A in a compact 2U form factor and well suited for both bench use and automated test system applications. B&K Precision's MR Series offers multi-range functionality and provides users with added flexibility in the form of additional voltage and current combinations, capable of replacing multiple fixed-range power supplies.

The MR Series is B&K Precision's first cTUVus certified instrument family. The cTUVus certification mark demonstrates compliance with CSA and UL safety standards. Another first is the LXI compliant LAN interface and IVI drivers, which simplifies system development, and integration. Additionally, the MR Series provides a wealth of features customers expect, such as a wide range of industry standard interfaces combined with excellent regulation and low noise characteristics.

Compared to the N8900A Series from Keysight, the MR Series is a worthy competitor and deserves a closer look. Consider the fact that it includes faster command response times (10 ms vs. 25 ms), a single-phase AC input, a built-in solar array simulator, and higher power density (2U vs. 3U form factor), all at a significantly lower price point.

B&K Precision's MR Series has a 3-year warranty and includes a User Manual (downloadable), Certificate of Calibration, Test Report and AC Power Cord. Optional Accessories are a RKPVS Rack Mount Kit, and SASPVS Solar Array Simulation Software. Contact COMTEST for more information on B&K Precision's MR Series on sales@comtest.co.za

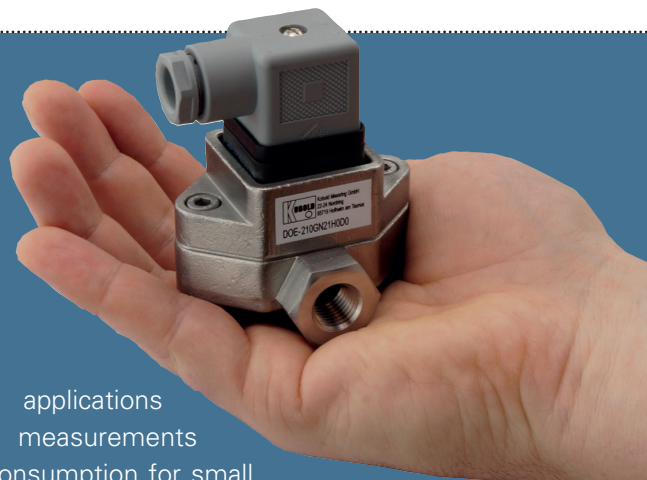
MINI Oval Wheel Flowmeter

INSTROTECH now offers another space miracle from Kobold for OEM customers. With an all stainless steel body and temperature measurement for fuel consumption, the DOE offers different pulse output options including one to measure pulsating flow from, for example, peristaltic pumps.

Temperature measurement enables appropriate electronics to compensate for changing densities of liquids. DOE can be used for liquids with different viscosities of up to 1000 cP. It provides an accuracy of +/- 1% of reading under reference conditions.

Other features include:

- Measuring ranges: 0.5 ... 36 l/h and 1 ... 40 l/min
- Material: stainless steel
- Pressure max: 64 bar; Temp max: 80 °C



DOE applications include measurements of fuel consumption for small aircraft, motor boats, and mobile power generators. Applicable media: all viscous, non abrasive clean liquids, like: fuels (incl. diesel and petroleum), oil, grease, chemicals, pastes and ink.

Contact INSTROTECH for more information on Kobold's DOE Mini Oval wheel flowmeter on 010 595 1831 or sales@instrotech.co.za

Input requested: A proposal for article processing charge for the SAIEE Africa Research Journal

The SAIEE Africa Research Journal (SAIEE ARJ) is an open access (OA) journal and, since 2019, it has been indexed through the IEEE Xplore Digital Library.

The journal is also indexed by Scientific Electronic Library Online (SciELO) South Africa. All journals on the SciELO list are recognised by the Department of Higher Education and Training (DHET) and published articles receive subsidy. For public higher education institutions (HEIs) in South Africa, each article accrues approximately ZAR 130,000. Because of the research output and associated subsidy process, an article subsidy is received approximately two years after publication. The subsidy is granted to the HEI and in the case of a number of institutes, the subsidy is re-invested for future research work.

For making each article available, IEEE Xplore charges the SAIEE. The current cost is US $ 500 / article. This is referred to as the article processing charge (APC).

The current SAIEE ARJ APC is based on the number of pages and is ZAR 200/page. This was set a number of years ago when the journal was published in print.

For the OA option, IEEE journals currently charge an APC ranging from US $ 1,750 to US $ 2,045.

To date, we have received a two-year grant from a resource within IEEE and covered costs in this way.

However, we have to formulate a long-term, sustainable plan. In discussion with the SAIEE Publications Committee, some options have been suggested and we would welcome your responses to these and a few other questions in the survey below.

While articles are written primarily by academics, postgraduate students and postdoctoral research fellows, the audience includes science councils and industry (typically the research and development arm of industry). If there is a desire to make a financial contribution for the journal, this would also be welcome.

To streamline inputs, we provide an online form.
Submission deadline: Wednesday, 13 May 2020.

Robust oxygen analyzer ensures quality of N2 for oil and gas industry in challenging conditions

A major supplier of nitrogen generators has selected Michell's XTP601 oxygen analyzer to ensure N2 quality as part of its engineered systems for the oil and gas industry in the middle east.

The containerised or skid-mounted nitrogen generating systems have to withstand the large variations in ambient temperatures found in deserts and tropical areas which range from below freezing to over 55 °C. In addition to the wide temperature differences, the systems also have to cope with the harsh, corrosive environments found in coastal and offshore installations.

Its compact size and integrated HMI makes it easy to install into the N2 generator and simple for operators to interrogate once in use.

Contact INSTROTECH for more information on sales@instrotech.co.za.

SONIC INDUSTRIAL IMAGER

A fast, simple way to detect compressed air, steam, gas and vacuum leaks

COMTEST is offering the Fluke's ii900, a handheld sonic industrial imager that enables maintenance teams to quickly and accurately locate air, steam, gas and vacuum leaks in compressed air systems. The straightforward, intuitive interface allows technicians to isolate the sound frequency of the leak to filter out background noise. In a matter of hours, the team can inspect the entire plant, even during peak operations.

Using SoundSight™ technology, this industrial imager offers a new way to locate issues using sound. Leak identification is simple, a SoundMap™ is displayed in colour over a visual image of the equipment allowing for fast visual location. With the visual image, it is easy to scan a large area quickly and even possible identify leaks from a distance.

The ii900 enables users to do more with existing air compressors, for example:

- Delays the capital expense of purchasing an additional compressor
- Ensures proper air pressure to pneumatic equipment
- Lowers energy costs (optimization of compressed air budget)
- Reduces leak detection time
- Improves reliability on the production line

The ii900 makes leak detection part of a typical maintenance routine, for example, the training of a maintenance team is possible in a matter of minutes and provides for the validation of repairs.

Finally, the ii900 is specifically designed for industrial maintenance teams, maintenance leads, plant maintenance managers and plant operations managers, who rely on compressed air, gas or vacuum in their routine operations.

With minimal training, technicians can begin checking for air leaks as part of their typical maintenance routine. The ii900 means a better, quicker, simpler way to check compressed air leaks, and at the same time conduct gas and vacuum leak identification. Contact COMTEST sales@comtest.co.za for more information on Fluke's ii 900 Sonic Industrial Imager, or for technical or seminar information, demonstrations or to locate the nearest authorised dealer.

VIDEO LINK

ABB Dodge Gear Reducer Proves Effective For Kwena Coal Mine's Performance

Victor Strobel | BI Offer Marketing Manager

The outstanding performance of ABB's Dodge gear reducer at Kwena Coal Mine in Mpumalanga has led to leading distributor Bearings International (BI) continuing its successful business relationship with Swiss-Swedish multinational ABB through the purchase of a second unit to be installed on another key conveyor.

ABB has a long-standing agreement to plan inventory for the ABB Dodge Torque Arm II (TAII) gear reducer supplied to Kwena Coal mine, with ongoing discussions and planning underway for a third installation.

Kwena coal mine initially purchased an ABB Dodge Torque Arm Reducer from BI in 2013, at a time when the mine was looking for innovative solutions to increase operations efficiencies and lower production downtime. The TAII gear reducer is used in the drive mechanism of a 200-m-long, 600-mm-wide coal conveyor carrying 700 tph of coal. This main conveyor is a critical application, feeding coal into the wash plant.

"An excellent relationship with the end user and a branch in close vicinity allows for this site to be used as a reference when engaging with users from other sites. The end user was and continues to be highly satisfied with the reliability, minimal maintenance required, and longevity of the unit," says BI Offer Marketing Manager Victor Strobel.

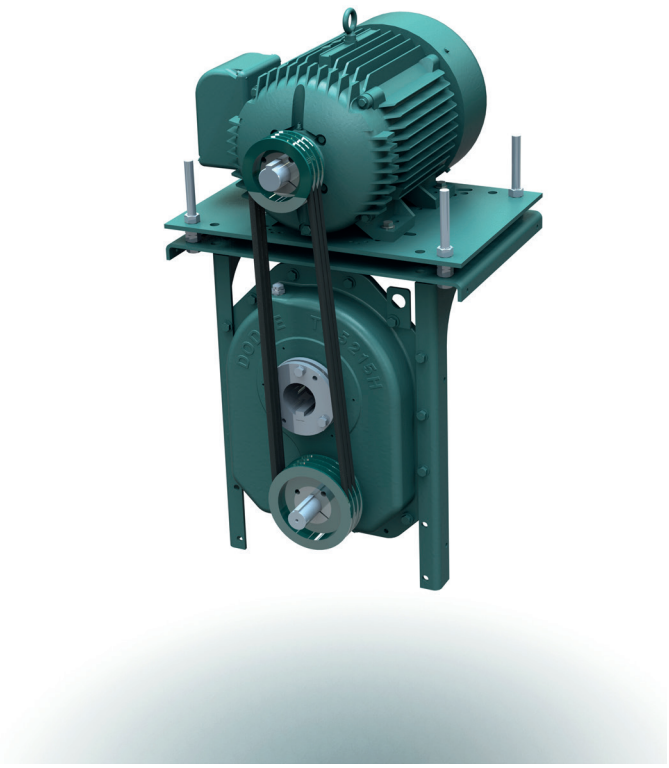
The shaft-mounted TAII gear reducer mounts directly onto the driven shaft and is ideal for tough applications where a long operating life is essential, making it a perfect solution for a coal mine like Kwena. The reducer can also be used in a range of environments due to the many accessories available.

These reducers are manufactured at the ABB Greenville Plant in South Carolina in the US to American Gear Manufacturers' Association (AGMA) standards, utilising only heavy-duty tapered roller bearings throughout the unit for an average bearing life of 25 000 hours at a 1.0 service factor.

The units adhere to strict manufacturing principles, ensuring quality and consistency in the manufacturing process. Regular quality checks are performed throughout the process, ensuring materials and finished components meet requirements consistently. All the gear reducers are subject to final test runs upon assembly to ensure all parameters are within technical specifications.

A key feature of the TAII gear reducer is the advanced dual-seal system, featuring inner seals made form hydrogenated butadiene nitrile rubber (HBNR) on the input and output shafts. The heavy contact seals' primary function is to retain oil inside the reducer.

Discussions are underway for a third ABB Dodge TAII gear reducer at Kwena in Mpumalanga



The ABB TAII gear reducer is used in a critical conveyor application, feeding coal into the wash plant

The light-contact seals are fitted outward from the heavy contact seals so as to keep dust and debris away from the inner seal, prolonging the life of both. The HBNR material has an operating temperature range of -40°C to 150°C, and shows less wear on the shafts than other types of seals with similar high points.

The TAII gear reducer utilises a twin-tapered bushing that eliminates fretting corrosion, and makes fitment quick and easy with regular hand tools, allowing the gearbox to be removed quickly should the need arise to change a conveyor pulley or the conveyor pulley bearings between the gear reducer and the pulley.

Spares are simplified, since various shaft sizes can be accommodated by a single gear reducer, which means there is no need to stock a gear reducer for each shaft size on the plant. Stores simply need to keep common reducers and associated bush kits on hand.

Having an externally accessible backstop means direction changes can be easily achieved in the field without needing to disassemble the gear reducer. These backstops are compatible with oils containing extreme pressure (EP) additives. The complete lift-off design ensures zero drag or shaft wear once up to operational speed.

Pry slots along the mating surface ensure the reducer can be repaired easily, without damaging the case. Service parts are availed in different levelled kits, taking the guesswork out of which part to replace. Also making the unit fully serviceable rather than just disposable. wn

Specialised Dry-Type Transformers For Saldanha Port Upgrade

Transnet's upgrade of its port facility at Saldanha Bay will include dry-type transformers from specialist company Trafo Power Solutions.

The company is supplying specialised transformers for the Tippler 3 project at the iron ore load-out station. Factory-acceptance testing was completed in December 2019, according to Trafo Power Solutions managing director David Claassen. Delivery to site is scheduled for February 2020.

The construction of a third tippler at the Saldanha Bay port is to sustain iron ore export volumes of 60 million tons per year when the existing tipplers are refurbished in future. It will integrate with the rail system bringing ore via the 860 km line from mines in the Northern Cape. Key aspects of the new infrastructure comprise the 285 tonne tippler itself, a loading vault below ground and a conveyor tunnel. New buildings, service roads, bridges, railway lines, conveyors, lighting and bulk electrical supply infrastructure are also part of Transnet's upgrade project.

Trafo Power Solutions' contract was for the design, supply and commissioning of five dry-type transformers.

There are two 1000 kVA units and a 3150 kVA unit, both stepping down from 11 kV to 400 V. The other two units are 3500 kVA and 4500 kVA capacity respectively, taking 11 kV to 3,3 kV.

To resist the corrosive sea air, all the transformer enclosures will be manufactured from 3CR12 grade of stainless steel. The enclosures are also to be IP33-rated to ensure a high level of ingress protection against moisture and dust.

"The enclosure design also incorporates cable boxes and Type C, totally enclosed plug-in bushings for the terminations," he says. *"This provides a boot covering which is touch-potential safe, and also provides for efficient plug-and-play installation."*

This is a significant improvement on the regular lug and bolt copper connection, which would just be shrouded by a heat-shrunk material. The special terminations also facilitate easier maintenance or removal.

Measurement of partial discharge level during routine testing.

"The units will provide the medium-voltage supply for the Tippler 3 project and its associated infrastructure, including equipment like conveyors," he says. *"All the transformers will be supplying non-linear load to a certain extent, so they have been designed with a K-factor of four."*

The K-factor is a measure of a transformer's ability to withstand the heating effects of non-sinusoidal harmonic currents created by electronic equipment. The higher the K-factor, the greater the harmonic heating effects.

As dry-type transformers are cooled without the use of oil, these units will receive forced ventilation when a preset temperature is reached. This ventilation is provided from a row of fans which Trafo Power Solutions has designed to be bolted below the location of the transformers.

Designed locally by Trafo Power Solutions, these dry-type transformers are manufactured in Italy by strategic partners TMC Transformers, experts in cast resin transformer technology. All products are routinely factory-tested according to IEC standards, but type-testing and special testing can also be conducted.

"The standard applicable to dry-type power transformers is IEC 60076-11," Claassen says. *"TMC's advanced laboratory facilities allow us to conduct the full range of tests in-house, in accordance with what these standards and whatever other requirements are designated by the customer."*

At Saldanha, Trafo Power Solutions is also responsible for building auxiliary protection and control panels, which it locates remotely from the transformers. These include temperature control sensors that communicate with the port's broader control and monitoring network.

The Gautrain Project

A **watt**now exclusive interview with William Dachs, the new Chief Executive Officer of the Gautrain Management Agency (GMA)

The Gautrain project was a huge one – before that South Africa had not had a mass rapid transit railway system in operation. Quite literally, this involved the creation of significant infrastructure from nothing.

Dachs was appointed as CEO, with effect from 1 February 2020. He previously served as Chief Operating Officer (COO) of the GMA since 2014. Before that, Dachs worked as the Technical Services Senior Executive Manager. He is a professional engineer registered with the Engineering Council of South Africa and holds degrees in both civil engineering and law.

To briefly contextualise - why was Bombela Concession Company awarded the tender?

Gautrain was always designed to be a Public-Private Partnership (PPP). Bombela Concession Company won the tender to design, build, operate and maintain, and partially finance the Gautrain rapid rail system in 2006.

Bombela comprises of a consortium of private companies to form a PPP. Its shareholders with civil construction companies and Original Equipment Manufacturers (OEMs) and local Broad-Based Black Economic Empowerment (B-BBEE) companies produced the trains and signalling systems.

The tender was for the whole solution to design, build, integrate and operate the new rapid rail systems for a 19½ year period. It was a private sector response to the government's call for a PPP, which typically is not found in government tenders. The government recognised the size and complexity

ST-Talks - Railways Webinar: 21 May 2020 @ 1pm CAT. Invitations will be sent to SAIEE member in due course.

BY I VIVIENNE FOUCHÉ

of the project at an early stage and therefore introduced a different contracting model from the norm.

Bombela was awarded the 19½ year contract as they presented the most competitive and compelling case in the bidding process. The consortium also had to finance the project partially and further continues to earn its returns today by continually meeting the ongoing required standards. Over the whole lifetime of providing this service, the Gautrain system must be kept clean, safe, secure and well-maintained. The tender and its ongoing operation and maintenance parameters are genuinely unique in many ways.

Which international models did you look to for inspiration and guidance, and how did you need to adapt these to South African conditions?

From a rail perspective, we looked all around the world, including Malaysia, the United States, Europe and the United Kingdom. The trains, themselves were supplied by Bombadier and composed of a fleet of 24 Electrostar electric multiple units or EMUs, as used in the UK. In South Africa, these are formed into four- or eight-car sets. The vehicles were manufactured in the UK, with final assembly taking place in South Africa.

The contracting model came from the UK, with inspiration from urban light rail projects that were based on a PPP model.

The National Treasury did a great job in adapting the international PPP model for South African conditions. One of the main differences with the UK PPP

model involves our socio-economic and B-BBEE impact. We made sure that Bombela spent money locally and created as many jobs as possible.

During the development period of Gautrain, significant contributions were made to socio-economic development in Gauteng. Some of these achievements include:

- ±R5 450 million was procured from, or sub-contracted to, black entities, and ±390 black entities benefited from the project during this period;
- About R2 780 million was secured from, or sub-contracted to, new black entities, and approximately 120 new black entities benefited from the project during this period; and
- Around R1 420 million was procured from, or sub-contracted to, small, medium and micro enterprises and about 310 small, medium and micro enterprises benefited from the project during this period.
- A significant number of people have been employed on the project. It is estimated that by the end of June 2012, an estimated total of 121 800 direct, indirect and induced jobs had been created.
- About R3 590 million worth of South African materials, plant and equipment had been procured up to the end of June 2012.

From an economic perspective, the Gautrain has been very successful in terms of job creation, the encouragement of property development and reinforcing development nodes, supply chain stimulus, SME development and the support and facilitation of tourism. For each year of Gautrain's operations, R1.7 billion is added to the provincial economy[1].

What were some of the leading engineering challenges?

The Gautrain system currently consists of two main routes: a north-south line from Hatfield to Marlboro, and an east-west line from Park Station (via Marlboro) to OR Tambo International Airport. And so, during the duration of the project, we put down 80 kilometres of the rail system in the most built-up area in southern Africa.

As you drive between Pretoria and Johannesburg on the M1/N1, you will notice that you are driving through terrain that is quite rugged and not flat. However, if you are running a rail system, it must be flat – the steepest you can go to is a one in 40 gradient. Thus, the hilliness on this section of the route was one of the challenges we faced. Of the 80 kilometres of railway lines, 15 kilometres are underground. Another 15 kilometres are raised above the ground on viaducts to deal with this.

Another challenge was the need to include several tunnels under the Sandton-Rosebank area, one of the dense residential and economic heartlands of Gauteng. Designing and fitting this railway system into a very built-up area of Gauteng had its difficulties. The construction works along Rivonia Road between Rosebank, and the Sandton Station was challenging, as there was minimal space to build 40 metres down underneath this built-up area.

We faced an additional challenge in the Centurion area, where a lot of the ground is a dolomite area. This type of stone is risky and potentially dangerous when building because if you add water to it, it dissolves. In solution, the rail line had to be put on top of the dolomite because we couldn't trust its stability. The result is, in certain sections, commuters are riding on a flat bridge that was built on dolomite.

In total, the railway line makes use of some nine kilometres of tunnel and 15 kilometres of bridges, especially approaching Pretoria where you will see several viaducts.

In response to these challenges, we rose to the occasion with the use of technology as well as excellent design and construction and came up with some stunning engineering solutions.

What can you tell us about project management?

I'd say that project management was the toughest challenge. We had a very tight time-line and a fixed budget for Bombela.

In turn, Bombela put in place some brilliant project management teams and construction solutions. They were working on ten stations across 80 kilometres of the rail line, with very varied site conditions, and so they had to project manage thoroughly and carefully.

The timing of the 2010 FIFA World Cup in June/July of that year also meant that there was no room for any slippage, and Bombela did a fantastic job in terms of meeting the time-lines. I wouldn't say that the project ran smoothly! But large projects are never without its challenges. It was completed, and very well.

Phase 1 included stations at Sandton, Marlboro, Midrand, Rhodesfield and Johannesburg International Airport. Phase 2 extended the system from Sandton to Rosebank and Park Station – in Johannesburg – and from Midrand to Centurion, Pretoria and Hatfield,

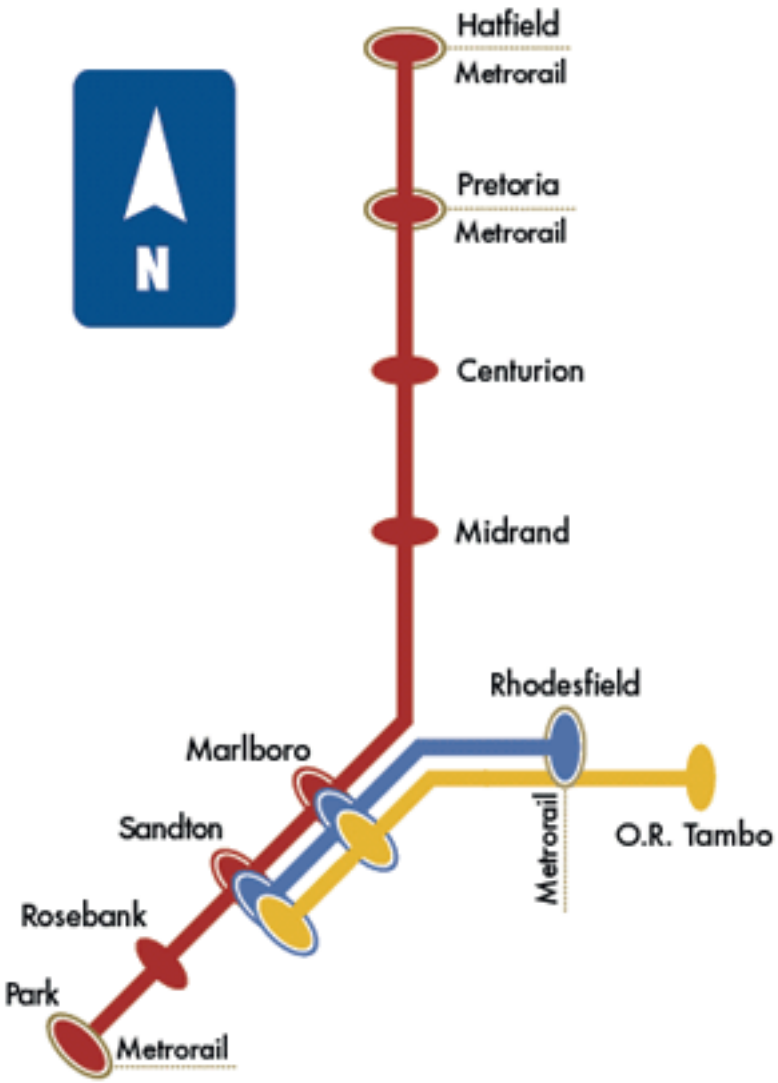
completing the 80-kilometre network. Construction officially began on 27 September 2006 with phase 1 - the line stretching between the airport and Sandton. Bombela had a soft target to complete this leg in time for the 2010 FIFA World Cup. I say a soft target because the completion of this leg of the Gautrain was not a World Cup project, but rather a long-term investment in the transport system.

Nonetheless, it was essential to be ready if possible, if the project wasn't compromised, and hence the focus on the airport line first. In the end, we opened this section of the Gautrain on 7 June 2010, just a few days before the World Cup began on 11 June. There was, of course, massive excitement!

The work then continued on the long line from Hatfield to Park Station. Construction of the Gautrain system as it currently exists – which is known as the development phase – was completed with the official opening two years later, on 7 June 2012, and this signalled the start of the full operations, with all ten stations open and all systems working. We had, along the way, had phased openings of different sections as different parts came on board.

I'd say that over 1,000 engineers in total worked on this development phase of the Gautrain project, with significant numbers of construction and consulting companies in the country involved in some way or another.

Today, in our tenth year of operation, it gives me enormous pride to think of how the Gautrain system continues to operate to the same excellent standards. The Gautrain operates according to a punctuality rating of over 98 per cent[2]. I commute daily via the Gautrain, and my office is across from the Midrand Station. I'm very familiar with the time-table and when I tell a visitor to my office, for example, that *"A train will pull in from the north in three minutes"*, I am entirely confident that this will happen.



The Gautrain system currently consists of two main routes: a north-south line from Hatfield to Marlboro, and an east-west line from Park Station (via Marlboro) to OR Tambo International Airport.

This simple fact reminds me, with great satisfaction, of the unique multi-disciplinary engineering approach which brought this project to successful fruition, and its continued ongoing success. It works because of the many different engineering disciplines that have come together in such areas as (to name but few) the signalling, the safety braking systems, the concrete designed by civil engineers and of course the control of the power and current drawn from the expertise of electrical engineers, which powers the entire Gautrain system.

What are the benefits of the Gautrain system today?

A tremendous amount has already been written on this particular aspect of the Gautrain. In brief, it begins with the relief that the Gautrain offers to

FEATURE continues from page 29

Gautrain Park Station

individual commuters and the provincial authorities of alleviating congestion on the roads.

The reality of the Gautrain provides options for passengers from Pretoria to Park Station and from Sandton to Kempton Park. It's important to remember that the train service is far more reliable from a time perspective than commuting by road.

The provision of a route to and from OR Tambo International Airport assists local travellers and tourists. From their perspective, it means that they land at the airport and are then able to make use of a world-class train service taking them out to the economic hub of the province. This improvement in the public perception of people coming into South Africa is perfect for both Gauteng as well as the country.

From an environmental perspective, the Gautrain offers a significant benefit over commuting by road in terms of its better carbon intensity in comparison. Saying that, carbon-efficient systems must become the norm. And of course, the Gautrain arguably assists with congestion and alleviating wear and tear on the roads.

Another benefit brought by the Gautrain system has been the encouragement of property development nodes around the railway lines, especially in the Rosebank, Sandton and Park Station areas. It is fair to say that the Gautrain has spurred on the development of Gauteng's spatial landscape.

In fact, in 2018, 60 per cent of all offices being developed around South Africa was around the Gautrain stations. Its presence has encouraged the development and upliftment of nearby areas.

We've also spoken about job creation. For every rand that we spent, R2.60 worth of economic benefit has been achieved. The Gautrain system has created an economic impact second to none and achieved every objective that it had set out to do.

Future expansion of the Gautrain?

As mentioned previously, the establishment of the Gautrain as it currently exists was the starting or development phase, linking the most important economic hubs in the province. According to a 25-year master plan developed under Gauteng Transport MECs Ismael Vadi and Jacob Mamabolo, we plan to build another 150 kilometres of the rapid rail system. This is intended to add on links to such areas as Lanseria Airport, Randburg, Cosmo City, Roodepoort, Soweto, Mamelodi, Menlyn, the Mall of Africa, Fourways and Boksburg. And so, the current network will comprise the central core, with the spokes spreading out more widely.

It's an ambitious 30- to 40-year build programme and an essential part of helping to grow and change the economy. We had hoped to start the detailed planning, design and land acquisition stage during 2020 and move into the tendering stage in the next two to two-and-a-half years, but the realities brought about by the COVID-19 global pandemic have altered this plan. We estimate that the pandemic has brought about a delay of easily one year.

Nonetheless, the good news is that the establishment of the Gautrain system as it stands today remains only the start. We need to think about the challenges that lie ahead, including the environmental impact, as well as what Gauteng will look like in 20 years.

Every day, some 500 people come into the province – whether they are born or arrive here – and we will need to have efficient mass movers of people, which means rail.

The government must respond to this need, and it is the response in turn of engineers that, I believe, assists in creating enormous value in society, both in the present and the future. wn

Electricity as the enabler for the Heavy Haul railway operations of Transnet

The South African railway industry began in 1860 with the opening of the first railway line between Point and Durban [1]. The discovery of commodities such as diamonds in Kimberley and gold in Johannesburg intensified the construction of railway lines in the country [2]. As a result, currently, Transnet's railway lines traverse all the provinces from mines and factories to the harbours.

BY | KHIMANE MOTUPA, MSAIEE AND WILLIE COETZEE, MSAIEE

Standing tall above all South African freight railway lines are the two heavy haul lines, namely the Sishen-Saldanha Iron Ore line (Oreline) and Richards Bay Coal line (Coalline) [3].

Transnet is one of the 11 members of the International Heavy Haul Association (IHHA) [4], a worldwide non-governmental, scientific and technological organisation of heavy haul railway operators.

A heavy haul railway operation satisfies a minimum of two of the following criteria [5]:

- The combined minimum loading of 5000 metric tons per train or combined trains.
- The revenue freight is hauled for a minimum of 150 km with a minimum annual gross haulage of 20 million tons.
- The minimum axle loading is 25 tons.

The route line distances of the Oreline and the Coalline are 861 km and 580 km respectively [3] and transported 58.4 and 72.0 million tons respectively in 2018/19 financial year [6] with the Coalline being operated at 26 ton/axle and Oreline at 30 ton/axle [7]. A 200-coal train can have a mass of 20 800 gross tons and up to 2.5 km long;

similarly a 342-wagon iron ore train's weight can be up to 41 400 gross tons and is approximately 3.78 km long.

Therefore, these statistics position Transnet comfortably as a member of the IHHA.

This article gives a brief overview of how electricity enables the hauling of trains and wayside measurements of train condition parameters of the heavy haul lines of Transnet.

ELECTRICITY FOR THE HEAVY HAUL FREIGHT TRAINS

The need for more efficient rail transport for export coal and steamship bunker coal to Durban Harbour was the driver to electrify the first railway line in South Africa, which was from Glencoe to Pietermaritzburg.

The 3kV DC (direct current) electrified line was put into service, in stages, between Glencoe and Mooi River in 1925 and between Mooi River and Pietermaritzburg in 1926 [8].

Similarly, the need for increased capacity, which required operating heavier and longer trains, was a factor that influenced the decision to electrify the Coalline and the Oreline. Electric locomotives are better than diesel locomotives [9] and should be the traction technology of choice whenever possible. However, due to the power supply capacity limitations, diesel locomotives are used on the Oreline heavy haul trains to supplement via remote activation the power of the electric locomotives on critical gradients.

Alternating Current (AC) electrification technology is best suited for the high power demand of heavy haul operations. Consequently, the electrification of the Oreline is at 50 kV AC 50 Hz and the Ermelo – Richards Bay section of the Coalline is at 25kV AC 50 Hz. AC electrification is superior to DC electrification in many aspects. DC

A 200-wagon loaded coal train on the 25kV AC electrified Coalline south of Ermelo (Source: S. Tosen)

substations have additional power circuit equipment such as rectifiers and harmonic filtering equipment.

The increased amount of equipment means a higher risk of failure [10] and, consequently, a higher number of maintenance tasks per traction substation. The traction substation spacing is shorter on DC electrification, with an average of 10 km to minimize the overhead contact line voltage drop. The AC electrification overhead contact lines require significantly less copper equivalent than wiring for DC electrification.

Due to historical reasons, and the smoother gradients, the electrification used from the coalfields to Ermelo is 3 kV DC to supply power for 100-wagon trains. These trains are combined in Ermelo [11] into a maximum 200-wagon trains and hauled with dual voltage 3kV DC/25kV AC locomotives to Richards Bay. Unlike on the Oreline, the Coalline train configuration does not use diesel locomotives.

ELECTRICITY FOR THE WAYSIDE MEASURING EQUIPMENT ON THE HEAVY HAUL LINES

By ensuring the safety of Transnet trains, wayside equipment is installed next to the railway track. This equipment, which requires electricity, includes colour light signals, points machines and railway telecommunication equipment. Due to the higher axle loads and long trains, the heavy haul railway lines require wayside train condition measuring equipment. Examples of this type of equipment, which is electrically powered, are listed below:

- wheel profile measuring equipment;
- assize in motion weighbridge;
- skew bogie detector with measurement of lateral forces;
- wheel impact/weigh in motion (WIM-WIM);
- hot wheel detector;
- train acoustic detection systems (TADS);
- dragging equipment detector (DED) and
- broken rail detector.

Some of the measuring equipment provides only alarms when a measured parameter is exceeded. Other equipment provides both alerts and measured parameter values. The warnings are transmitted to the Centralised Traffic Control Centre of the heavy haul line so that the Train Control Officer can take immediate action in the interest of train safety. Measured parameter values are used for on-condition maintenance, and lately also for predictive maintenance.

Transmission of the alarms and measurements is via the Integrated Train Condition Measuring System infrastructure to which the measuring equipment is connected. The last link in the chain that requires electricity is the Automatic Vehicle Identification tag readers, located at strategic locations along the line, that read the Automatic Vehicle Identification tags installed on the wagons and locomotives. This ensures an alarm or measured parameter is assigned to the correct wagon or locomotive on a train.

Wheel profile measuring equipment at Ermelo (Source: S. Tosen)

CONCLUDING REMARKS

In 1925 the railway was the primary user of electricity in one geographical area only. This has evolved over many years as the railway lines have been electrified resulting with Transnet now being one of the country's major industrial users of electricity. What could not have been imagined in 1925 is the extent to which electricity is now used in wayside equipment, that never existed before, to support the operations of a heavy haul railway.

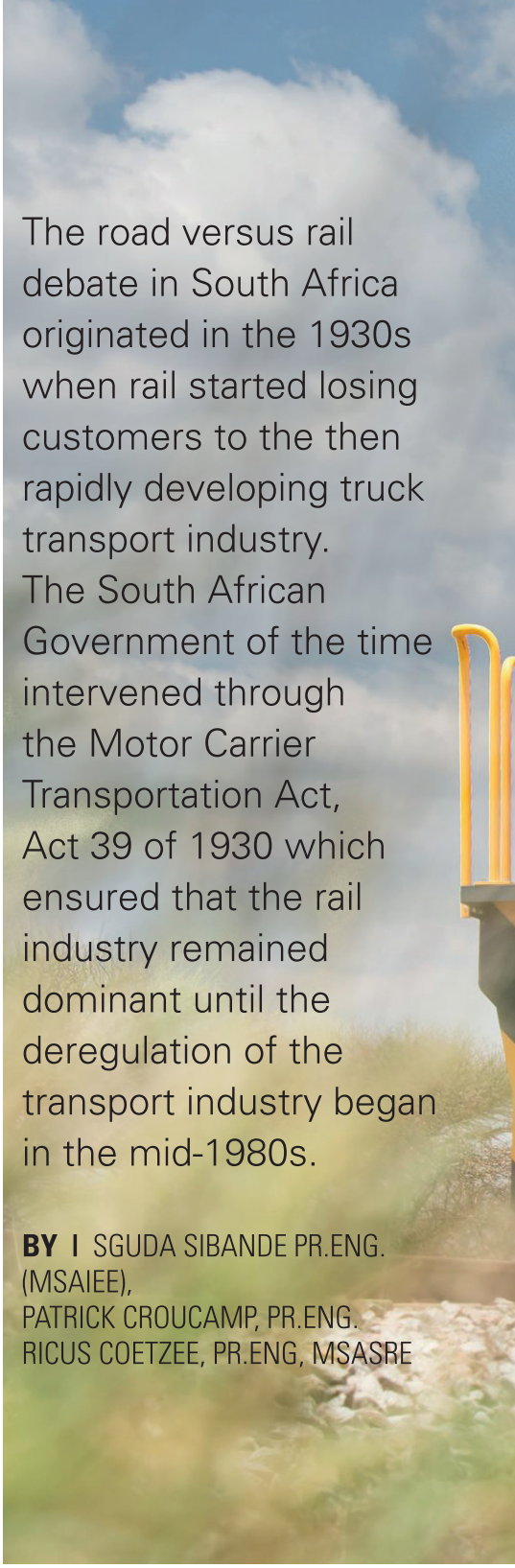
Electricity is indispensable to the process of Transnet's heavy haul lines because it enables the movement of the trains, as well as the operation of the wayside equipment which ensures train safety and provides train condition measurements.

Transnet's heavy haul railway lines operate analogous to a conveyor belt and when load shedding occurs it detrimentally affects the operation of these lines.

The high capital investment in heavy haul railway operations necessitates continuous optimisation of asset utilisation to satisfy changes in customer requirements. To this end, Transnet introduced a 375-wagon manganese train service on the Oreline in October 2019. Each train has a gross mass of 23 625 tons, and the train length of 4 km is a world record for a regular train service. wn

ST -TALKS

Migration from road to rail in South Africa



The road versus rail debate in South Africa originated in the 1930s when rail started losing customers to the then rapidly developing truck transport industry. The South African Government of the time intervened through the Motor Carrier Transportation Act, Act 39 of 1930 which ensured that the rail industry remained dominant until the deregulation of the transport industry began in the mid-1980s.

BY I SGUDA SIBANDE PR.ENG. (MSAIEE),
PATRICK CROUCAMP, PR.ENG.
RICUS COETZEE, PR.ENG, MSASRE

The challenge the railways faced was that the railway construction process generally avoided mountains and high gradients; hence the general rail links are more prolonged than road links which may affect fuel efficiency per ton-kilometre. The road infrastructure has even further improved by the introduction of new highways. The long train distances may have a competitive disadvantage when comparing arrival times at destination. As part of railway revival, the Heavy Haul Rail Operator in South Africa (rail operator - Transnet) embarked on a considerable investment drive called Market Demand Strategy (MDS). The MDS is to revamp both the infrastructure and the rolling stock to increase annual tonnages to 350 million tonnes by 2019.

According to the MDS, Transnet currently transports only 13% of the available rail-friendly loads with the rest being transported by road. There has been a significant effort from the rail operator to lure customers from using the road to use rail with particular focus on the main corridors such as Durban-Johannesburg, Johannesburg-Cape Town, Port Elizabeth-Cape Town and Johannesburg-Port Elizabeth. Among the significant problems with rail are the customer and societal perception on the reliability, effectiveness and to some extent cost because railways cannot focus on door to door delivery.

Currently, the major rail customers are the mines that transport commodities such as coal, iron ore and manganese. The business is therefore vulnerable as it is heavily dependent on the macro environment of which they have no control over. Furthermore, these types of commodities are not future proof. On the other hand, containerised goods such as Fast Moving Consumer Goods (FMCG) and vehicles are future proof as these will always be on demand for as long as humankind exists.

As South Africa is one of the leading agricultural producers in Africa, it may be prudent to target this market as well, seeing as it has a relatively fixed output and timing, which makes planning easier. As a further bonus, rail infrastructure is already present in most of the pick-up and delivery points.

For example, on the Gauteng-Swaziland corridor road freight in 2013 was 38 million tonnes compared to zero tonnes for rail. On the Gauteng-Musina corridor road freight in 2013 was 12 million tonnes compared to 4.5 million tonnes for rail. The types of load on these two corridors consist of containers, cars, fuel, cement, food and

ST-Talks - Railways Webinar: 21 May 2020 @ 1pm CAT. Invitations will be sent to SAIEE member in due course.

beverages, all of which are both road and rail friendly. The key differentiators, among others, are accessibility, speed, reliability, flexibility and costs.

Transnet introduced Market Demand Strategy (MDS) to encourage customers with rail friendly cargo to migrate from road to rail. The emphasis of the MDS is mostly on increasing capacity, acquiring and renovating infrastructure and future sustainability and growth of the organisation and the country. This does not, however, address critical fundamental issues such as accessibility, flexibility and costs as a train cannot do point to point delivery, and a minimum number of tonnages must be hauled before it is feasible to use a train.

The question is, what can Transnet do to overcome these primary challenges, including perceptions so that it can compete and succeed to move road cargo to rail? A road to rail strategy may lead to significant growth in freight

volumes in the foreseeable future, which will also lead to substantial growth in electricity and diesel fuel demand. This requires that the organisation must introduce energy-efficient strategies to ensure that the increase in volumes does not translate into a substantial increase in energy usage, which may put more strain on an already strained energy producer. The energy-efficient strategies may include maximising train regenerative energy, optimising energy efficiency and expanding automation of systems.

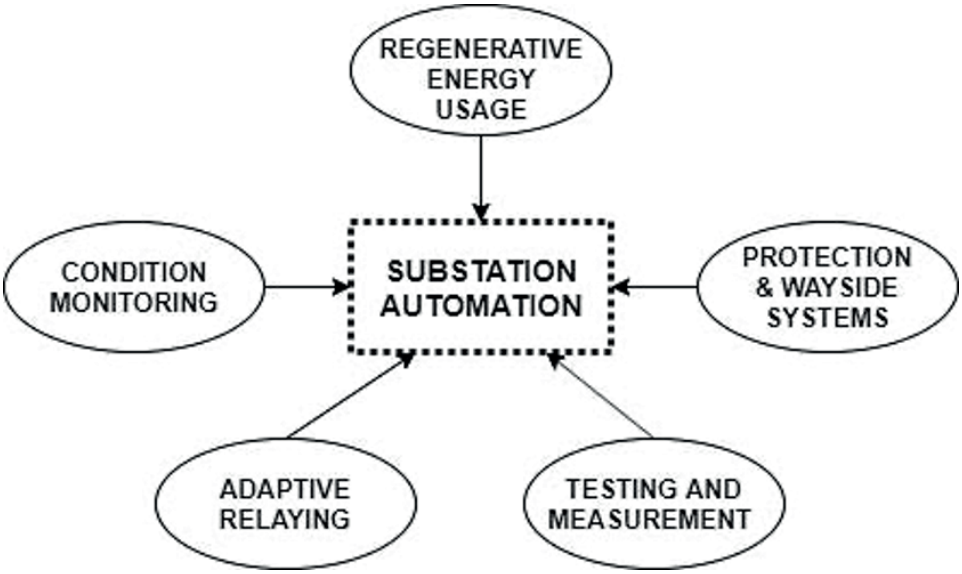


Figure 1: Substation automation dimensions

TRAIN REGENERATIVE ENERGY

Regenerative energy in trains is produced during the braking phase of a train movement. When a train employs regenerative braking, the current in the electric motors is reversed, slowing down the train. In contrast, the engines generate electricity by converting the kinetic energy of the train to electrical power. This slows down the train as the motors generate electricity by converting the kinetic energy of the train to electrical energy.

The quantity of energy regenerated varies significantly as it is dependent on factors such as the size of traction motors, the number of locomotives in a train, ruling gradients and train handling methods. This generated electricity can be returned to the national grid, dissipated in the form of heat through rheostatic braking. This generated electricity can also be used to power other trains within the section, or it can be used to offset power demands of other loads such as lighting in substations or signal relay rooms. Rheostatic braking is employed when the regenerated electric energy cannot be returned to the supply or when there are no other trains in the section to utilise the excess energy. In South Africa, some AC electrified lines are configured to feed the regenerative energy back into the national grid. In contrast, all $3kV_{DC}$ electrified lines employ rheostatic braking if there are no trains in the section to utilise the regenerated power. Applying regenerative braking has an added advantage of reduced wear on mechanical brakes.

Generally, the loaded heavy haul trains start their journey from the mines which are situated inland and at a higher altitude to the major export ports, such as Richards Bay and Saldanha, which are located at the coast close to sea level. The section of the coal line between Ermelo and Richards Bay is electrified at $25kV_{AC}$, and it begins at an altitude of 1860m to near sea level in Richards Bay. The iron ore line runs from Sishen to Saldanha, from an altitude of 1067m to sea level at the Port of Saldanha.

The profile of the lines from high to low altitude allows for the loaded trains to coast with an opportunity to save energy while converting the kinetic energy into electrical energy and feeding it back into the national grid. Using mechanical simulation software, assuming theoretical train handling and working based on mechanical coupler force, it is shown that an estimated 42GWh can be regenerated when a train that consists of five locomotives is used on the Sishen-Saldanha line. This indicates that there is a minimum of 30% energy saving potential per train – if a train is handled autonomously. The difference between simulated and recorded energy data may be attributed to factors such as manual train handling and other infrastructure limitations that require enforcement of speed restrictions. The deviation between measured and simulated energy data shows that accurate measuring of energy efficiency is a critical step toward improving the energy efficiency of the system as per ISO50001 Energy Management Systems standard. Improved energy data and information systems will provide insights into energy usage and areas of possible improvement.

AUTONOMOUS OPERATION

Significant infrastructure upgrades are therefore necessary before autonomous train operations can be

realised, which will, in turn, result in energy-efficient railway operations. The required infrastructure upgrades are in line with the fourth industrial revolution. They include transitioning to full substation automation, adaptive relaying, real-time energy management system, automated neutral section and voltage changeover stations, real-time condition monitoring systems and automated calibration systems among others as shown in Figure 1.

The automation and control systems should adhere to all electrical design and communication standards/ protocols applicable to the traction substations such as IEC61850. This protocol enables the communication between Intelligent Electronic Devices (IED), which may be in the substation (device to device communication) or exterior (substation to substation communication).

Data transmitted between devices and substations must be secure at all times as interference by unauthenticated users will result in disruptive operations and further hinder safety. The automation system must consist of a data acquisition system, data transmission system, a processing unit and a control unit which will allow settings to be adjusted remotely if required. The end product is to be viewed by the National Electrical Control (NEC) centre) through a simplified dashboard for remote viewing. The communication between the NEC and the substations must be bidirectional in the sense that commands initiated by the NEC will be processed and implemented by the intelligent devices found in the substation.

The automation system may be integrated with an energy storage system along with regenerative braking initiatives. When the energy storage system is being operated as a supply system, it may be treated as a substation and monitored for critical faults that exist in a substation. Energy storage systems along the line may also be able to communicate with the two adjacent substations for energy distribution and protection functions.

If a particular substation is unavailable, the automation system can make use of adaptive relaying and protection. When a substation is offline, the automation system will be able to reconfigure the feeding scheme and instruct certain Motor Operated Track Switches (MOTS) to open and close. As the feeding scheme is changed, the protection settings need to be adjusted as the sections become longer.

The MOTS function is to be automated by permitting adaptive relaying, increasing the efficiency of the line as opposed to current operating methods where protection settings are calculated separately and programmed onto the protection relays manually.

South Africa's railway operator predominantly uses $3kV_{DC}$ and $25kV_{AC}$ in most of its electrified corridors except for the Sishen-Saldanha line which is $50kV_{AC}$. It is therefore required to have a voltage changeover automation system that effectively "couples" $3kV_{DC}$ and $25kV_{AC}$ supply systems. This automation system is installed on the actual line on the different Overhead Traction Equipment (OHTE) structures and is referred to as the On-the-Fly (OTF) system.

The OTF system is only applicable to dual voltage locomotives that can operate using $3kV_{DC}$ and $25kV_{AC}$ supply systems. Generally, the engine senses the supply type and accordingly switches to the onboard locomotive equipment by activating the changeover switch installed on the roof of the locomotive.

Before the OTF system, locomotives required an AC/DC changeover yard where trains were stopped, engines were removed or added as necessary, and the power switched accordingly. The OTF system is an integration of infrastructure protection and locomotive protection systems. These systems must act in a coordinated manner to offer a high level of protection to assets and personnel.

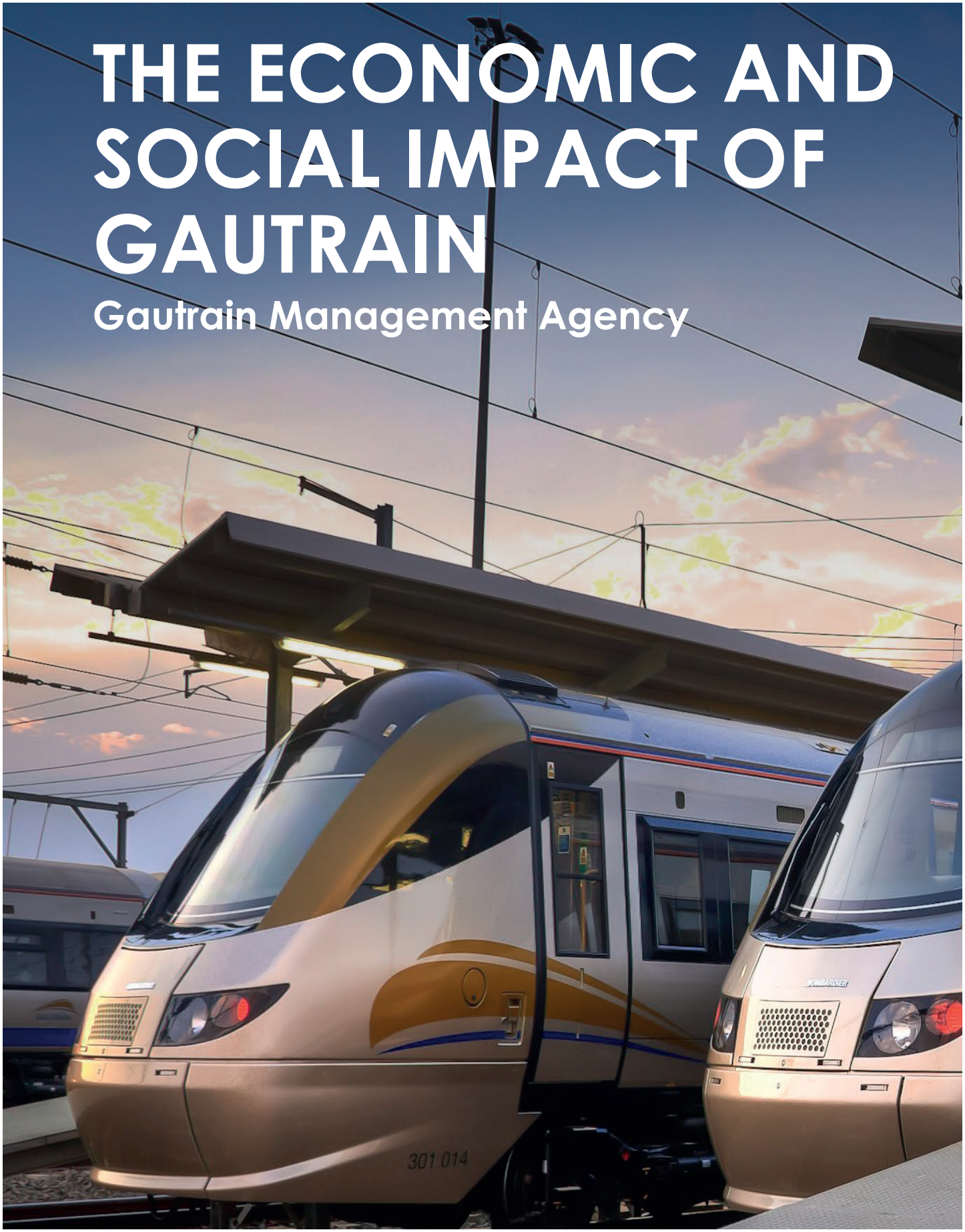
The introduction of the fully automated OTF voltage changeover section is unique, not only to South Africa but to the industry as a whole. This smart, efficient and resilient system allows for safe transition between different supply systems with minimal human intervention or reliance on extra resources. Therefore increasing system capacity as diesel locomotives with a previous function of hauling wagons from one supply system to the other are now re-allocated in other corridors.

Trains traversing a voltage separation section can do so in two manners; the first being with pantographs raised and touching the contact wire and the other with the pantographs lowered and not touching the contact wire. An automated OTF system designed by Transnet was commissioned successfully.

In closing, there is significant technical progress on addressing core issues related to migration from the road to rail, and the implementation of the fourth industrial revolution by Transnet is in full swing. wn

THE ECONOMIC AND SOCIAL IMPACT OF GAUTRAIN

Gautrain Management Agency



FOREWORD

I am delighted to introduce this new report on the economic and social impact of Gautrain. We have been aware for some time of the various ways in which Gautrain is benefiting the Gauteng province, and it is always most informative to see the evidence compiled in one place.

This report provides a quantification of the impressive jobs impact of Gautrain. The system was a major employer of Gauteng residents in its construction stage and this has continued through to the operational phase. You will see from this report that Gautrain provides long term, stable jobs and has invested heavily in the skills of its workforce.

Gautrain is also without doubt fundamentally changing perceptions of public transport amongst Gauteng residents. The report quantifies the strength of these effects, and describes the considerable economic value to Gauteng that occurs when people switch from vehicles to Gautrain.

Analysis is also included on some of the wider ways in which Gautrain is strengthening the economic performance of the province. Land use patterns are becoming more sustainable as we see development increasingly concentrated around public transport nodes. There is also a clear connection between Gautrain and the way in which the province is perceived externally – we are increasingly seen externally as a modern, business friendly location and the Gautrain infrastructure has helped to shape this view. Finally, we are at last seeing the benefits of better connections between the cities of Ekurhuleni, Johannesburg and Tshwane. All globally competitive city-regions need to be well integrated, offering residents and investors to a wide range of different market and job opportunities. We must work day-in day-out at spatial integration across Gauteng, otherwise we will get left behind by competitor locations.

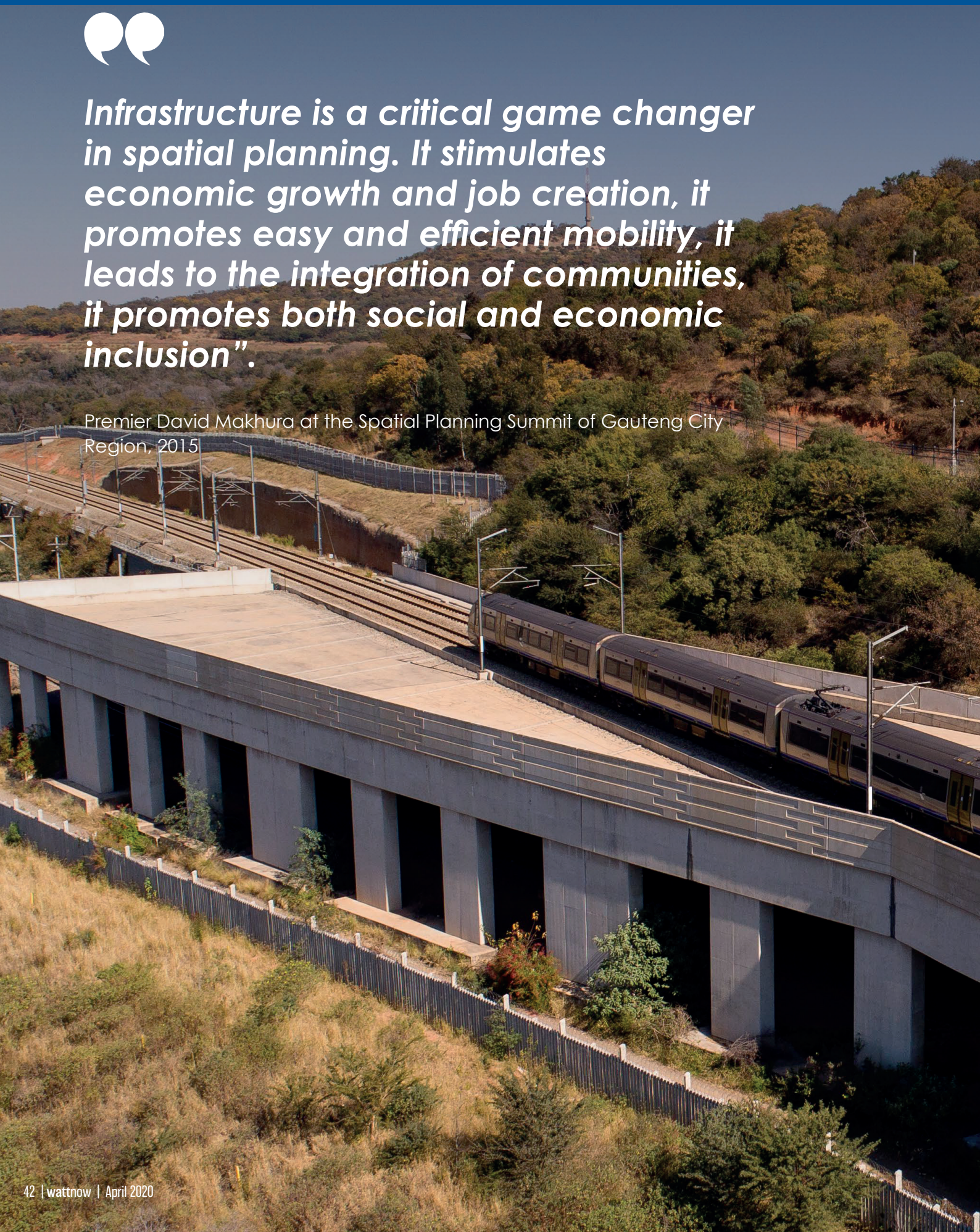
I am particularly pleased with the analysis on how Gautrain is benefiting township residents. Whilst we still have a long journey ahead of us in enabling widespread use of Gautrain by township residents, it is clear that the system is already benefiting many residents both via direct employment and via the clustering of new economic activity near to townships.

I expect to see this report used in full, as we seek to better make the case for further investment in Gautrain.

Mr Phalama Jacob Mamabolo,
Gauteng MEC for Public Transport
and Road Infrastructure

GAUTRAIN
FOR PEOPLE ON THE MOVE

RAILWAYS continues from page 41



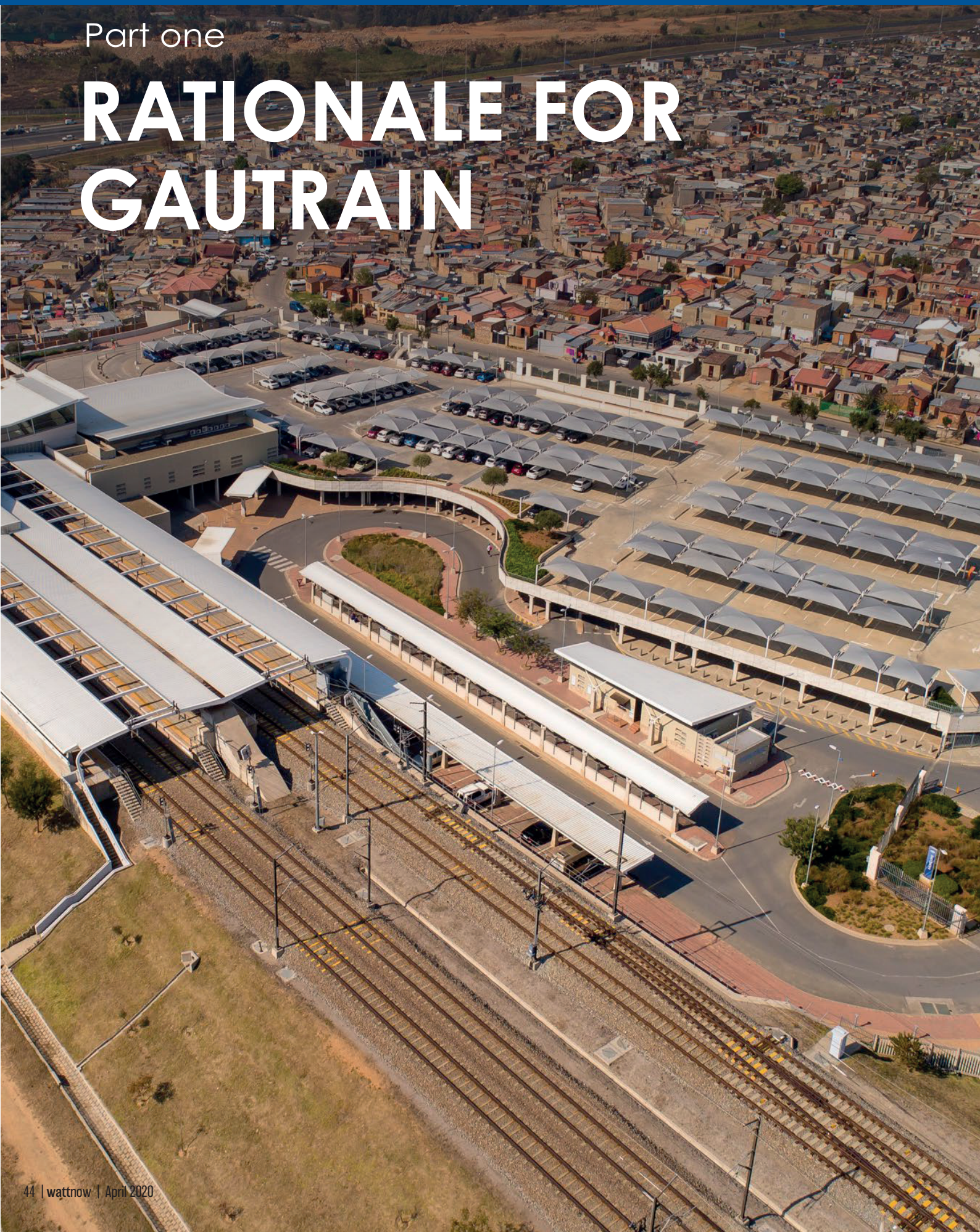
Infrastructure is a critical game changer in spatial planning. It stimulates economic growth and job creation, it promotes easy and efficient mobility, it leads to the integration of communities, it promotes both social and economic inclusion".

Premier David Makhura at the Spatial Planning Summit of Gauteng City Region, 2015

RAILWAYS continues from page 43

Part one

RATIONALE FOR GAUTRAIN



Why Gauteng
NEEDS GAUTRAIN

Gauteng is facing a number of urban challenges that need to be tackled if the province is to realise its economic potential. Gautrain has played an important role in combating some of these and will play even more of a role in the future.

RAPID POPULATION GROWTH

- Gauteng's population was 12.3m in 2011 and it is expected to increase to **18.7m by 2037**
- Forecast **annual population growth** in Gauteng (+1.7%), is well above the rate expected in the rest of South Africa

SIGNIFICANT TRAFFIC CONGESTION

- **Peak hour trips** on key arterial roads generally take **70% longer** than equivalent trips during the off-peak
- If no improvements are made average road speeds of 48km/hr could deteriorate to **10km/hr by 2037**

DEEP POVERTY AND INEQUALITY

- Gauteng's **unemployment rate is high** at **29%**, which is above the South African rate of 27%
- Employment in the formal sector has declined to around **77%** - more formal sector jobs are required, especially for women and young people

POOR AND DETERIORATING AIR QUALITY

- Since 2006 the concentration of PM10 in Gauteng's atmosphere increased by c.**20%**, making air pollution high compared to other provinces
- PM10 levels exceed Gauteng Province Air Quality Objectives on a significant number of days each year

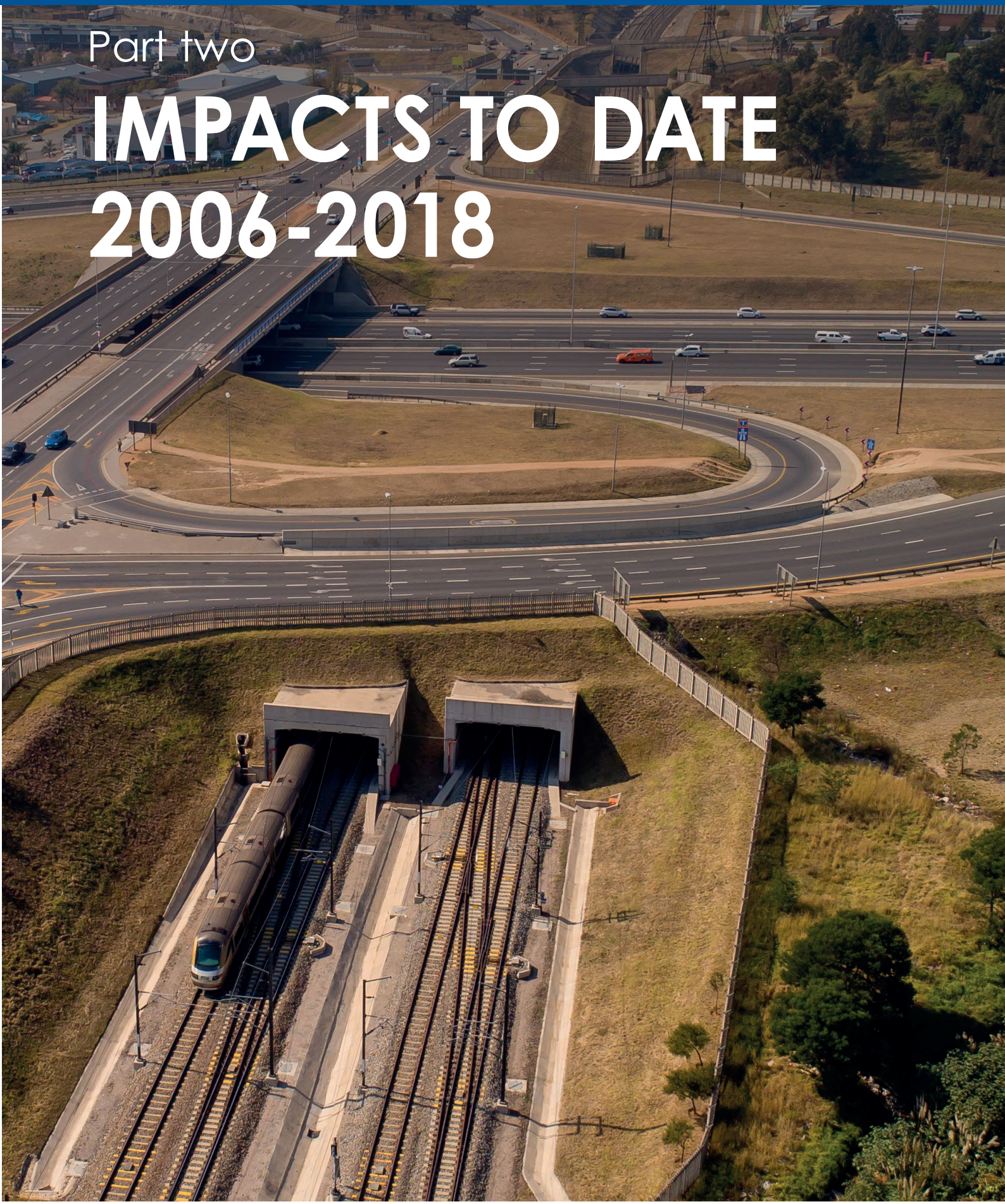
INTENSE GLOBAL COMPETITION

- The city of **Johannesburg is ranked 42nd** out of 44 cities on the Global Power City Index (2018) - other cities that have invested in transport mega-projects are making strong progress (e.g. Jakarta at 41st, Fukuoka at 37th, Tapei at 35th and Kuala Lumpur at 32nd)
- **Gauteng needs to invest in infrastructure** to better compete on the global stage

RAILWAYS continues from page 45

Part two

IMPACTS TO DATE 2006-2018



FIVE PILLARS OF IMPACT

Gautrain has played an important role in combating some of the urban challenges that Gauteng faces through the delivery of a range of economic and social impacts. A taster of some of these is provided in the diagram below. Gautrain will play a more significant role in the future as further investment is made in the network.

RAILWAYS continues from page 47

THE FIVE WAYS THAT GAUTRAIN BENEFITS GAUTENG

DELIVERING JOBS AND SOCIAL INVESTMENT

Large scale capital investment creates jobs in the construction and manufacturing sectors. **Gautrain is also a big operational employer.** Many of these **benefits flow directly to target communities** and labour market groups.

INFLUENCING TRANSPORT CHOICES

Gautrain is shifting opinions and consumer decisions related to public transport, **reducing pressure on the road network.** Reduced car usage means fewer accidents, less pollution and more productive time for workers in the provincial economy.

REINFORCING DEVELOPMENT NODES

Transit nodes are proven to shape locational decisions relating to development and commercialisation. Clustering and concentrating **development leads to more efficient land use, more collaboration between firms and unlocks wider benefits of agglomeration.**

INTEGRATING THE REGION AND ITS COMMUNITIES

The most successful global city regions are well integrated, with businesses having the ability to access broad and deep labour markets and a wide customer base. Access to new staff and clients are vital ingredients in stimulating economic growth.

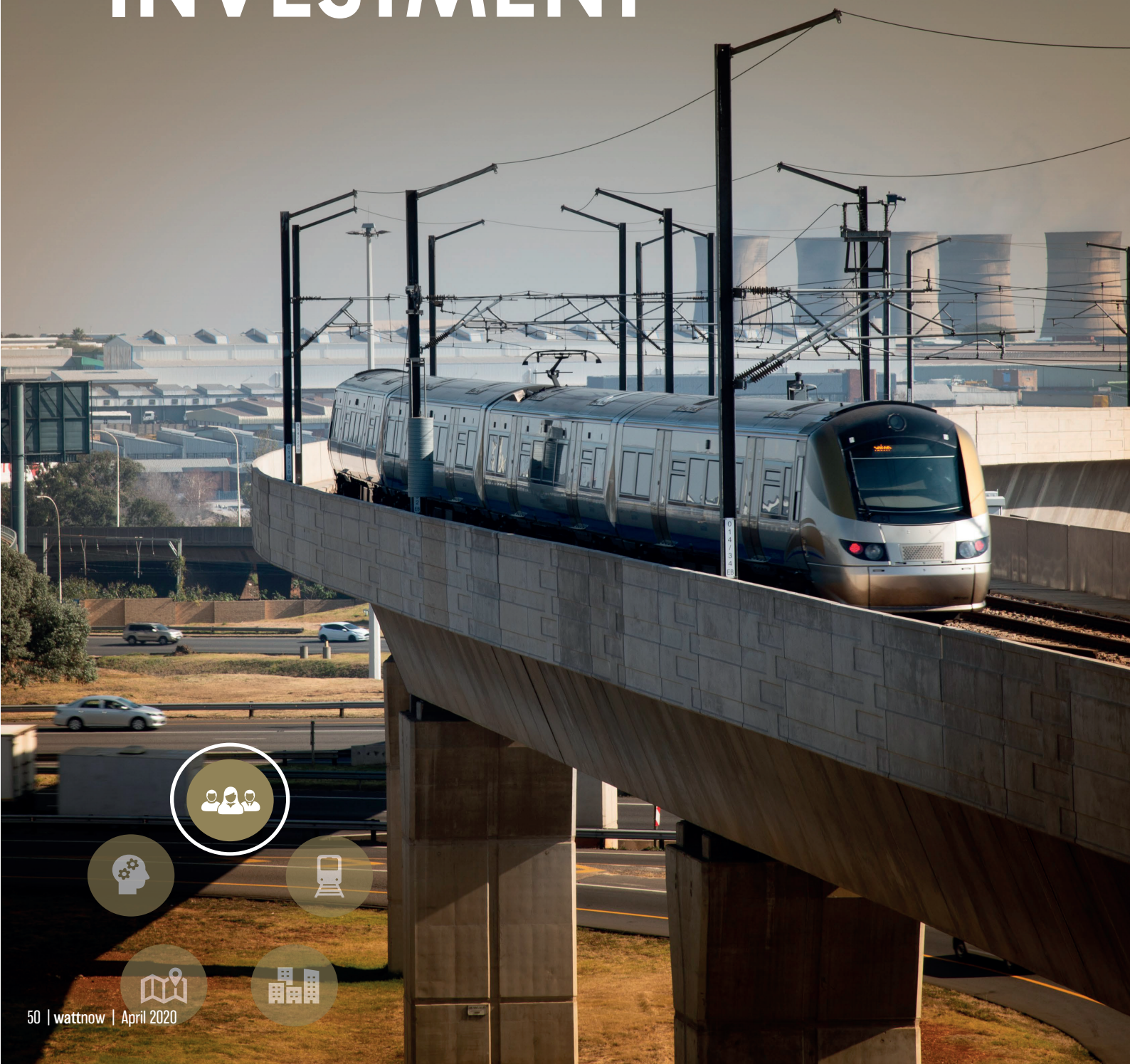
CHANGING PERCEPTIONS AND ATTRACTING INVESTMENT

Gautrain is a modern infrastructure system that is changing the image of Gauteng. This encourages repeat visits from businesses and leisure tourists, enhanced investment flows and a general uplift in the visibility of the province in international networks.

RAILWAYS continues from page 49

Part two | Impacts to date 2006-2018

DELIVERING JOBS AND SOCIAL INVESTMENT



DELIVERING JOBS AND SOCIAL INVESTMENT

The construction and operational phases of Gautrain have directly delivered a significant number of jobs to the Gauteng economy. Spend on Gautrain has also helped to support the wider economy through corporate supply chain expenditure and wage expenditure.

Construction Phase Impacts
(Over Six Years)

c.**R26.5bn** spent during construction phases

Spend created c.**35,000** direct jobs for South African people

Around **87,300** additional jobs supported though supply chain and wage spend

Over **R12bn** of salary delivered

c.**R19.4bn** contribution to GDP of Gauteng

Source: Seriti and Hatch Calculations

For every **R10m** spent on construction work, **45 jobs** were supported directly and via supply chain and wage spend

Operational Phase Impacts
(Over Six Years)

Operational phase has delivered c.**10,900** direct jobs for South African people

Around **61,000** additional jobs supported though supply chain and wage spend

Around **R12bn** of salary delivered

c.**R20.4bn** contribution to GDP of Gauteng

Source: Seriti and Hatch Calculations

For every **R10m** spent on salaries, **60 jobs** are supported directly and via supply chain and wage spend

**1 job = 1 full year of employment. This is a typical approach for monitoring employmer impact in South Africa.*

RAILWAYS continues from page 51

Delivering jobs and social investment

CONSTRUCTION PHASE INCLUSIVE BENEFITS

c.3,800 direct jobs for women

Source: Seriti

"The Gautrain project has enabled me to learn from international experts, and the experience and skills I have gained on this project are unparalleled. I was responsible for ensuring machinery always worked properly and I was selected to be the site safety

Instrument Mechanic

c.20,300 direct jobs for young people

Source: Seriti

"When I joined the Gautrain project I had no experience whatsoever except the theory I had learned from university. I am fortunate to have gained a very unique experience as a young female engineer working on a Tunnel Boring Machine (TBM)."

TBM Surface Supervisor and grant recipient from Bombela Civils Joint Venture

c.29,900 direct jobs for Historically Disadvantaged Individuals (HDIs)

Source: Seriti

"Before I worked for Gautrain I was struggling to make ends meet. With Gautrain I have received basic computer skills training and I attended a concrete construction course. This allowed me to be quickly promoted to a Works Inspector. I'm now studying a Supervision of Building Construction Course at college."

Work Inspector

The Concessionaire, its contractors and sub-contractors spent around **R128m** to improve employee skill levels during the construction process.

Women received over **5,000** months of training during the construction phase and over **120** women participated in the Women Leadership and Mentoring Programme for Electrical and Mechanical Works.

RAILWAYS continues from page 53

Delivering jobs and social investment

OPERATIONAL PHASE INCLUSIVE BENEFITS

c.3,000 direct jobs for women

Source: Seriti

"The reasons I like working for the Gautrain are: I like working the shifts that I work on a daily basis; the safe environment that the Gautrain offers their employees; the people I work with are friendly and are a pleasure to work with; the trains are clean and safe to drive. The Gautrain also offers many benefits to their employees and there is a lot of growth opportunities."

Train Driver

c.5,800 direct jobs for young people

Source: Seriti

"My life changed since working at the Gautrain for the better as I am now able to provide for my family as a young person knowing that the company I work for is stable and safe, as safety in the company is of utmost importance. I have learned a lot of people skills by working for the Gautrain and with a lot of different people and cultures."

Station Support Officer

c.10,100 direct jobs for Historically Disadvantaged Individuals (HDIs)

Source: Seriti

"Exposure to the transport industry that operates to a global standard and the interaction with international people is good. I have a better understanding of operations and have learned the importance of efficiencies which I now apply in different areas of my life."

Operations Controller

The Concessionaire has spent around **R59m** to date on training and skills development for operational staff.

This is core to the Gautrain Management Agency's broader ambitions to help develop staff and ensure progression within the organisation.

RAILWAYS continues from page 55

Delivering jobs and social investment

PROVIDING A WIDE RANGE OF LONG-TERM JOBS

Gautrain has delivered a spectrum of jobs during its construction and operational phases. Many roles have low barriers to entry and offer a good route into secure and formal employment. There are roles to suit people with different skill levels and good opportunities to progress.

Average length of employment at Gautrain
= 5.75 years

Average length of employment in South Africa
= 4 years

Source: Stats SA 2014

ENTRY LEVEL: NFQ 0-1

(up to grade 9)

c.51%
CONSTRUCTION JOBS
Source: Construction Industry Development Board and Hatch Estimates

0%
OPERATIONAL JOBS
Source: Bombela Operating Company

- Labourers
- Ticket Inspectors
- Cleaners
- Security Guards

MID LEVEL: NFQ 2-4

(College/ Apprenticeships)

c.13%
CONSTRUCTION JOBS
Source: Construction Industry Development Board and Hatch Estimates

93%
OPERATIONAL JOBS
Source: Bombela Operating Company

- Document Controllers
- Marketing Officers
- Mechanics
- Train Drivers
- Project Managers

HIGHER LEVEL: NFQ 4+

(University Diploma and up)

c.35%
CONSTRUCTION JOBS
Source: Construction Industry Development Board and Hatch Estimates

7%
OPERATIONAL JOBS
Source: Bombela Operating Company

- Architects
- Quantity Surveyors
- Transport Planners
- Executive Managers
- Accountants

Delivering jobs and social investment

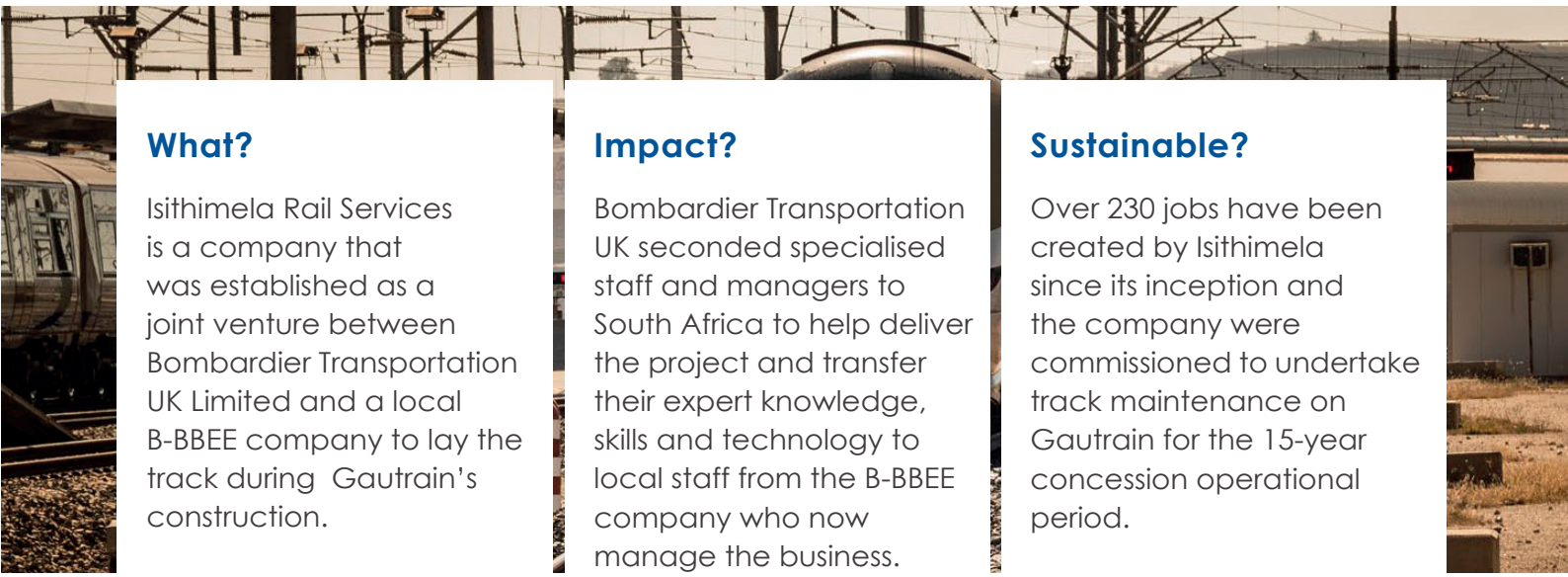
LOCALISATION VIA PROCUREMENT

The Gautrain Management Agency (GMA) has taken a proactive approach to maximise the social and economic benefits of its investments to local people and businesses. A robust approach to procurement has been developed to support this.

- The GMA has delivered a **Transformation and Supplier Development Framework**. This responds to the priorities in the South African National Development Plan 2030 and the Transformation, Modernization and Re-industrialisation Strategy for Gauteng.
- The framework guides procurement and aims to increase direct and supply chain spend with B-BBEE compliant enterprises, support supplier development, promote skills transfer and catalyse economic growth:

  - ✓ Strict rules are set out as part of procurement competitions (e.g. bidders for contracts above R30 million must subcontract 30% of the contract value to a B-BBEE, EME or QSE)
  - ✓ Successful tenderers have to produce and deliver a **Supplier Development Plan** which must respond to the GMA's economic development priorities
  - ✓ Procurement rules focus on maximising **localisation** and the value of any investment to the South African economy

Isithimela Rail Services



What?

Isithimela Rail Services is a company that was established as a joint venture between Bombardier Transportation UK Limited and a local B-BBEE company to lay the track during Gautrain's construction.

Impact?

Bombardier Transportation UK seconded specialised staff and managers to South Africa to help deliver the project and transfer their expert knowledge, skills and technology to local staff from the B-BBEE company who now manage the business.

Sustainable?

Over 230 jobs have been created by Isithimela since its inception and the company were commissioned to undertake track maintenance on Gautrain for the 15-year concession operational period.

RAILWAYS continues from page 57

TRAC SOUTH AFRICA, STELLENBOSCH UNIVERSITY

The Technology Research and Activity Centre (TRAC) South Africa is a Stellenbosch University programme that seeks to improve science, engineering and technology education in selected secondary schools in townships.

It includes "hands-on" intervention in classrooms as well as some educator training. The Gautrain Management Agency has supported the initiative for several years and continues to do so due to strong student achievement.

TRAC SOUTH AFRICA ERADICATING POVERTY | SU 100 1918·2018

Delivering jobs and social investment

A SIGNIFICANT COMMUNITY DEVELOPMENT PROGRAMME

The Gautrain Management Agency has developed a Social Investment Programme Fund to support community and growth initiatives. 10% of the value of Gautrain projects is allocated to the fund which focuses on education, community care and the environment.

R37.5m has been committed to community organisations for 2017-2021

Source: Gautrain Management Agency

11 Education Organisations

with projects focusing on teacher development, psychosocial support for students, and supporting people into education focused on the built environment and transport

Source: Gautrain Management Agency

6 Community Care Organisations

with projects focusing on women empowerment, people with disabilities and home farming initiatives

Source: Gautrain Management Agency

20 Early Child Development Centres

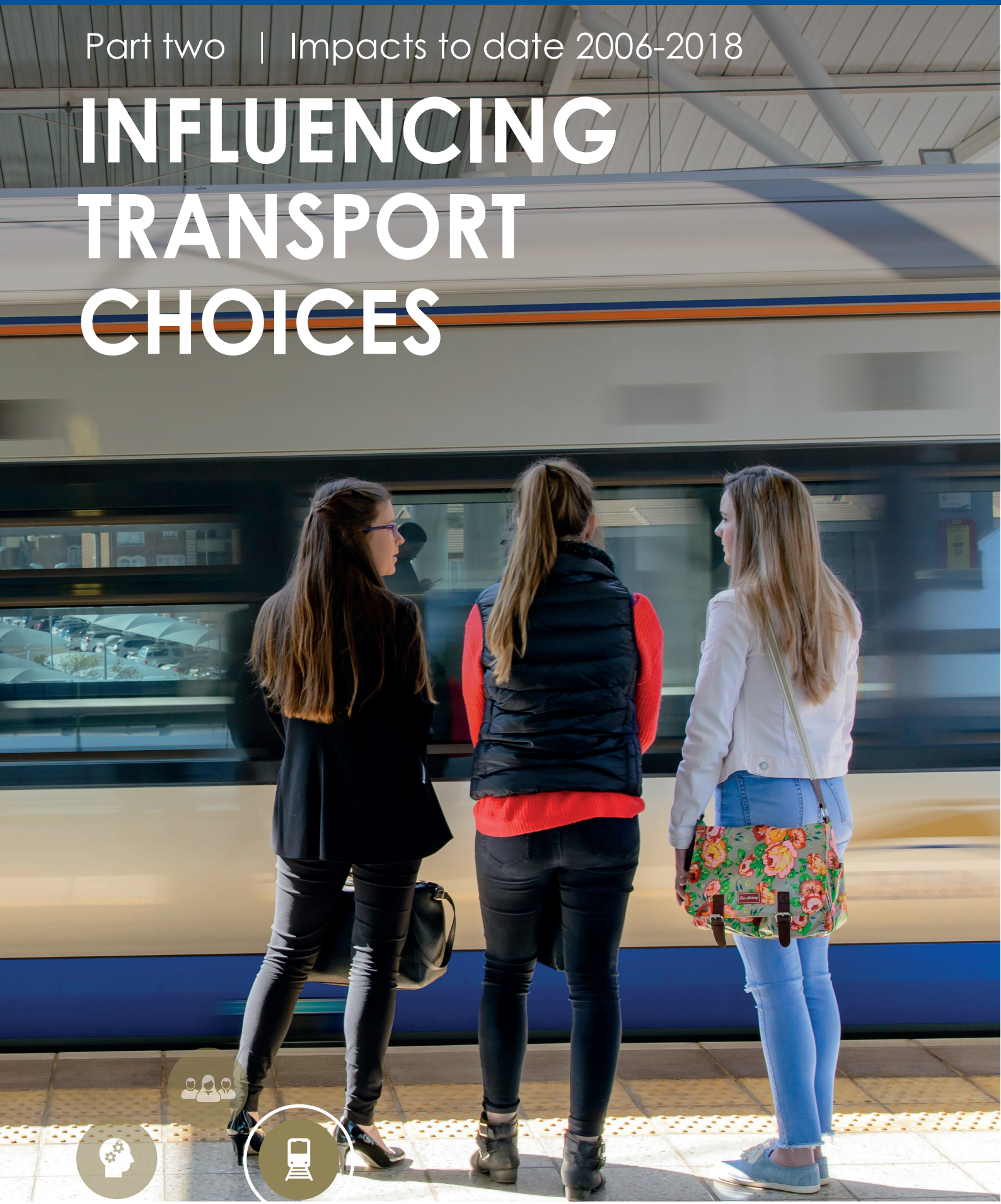
which include crèches, day care centres for young children, playgroups, pre-schools and after school care

Source: Gautrain Management Agency

RAILWAYS continues from page 59

Part two | Impacts to date 2006-2018

INFLUENCING TRANSPORT CHOICES

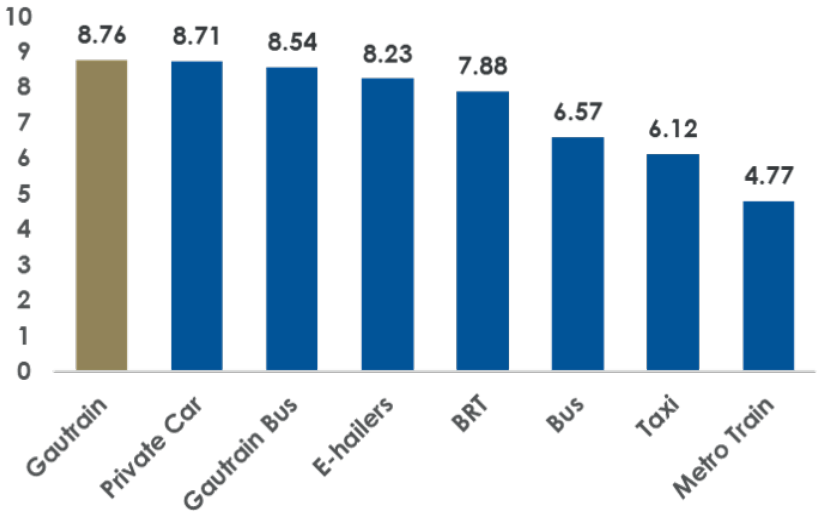


INFLUENCING TRANSPORT CHOICES

With the support of Gautrain, the perception of public transport in Gauteng is changing fundamentally. Gautrain is setting new standards and new norms for public transport.

Gautrain is shaping customer expectations

Quality of service rating (Max score = 10)



Source: Gautrain Management Agency Market Segmentation Report, 2017 N = 661

Gautrain has new approaches to safety and security

93% of users are satisfied with safety and security.

Source: Gautrain Management Agency Market Segmentation Report, 2017

Gautrain represents a new era in public transport

70% of Gauteng residents see Gautrain as innovative and progressive. **87%** of Gauteng residents think it is a good idea.

Source: Gautrain Management Agency Perceptions Survey, 2006 and 2011

Gautrain is exceeding expectations

70% of users believe Gauteng has benefited from Gautrain and **67%** think Gautrain is better than they expected.

Source: Gautrain Management Agency Perceptions Survey, 2006 and 2011

RAILWAYS continues from page 61

INFLUENCING TRANSPORT CHOICES

Gautrain has transformed commuter behaviour. This has resulted in modal shift from cars to Gautrain which has generated a number of social, economic and environmental benefits.

Just over **14m trips** were taken on Gautrain in 2018 - this was a 28% increase on the number of trips in 2012

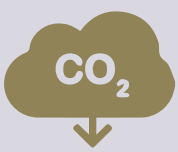
In total, **98m** trips have been taken during Gautrain's lifetime

Source: Gautrain Management Agency

Each person who has chosen to make a trip on Gautrain instead of by car has delivered...

R74 OF ECONOMIC BENEFIT PER TRIP

Reduced costs from fatal accidents



CO_2 emission savings

22 minutes of time saved on average

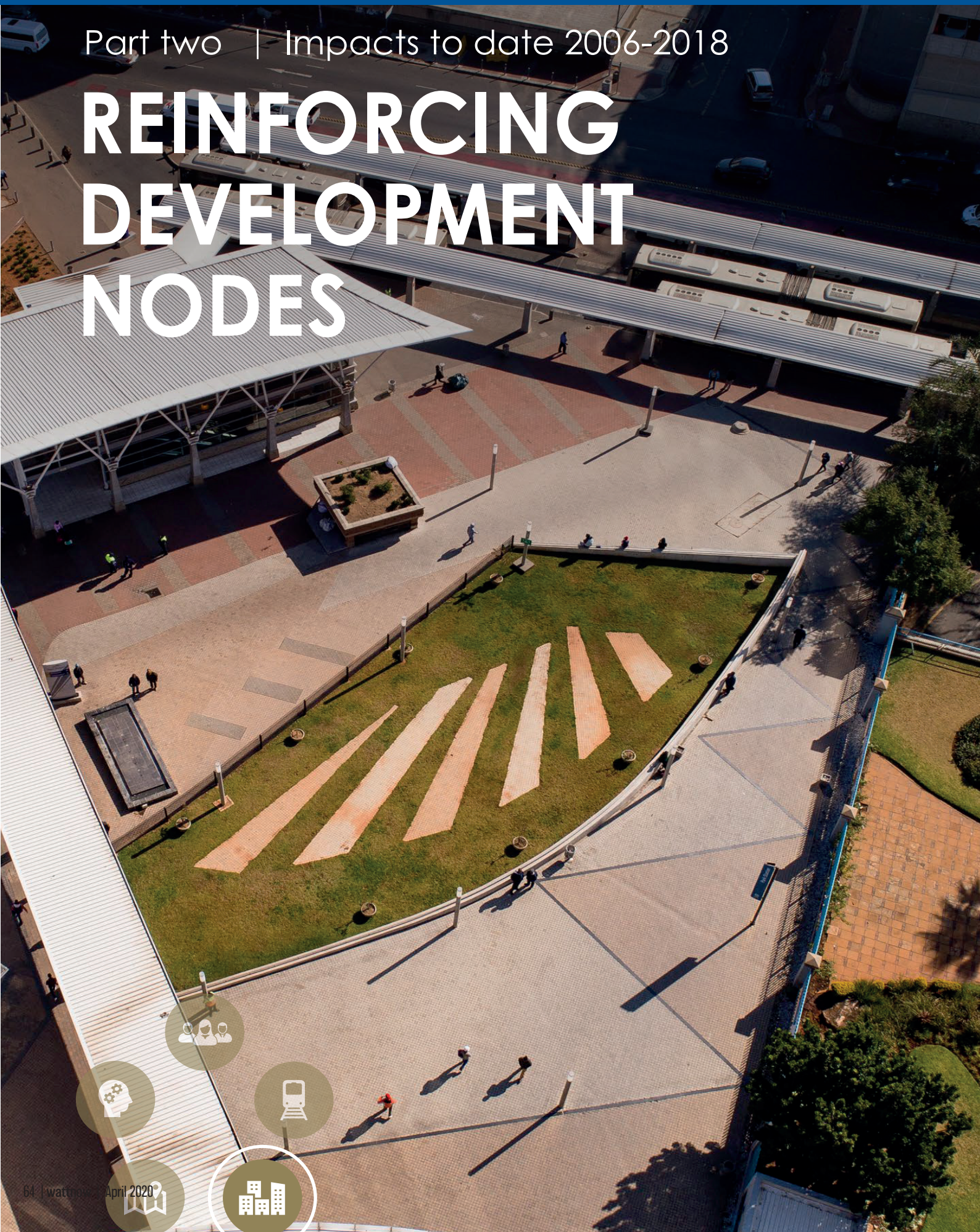
"While there may be some reservations about whether or not South Africans will leave their cars at home for the commute, the success of the Gautrain has shown that many are prepared to do just that"


Tickets- No Cash
Bankcards only
GAUTRAIN
GAUTRAIN
WARNING
Do not accept
assistance or help
from strangers
when using this TVM
CUSTOMER SERVICE
GAUTRAIN

RAILWAYS continues from page 63

Part two | Impacts to date 2006-2018

REINFORCING DEVELOPMENT NODES



REINFORCING DEVELOPMENT NODES

The arrival of a Gautrain station influences local development and commercialisation decisions. It presents new opportunities for developers and can have a profound impact on the value of land immediately surrounding the station.

Net Floorspace Change (2010-17)

Commercial space has increased within 2km of Gautrain stations since 2010. We estimate this new space is well occupied (87%) and supports a significant number of jobs.

Office	**+ 820,000 m²**
Retail	**+ 31,000 m²**
Other Commercial	**+ 805,000 m²**

(Includes new office space under construction and not yet classified)

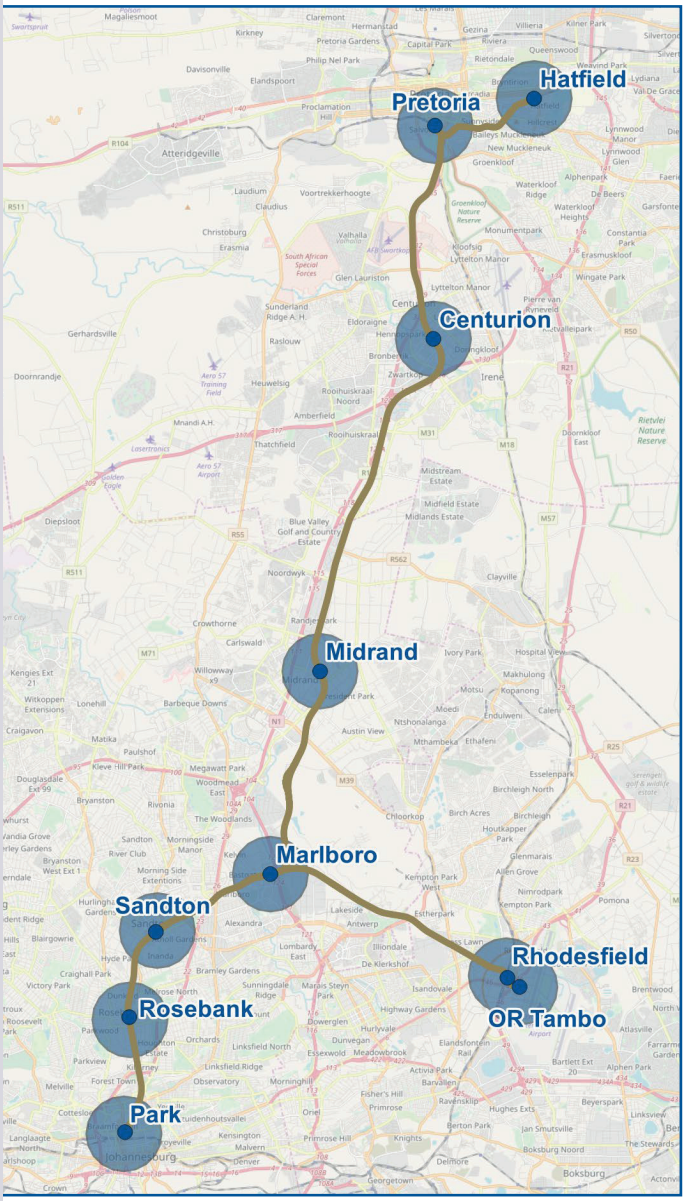
Total	**+ 1,656,000 m²**
Jobs Uplift	**+ 66,000**

New residential space has also been catalysed around stations and residential night time population has increased by over 3,000 since 2010.

Residential	**+ 138,000 m²**

2km buffer around Gautrain Stations

Source: GeoTerra, Homes and Communities Agency Employment Density Guidance, South African Property Owners Association



RAILWAYS continues from page 65

REINFORCING DEVELOPMENT NODES

Office

Within 2km radius

- Median **sales values per m²** have increased by **45%** around stations since 2010, higher than the change across Gauteng which was **22%**
- Gautrain is catalysing new commercial nodes – office floorspace has increased more rapidly around Centurion **(15%)**, Rhodesfield **(11%)**, O.R. Tambo International **(11%)** and Marlboro **(9%)** since 2010 than the 8% observed across Gauteng
- Gautrain is helping to consolidate existing commercial nodes – office floorspace has increased around all other stations by an average of **4%** since 2010

Source: Lightstone and GeoTerra

Retail

Within 2km radius

- Median **sales values per m²** have increased by **32%** around stations since 2010, higher than the change across Gauteng which was **-10%**
- Only modest retail floorspace growth has occurred around stations since 2010
- The fastest retail floorspace growth has been within the Midrand catchment **(8%)**

Source: Lightstone and GeoTerra

Other Commercial

Within 2km radius

- This category includes industrial, light industrial, warehousing, distribution and commercial space under construction (including office)
- Median **sales values per m²** have increased by **109%** around stations since 2010, higher than the change across Gauteng which was **10%**
- Most floorspace growth has been within the catchments of Midrand **(18%)**, Marlboro **(20%)** and Sandton **(48%)** since 2010
- All other stations have experienced similar or lower average floorspace growth than the Gauteng level since 2010

Source: Lightstone and GeoTerra

Residential

Within 2km radius

- Median **sales values** have increased by **52%** around stations since 2010, which is higher than the **34%** observed across Gauteng over the same period
- Median sales value have increased significantly around Rhodesfield **(47%)**, Midrand **(40%)** and Sandton **(36%)**
- There has been a **10%** increase in residential floorspace since 2010, supporting an additional 3,000 people to live in these areas

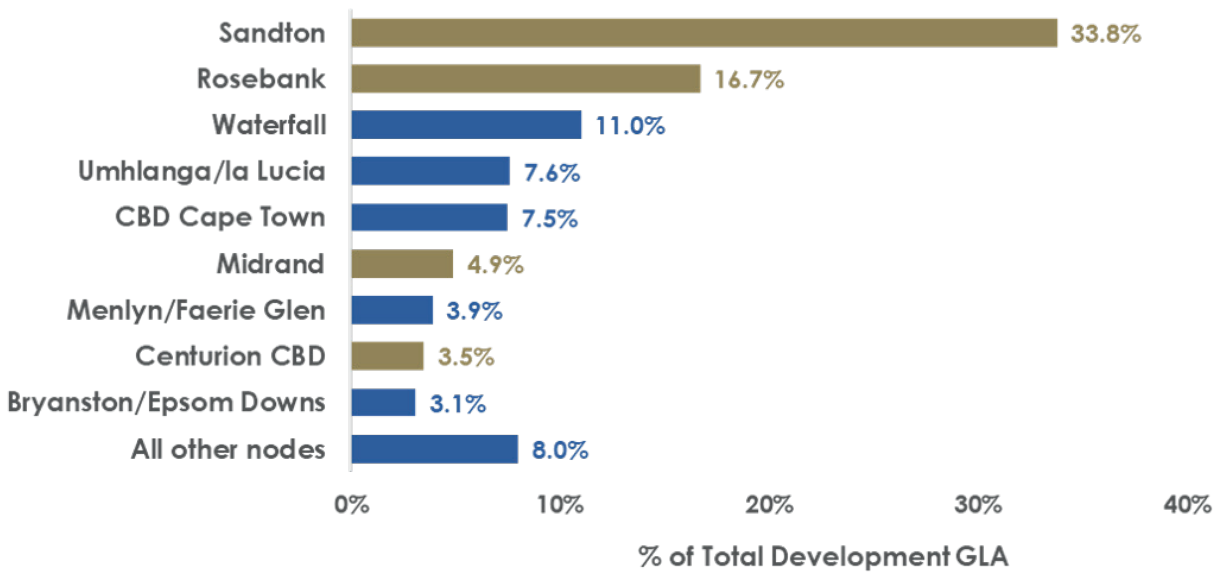
Source: Lightstone and GeoTerra

RAILWAYS continues from page 67

REINFORCING DEVELOPMENT NODES

A significant proportion of office development at the national level has occurred in Gauteng, particularly in places where there are Gautrain stations. This is because businesses want to locate in places that are easy for employees and clients to access and are well-connected to other nodes and services.

Office Development Activity by Node, June 2018



Source: South African Property Owners Association

59% **OF ALL OFFICE DEVELOPMENT ACTIVITY IN MAJOR SOUTH AFRICAN NODES IS LOCATED AROUND GAUTRAIN STATIONS**


OLDMUTUAL

RAILWAYS continues from page 69

Reinforcing development nodes

ROSEBANK

Key developments around Rosebank (2010-2017)

All in a 2km radius of station

1 THE CAPITAL

- Commercial/Hotel
- 52 apartments
- R100m
- 72 Bath Avenue, Rosebank
- 1km from Rosebank Station
- Completed in 2015

2 THE MEDIAN

- Residential
- 15 Stories
- N/A
- 23 Cradock Avenue, Rosebank
- 500m from Rosebank Station
- Completed in 2018

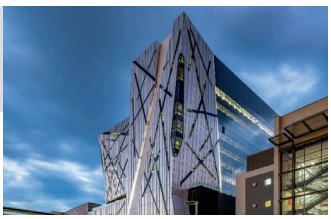
3 ROSEBANK TOWERS

- Office
- 25 000m^2
- R300m
- 15 Blemann Avenue, Rosebank
- 300m from Rosebank Station
- Completed in 2017

4 STANDARD BANK CENTRE

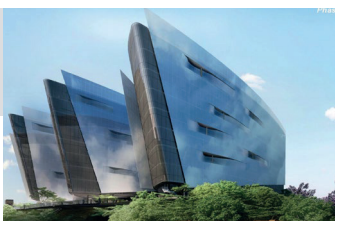
- Commercial
- 65 000m^2
- R300m
- 30 Baker Street, Rosebank
- 500m from Rosebank Station
- Completed in 2013

5 THE LINK



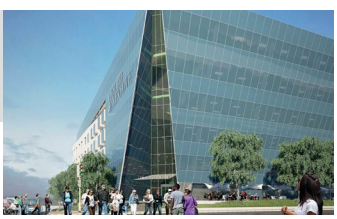
- Office/Retail
- 20 297m^2
- R1bn
- 173 Oxford Road, Rosebank
- Direct access to the station via walkway
- Completed in 2018

6 144 OXFORD ROAD



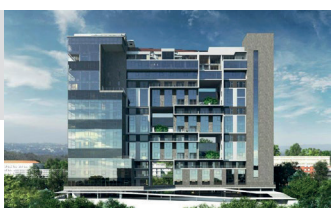
- Office
- 35 000m^2
- N/A
- 144 Oxford Road, Rosebank
- 600m from Rosebank Station
- Completed in 2018

7 OXFORD & GLENHOVE



- Office
- 22 000m²
- N/A
- 114 Oxford Road, Rosebank
- 500m from Rosebank Station
- Completed in 2017

8 PARK CENTRAL



- Commercial
- 20 Storeys
- N/A
- 6 Keyes Avenue, Rosebank
- Direct access to the station via walkway
- Completed in 2018

RAILWAYS continues from page 71

Reinforcing development nodes

SANDTON

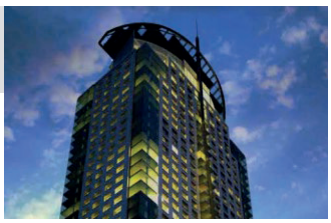
Key developments around Sandton (2010-2017)

All in a 2km radius of station

1 SIGNATURE LUX

- Commercial
- N/A
- N/A
- 135 West Street, Sandown, Sandton
- N/A

2 THE LEONARDO

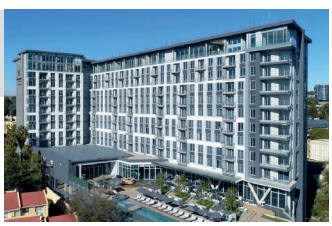


- Residential
- N/A
- R2bn
- 75 Madue Street, Sandton
- Completed in 2019

3 ADVOCATES

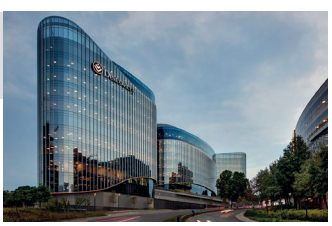
- Commercial
- 13 500m^2
- R476m
- 2 Pybus Street, Sandton
- Completed in 2019

4 THE CAPITAL



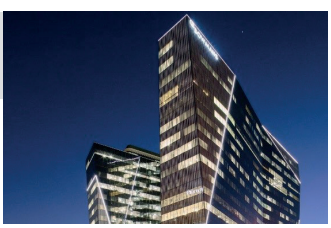
- Hotel/Residential
- 25 000m^2
- R500m
- 101 Catherine Street, Sandton
- Completed in 2018

5 DISCOVERY



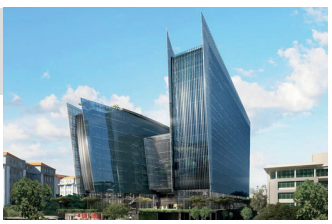
- Commercial/Retail
- 110 000m^2
- R3bn
- 1 Discovery Place, Sandton
- Completed in 2018

6 BOWMAN GILFILLIAN



- Commercial
- 35 000m^2
- N/A
- 165 West Street, Sandton
- Completed in 2017

7 HOGAN LOVELLS



- Commercial
- 67 000m²
- R2bn
- 140 West Street, Sandton
- Completed in 2017

8 OLD MUTUAL

- Commercial
- 120 000m²
- R1.2bn
- 93 Grayston Drive, Benmore Gardens
- Completed in 2017

RAILWAYS continues from page 73

Reinforcing development nodes
MIDRAND

Key developments around Midrand (2010-2017)

All in a 2km radius of station

1 GALLAGHER CONVENTIONS

- Commercial
- 32ha
- N/A
- 19 Richards Dr, Halfway House
- Under Construction

2 CHINA TOWN MALL

- Retail
- Over 400 units
- N/A
- Old Pretoria Road, Halfway House
- Completed in 2019

3 RIVERVIEW OFFICE PARK

- Commercial
- N/A
- N/A
- Janadel Avenue, Halfway Gardens
- Under Construction

4 SPARK SCHOOL

- Private School
- N/A
- N/A
- Corner Alexandra Avenue/Aitken Street
- Completed in 2016

5 GRAND CENTRAL

- Residential
- N/A
- N/A
- Exchange Road Grand Central
- Completed in 2017

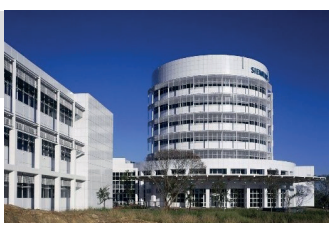
6 MIDRAND BUSINESS PARK

- Commercial
- 13,500m^2
- N/A
- Exchange Road Grand Central
- Completed in 2017

7 CO.SPACE

- Commercial
- 355 office units
- N/A
- Brand Road & Swart Dr, President Park AH
- Completed in 2017

8 SIEMENS



- Commercial
- N/A
- Refurbishment
- Janadel Ave, Halfway Gardens
- Completed in 2018

Reinforcing development nodes

CENTURION

Key developments around Centurion (2010-2017)

All in a 2km radius of station

1 CENTURION MALL

Retail
N/A
R298m
Longlake, Modderfontein, Lethabong
Completed in 2018

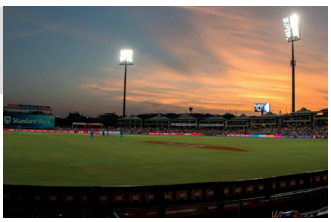
2 OAKTREE (CLUBVIEW)

Residential
128 units
N/A
212-224 End Street, lyttelton AH
Completed in 2019

3 OUTSURANCE

Commercial
N/A
N/A
1241 Embankment Road, Zwartkop
Completed in 2012

4 SUPERSPORT PARK



Commercial
22,000 capacity
N/A
283 West Avenue, Die Hoewes
Completed in 2017

5 AFGRI

Commercial
N/A
N/A
12 Byls Bridge Boulevard, Highveld Ext 73
Completed in 2017

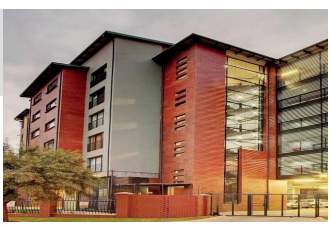
6 BYLS BRIDGE OFFICE PARK

Commercial
N/A
N/A
212-224 End Street, Lyttelton AH
Under Construction

7 SYMBIO CITY

Mixed Use
600,000m²
N/A
Centurion Lake, under 400m from station
Proposed

8 CENTURY SKYE



Residential
N/A
N/A
Corner of Glover Avenue and Murati Street
2019

RAILWAYS continues from page 77

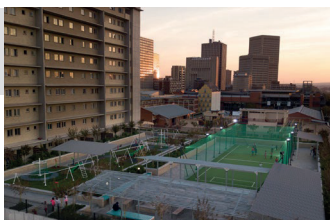
Reinforcing development nodes

PRETORIA

Key developments around Pretoria (2010-2017)

All in a 2km radius of station

1 SHARON'S PLACE



- Residential
- N/A
- N/A
- 89 Lilian Ngoyi Street, Pretoria Central
- Under Construction

2 STATION SQUARE MALL

- Residential
- N/A
- N/A
- 89 Lilian Ngoyi Street, Pretoria Central
- Under Construction

3 STATS SA

- Commercial
- 60 000m^2
- N/A
- 563 Old Pretoria Rd, Halfway House
- Completed in 2016

4 OPERA PLAZA

- Retail
- N/A
- N/A
- 230 Pretorius Street, Pretoria Central
- Under Construction

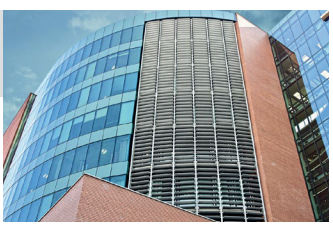
5 MERCEDEZ-BENZ FOUNTAINS

- Commercial
- N/A
- N/A
- 609 Thabo Sehume Street, Pretoria Central
- Completed in 2015

6 CENTRE FORUM

- Retail
- N/A
- N/A
- Corner Lilian Ngoyi/Johannes Ramakhoase St
- N/A

7 BATHO PELE HOUSE



- Office
- Ten Storeys
- R459m
- Lilian Ngoyi Street, Pretoria Central
- Completed 2016

8 FREEDOM PARK

- Mixed Use
- 52,000m^2
- R1.4bn
- Freedom Park, Salvokop
- 2016

RAILWAYS continues from page 53

Reinforcing development nodes

PARK

Key developments around Park (2010-2017)

All in a 2km radius of station

1 MABONENG PRECINCT

- Mixed Use
- N/A
- N/A
- 278 Fox Street, Johannesburg CBD
- Opened 2009, with ongoing development

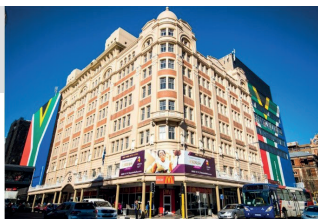
2 NEWTOWN JUNCTION

- Mixed Use
- 85,000m^2
- R1.4bn
- 100 Carr Street, Newtown
- Completed 2014

3 STATION DEVELOPMENTS

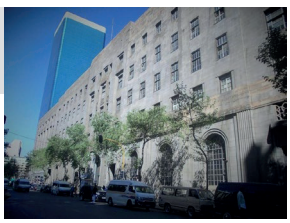
- Commercial
- 60 000m^2
- R1.2bn
- Park Station, Rissik St, Johannesburg
- 2012, with more investment expected

4 STUTTAFORDS HOUSE



- Residential
- 133 Units
- R65m
- 46 Rissik St, Johannesburg CBD
- Renovation Completed in 2012

5 POST OFFICE CONVERSION



- Residential
- 500 Units
- R450m
- Corner of Jeppe and Smal Street
- 2018/19

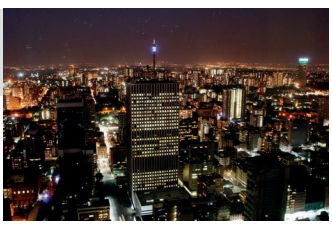
6 JEWEL CITY AND ABSA TOWERS

- Mixed Use
- 2,700 Flats
- R2bn
- Corner of Joe Slovo Drive and Fox Street
- Planned

7 PUBLIC REALM UPGRADES

- Public Realm
- N/A
- N/A
- Polly, Fox, Troye and Main Streets
- Under Construction

8 CARLTON CENTRE REFURB

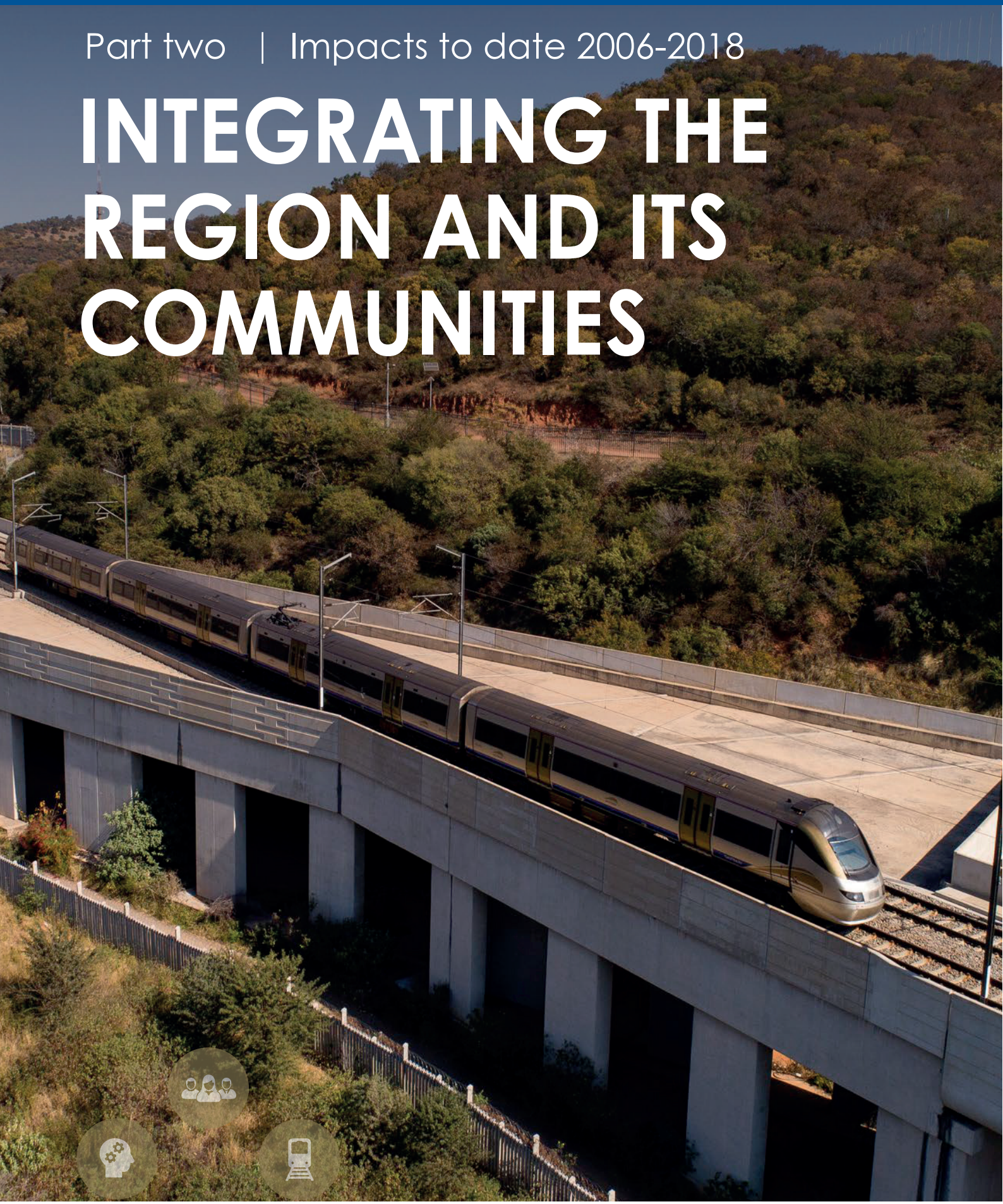


- Office
- 68,000m^2
- N/A
- 150 Commissioner St, Marshalltown
- Planned 2019

RAILWAYS continues from page 81

Part two | Impacts to date 2006-2018

INTEGRATING THE REGION AND ITS COMMUNITIES



INTEGRATING THE REGION AND ITS COMMUNITIES

Gautrain is supporting the economic integration of the Gauteng City Region and represents a key step in bringing the cities of Johannesburg, Tshwane and Ekurhuleni closer together.

LARGE CITIES AND INTEGRATED CITY REGIONS HAVE...

BROADER CATCHMENT AREAS FOR MARKETS AND TALENT
which helps attract and grow businesses

BROADER AND DEEPER POOLS OF LABOUR
which helps businesses find and recruit talent

More scope for
INTEGRATED SUPPLY CHAINS, CLUSTERING AND INNOVATION

HIGHER WAGES PER CAPITA
than smaller and less densely populated cities

MORE COMPETITIVE MARKETS
leading to greater efficiency and innovation

BIGGER AND DEEPER POPULATIONS
which justify investment in hard and soft infrastructure

Research from the Federal Reserve Bank of New York also demonstrates that there is a direct and positive relationship between the density of human capital and productivity.

SECTOR	PRODUCTIVITY INCREASE IF LABOUR POOL DOUBLES
Real Estate, Rental and Leasing	**16.8%**
Professional, Scientific and Technical	**15.5%**
Management of Companies	**14.5%**
Arts, Entertainment and Recreation	**14%**
Information and Cultural Industries	**13%**
Finance and Insurance	**11.5%**
Wholesale and Retail Trade	**10.5%**

RAILWAYS continues from page 83

INTEGRATING THE REGION AND ITS COMMUNITIES

Gautrain is making a significant contribution to creating a larger and more economically powerful Gauteng region.

Why do people use Gautrain to cross city boundaries?

Shifting from car to Gautrain typically saves

43 minutes

between Pretoria Station (Tshwane) and Sandton Station (Johannesburg) at a typical 7am peak

Source: Gautrain Management Agency and Google Maps

Shifting from car to Gautrain typically saves

44 minutes

between Rhodesfield Station (Ekurhuleni) and Sandton Station (Johannesburg) at a typical 7am peak

Source: Gautrain Management Agency and Google Maps

Shifting from car to Gautrain typically saves

31 minutes

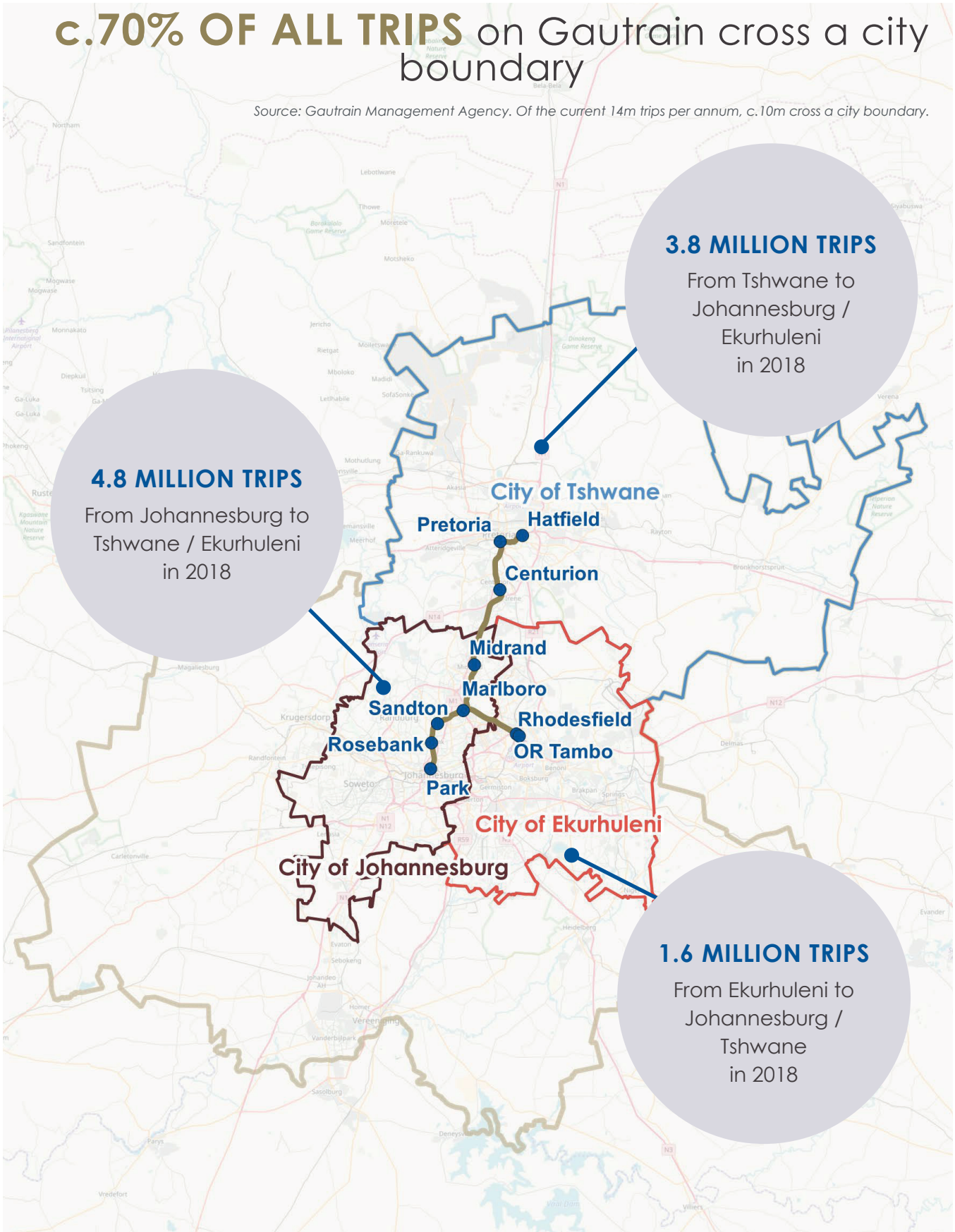
between Pretoria Station (Tshwane) and Rhodesfield Station (Ekurhuleni) at a typical 7am peak

Source: Gautrain Management Agency and Google Maps

> *"Transport has played a role in shaping the Gauteng City Region for most of its history... The Gautrain can be understood as a natural continuation of this... [It connects] the scattered urban centres of Johannesburg, Pretoria and Ekurhuleni into a highly accessible network, the likes of which the region has never seen before".*
>
> Mobility in the Gauteng City Region, Gauteng City Region Observatory, 2014

c.70% OF ALL TRIPS on Gautrain cross a city boundary

Source: Gautrain Management Agency. Of the current 14m trips per annum, c.10m cross a city boundary.



RAILWAYS continues from page 53

Part two | Impacts to date 2006-2018

CHANGING PERCEPTIONS AND ATTRACTING INVESTMENT

CHANGING PERCEPTIONS AND ATTRACTING INVESTMENT

Gauteng is rapidly becoming a globally attractive destination for business, investment and leisure. While there are a range of factors that have influenced this, Gautrain has been an integral part of putting the province on the map. It is a modern, safe, efficient and reliable transit system that visitors and investors expect to see and be able to use.

FOREIGN DIRECT INVESTMENT (FDI)

OVER R44BN of FDI into Gauteng in 2016

Source: Gauteng Province, Socio-Economic Review and Outlook 2018

This was the highest recorded in Gauteng since 2003

Johannesburg was the 2ND HIGHEST RECIPIENT of FDI in Africa between 2013 and 2016

Source: Gauteng Province, Socio-Economic Review and Outlook 2018

A key driver of this was the number of local and multinational companies headquartered in Gauteng

"The two most important factors highlighted by foreign firms in their decision to locate in Johannesburg are the city's advantageous agglomeration size and the world-class infrastructure that links Johannesburg to the rest of the world"

RAILWAYS continues from page 53

CHANGING PERCEPTIONS AND ATTRACTING INVESTMENT

CONFERENCES

OVER 80 CONFERENCE CENTRES in Gauteng

Source: Gauteng Growth and Development Agency Investment Handbook

Five have capacity for over 4,000 people

3 OF THE LARGEST 5 conference centres are within 3km of Gautrain stations

Source: Gauteng Growth and Development Agency Investment Handbook

This makes them easy to get to from the airport and other parts of the city

VISITORS

4.3M VISITORS came to Gauteng in 2016

Source: Gauteng Tourism Authority 2016/17 Annual Report

This was 43% of all visitors to South Africa

45% OF SOUTH AFRICA'S TOURISM REVENUE generated in Gauteng

Source: Gauteng Tourism Authority 2016/17 Annual Report

This demonstrates the strategic and economic importance of the region

> *"Tourism has emerged as the dominant tool for economic growth [in Gauteng], and a good niche exists in business events for developing and transition economies. Business tourism and events are some of the [Gauteng Tourism Authority's] focal points"*

CHANGING PERCEPTIONS AND ATTRACTING INVESTMENT

RADISON BLU GAUTRAIN, SANDTON

Radison Blu Gautrain report that the station opposite the hotel is *"key to the strong trade and high turnover we have"*. Guests appreciate the convenience, reliability and safety that Gautrain offers, which makes the hotel an attractive place to stay. The hotel report that around 62% of guests use Gautrain to get to/from the hotel. 15% of employees also commute to/from work on Gautrain.

SANDTON CONVENTION CENTRE, SANDTON

"Gautrain has been very positive for our business. We host both national and international conferences and are connected to three major hotels in Sandton. Many of our guests fly into O.R. Tambo and catch Gautrain into Sandton which is convenient and easy for them, especially as parking and congestion is so bad in Johannesburg. We also have visitors staying all over Gauteng who use Gautrain to get to us. We estimate at least 50% of all our visitors use Gautrain."

FNB STADIUM, NASREC

Gautrain is helping to change perceptions about Johannesburg for night time events. Over 7,500 people used it to travel to and from the Ed Sheeran concerts in 2019 and over 8,000 used it for the Global Citizen Festival in 2018. People use Gautrain to avoid the road congestion around the stadium during events, as well as the safety it provides traveling during the evening and night. Gautrain is helping to change perceptions about Johannesburg as a venue for night time events.

RAILWAYS continues from page 89

Part two | Impacts to date 2006-2018

KEY PERFORMANCE METRICS

KEY PERFORMANCE METRICS

Gautrain has delivered a significant economic contribution and a strong return on investment.

Annual Gauteng GDP when construction finished was
R1,174bn
Source: StatsSA

Average GDP growth over the last ten years has been:
2.4% per year
Source: StatsSA

ADDING TO ANNUAL GDP

During a *typical year* the construction phase added:
Source: Sereti and Hatch Calculations

R3.33bn
to GDP per annum

→ **0.28% per year**
to GDP of province
Source: Hatch Calculations

A *typical year* post-construction added:

Direct, supply chain and wage spend jobs *Source: Sereti and Hatch Calculations*	**R3.40bn** to GDP per annum	**0.28%** to annual GDP of province
Jobs supported by catalysed developments *Source: GeoTerra and Hatch Calculations*	**R2.74bn** to GDP per annum	**0.23%** to annual GDP of province
Construction jobs associated with new developments *Source: GeoTerra and Hatch Calculations*	**R0.50bn** to GDP per annum	**0.04%** to annual GDP of province
	R6.64bn to GDP per annum, in total	**0.56%** to GDP of province, in total *Source: Hatch Calculations*

RETURN ON INVESTMENT (ROI)

- ✓ Typical construction contribution of R3.33bn per annum
- ✓ Typical operational contribution of R6.64bn per annum
- ✓ 10 year value (undiscounted) = **R99.7bn** vs public sector investment of R26.5bn for construction and R12.5bn for operations over ten years

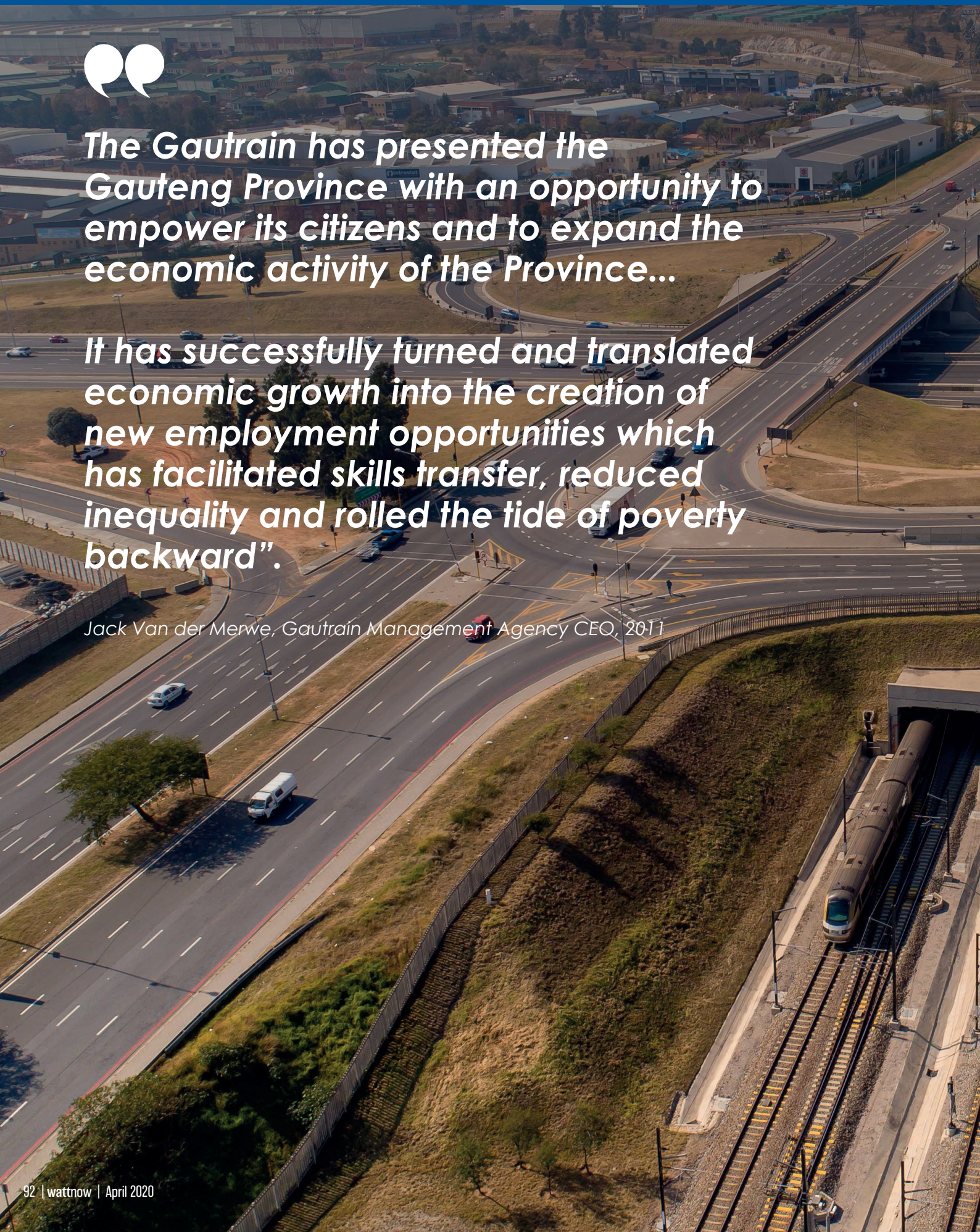
R1 : 2.6
Gautrain ROI
Source: Hatch Calculations

£1 : 3.0
UK Crossrail ROI
Source: UK DfT and Crossrail

AUD$1 : 2.0
Australia Inland Rail ROI
Source: Inland Rail

Note: Analysis excludes economic assessment of travel time savings

RAILWAYS continues from page 91



The Gautrain has presented the Gauteng Province with an opportunity to empower its citizens and to expand the economic activity of the Province...

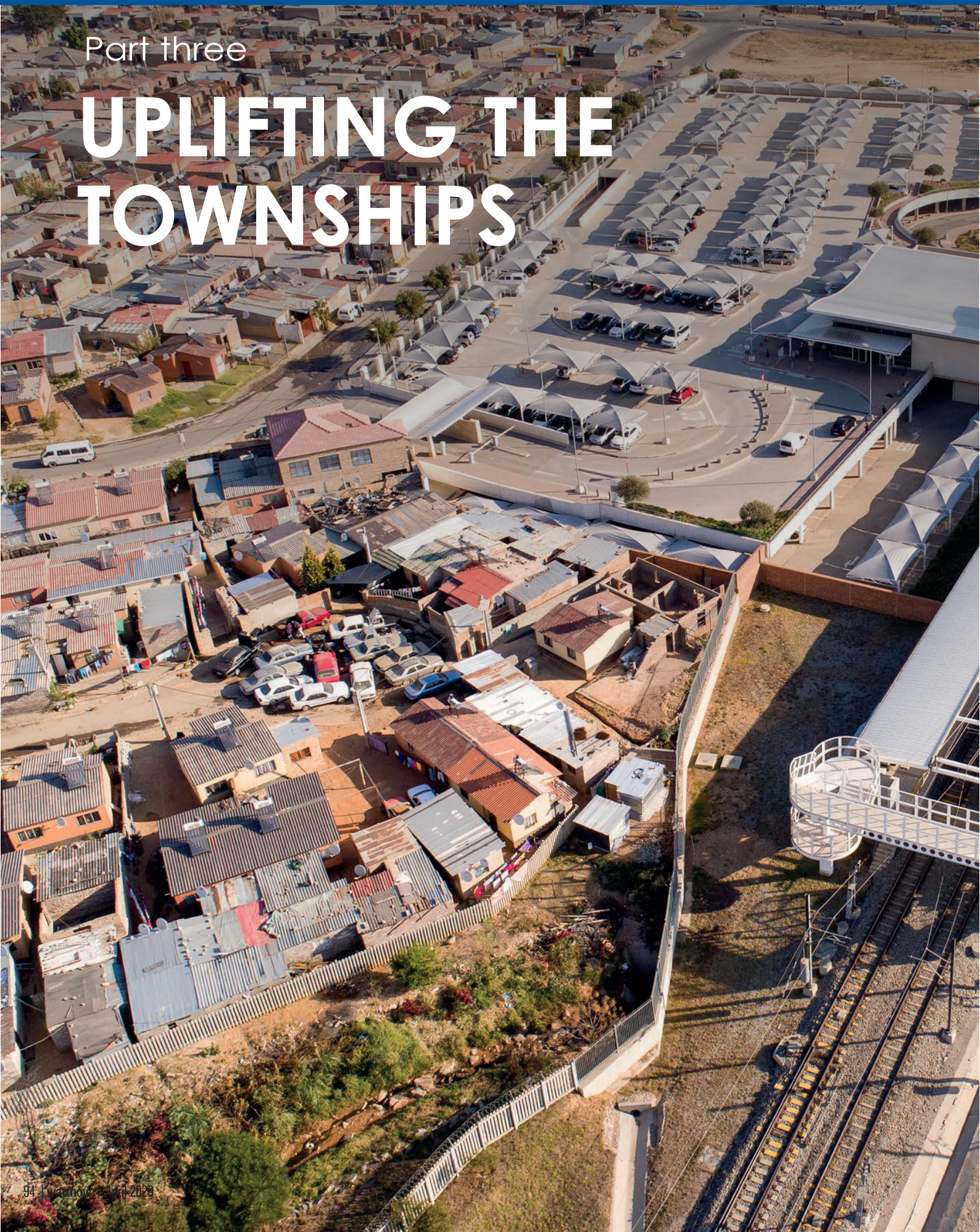
It has successfully turned and translated economic growth into the creation of new employment opportunities which has facilitated skills transfer, reduced inequality and rolled the tide of poverty backward".

Jack Van der Merwe, Gautrain Management Agency CEO, 2011

RAILWAYS continues from page 93

Part three

UPLIFTING THE TOWNSHIPS



UPLIFTING THE TOWNSHIPS

Gautrain makes a direct and indirect economic contribution to township economies via the provision of employment and the stimulation of new commercial developments around stations. The Gautrain Management Agency also spends money with township businesses through its supply chain.

GAUTRAIN PROVIDES SIGNIFICANT BENEFITS TO TOWNSHIP ECONOMIES

→ **Creation of jobs through Gautrain stimulated development close to townships**

Direct and Indirect Construction Jobs

E.g. engineers, labourers, technical specialists, managerial roles etc.

7,600 direct construction jobs taken by people from lower income households

Source: KPMG and Hatch Estimations

Direct and Indirect Operational Jobs

E.g. drivers, managers, cleaners, guards, engineers, ticket operators etc

7,000 direct operational jobs taken by people from lower income households

Source: Bombela Operating Company

**1 job = 1 full year of employment.*

RAILWAYS continues from page 95

Uplifting the townships

BRIDGING ECONOMIES

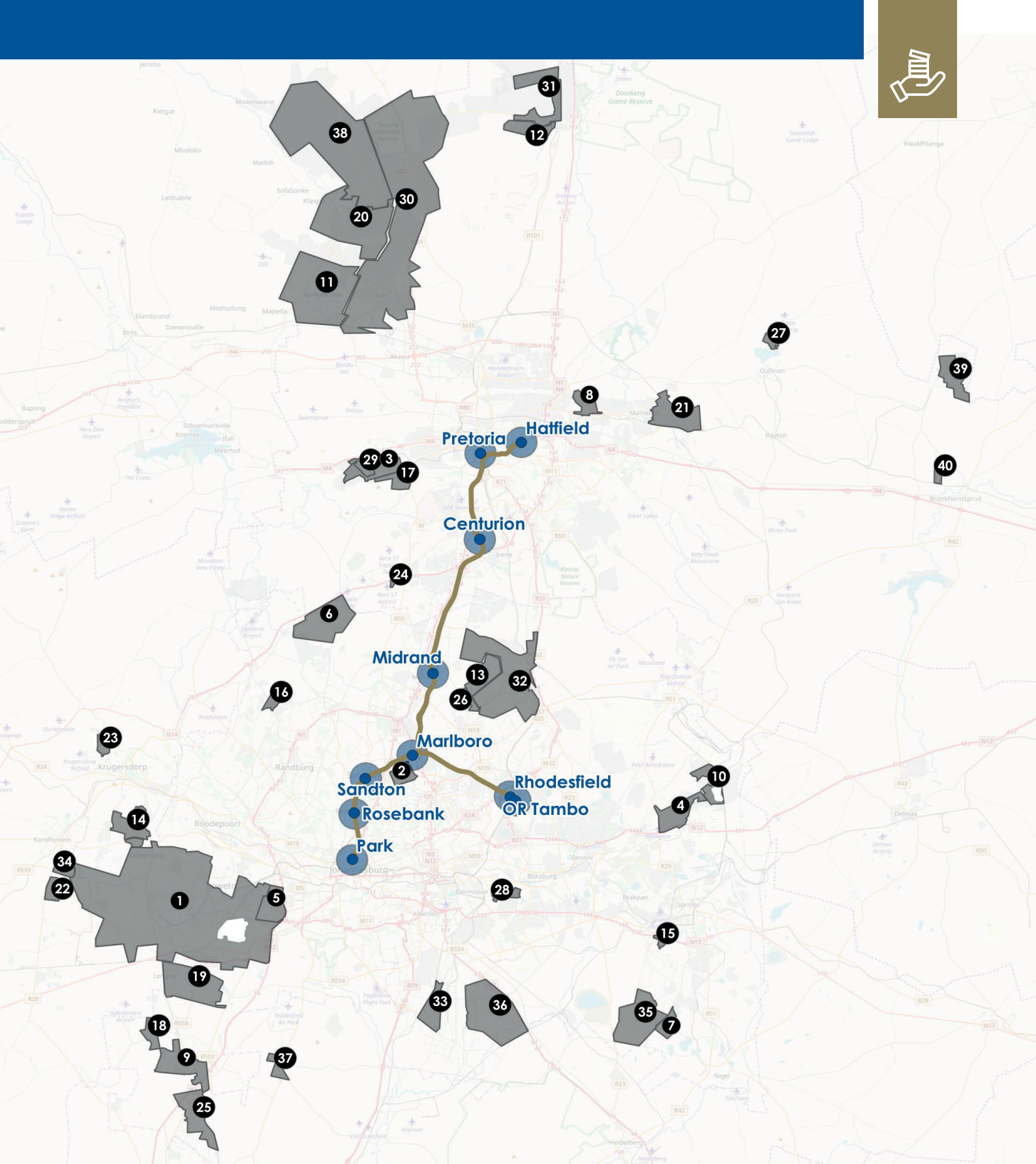
Alexandra

Alexandra is one of Gauteng's most prominent townships.

Sandton is easily accessible to residents of Alexandra due to the recent construction of the Grayston Drive pedestrian and cycle footbridge. Marlboro is also easily accessible. Commercial floorspace around Sandton and Marlboro stations has grown by +506,000m^2 since 2012. This additional space supports 18,400 jobs, a proportion of which will be taken by people from Alexandra.

The increase in footfall has also led to the development of a successful informal economy close to the stations.

Sources: Bombela Operating Company, Geoterra and Homes and Communities Agency



Key: **1** Soweto, **2** Alexandra, **3** Atteridgeville, **4** Daveyton, **5** Diepkloof, **6** Diepsloot, **7** Duduza, **8** Eersterust, **9** Ennerdale, **10** Etwatwa, **11** Ga-Rankuwa, **12** Hammanskraal, **13** Ivory Park, **14** Kagiso, **15** Kwa-Thema, **16** Kya Sand, **17** Laudium, **18** Lawley, **19** Lenasia, **20** Mabopane, **21** Mamelodi, **22** Mohlakeng, **23** Munsieville, **24** Olievenhoutbosch, **25** Orange Farm, **26** Rabie Ridge, **27** Refilwe, **28** Reiger Park, **29** Saulsville, **30** Soshanguve, **31** Temba, **32** Tembisa, **33** Thokoza, **34** Toekomsrus, **35** Tsakane, **36** Vosloorus, **37** Walkerville, **38** Winterveld, **39** Ekangala, **40** Zithobeni

RAILWAYS continues from page 89

Uplifting the townships

BRIDGING ECONOMIES

RADISON BLU GAUTRAIN, SANDTON

Around **50%** of Radison Blu Gautrain's staff live in Alexandra. Employees from Alexandra work in every operational department in the hotel, occupying a range of jobs including waiters, housekeepers, maintenance and kitchen porters. All staff receive detailed training with Radison Blu to help them reach the required skill level to work in the hospitality industry.

SAINT RESTAURANT AND BAR, SANDTON

Saint is a large and popular restaurant and bar within the Marc development. Around **40%** of their staff live in Alexandra, and occupy roles across all areas, including kitchen staff and waiters.

PROOF CAFE, SANDTON

Proof Cafe offers sandwiches, salads and coffee. They are popular with commuters traveling to and from Sandton regularly for work. Just over **33%** of their staff live in Alexandra and they are involved in daily food preparation as well as making and serving coffee.

Credit: Sandton Magazine

Credit: CF Media

DEHN protects AFRICA

DEHNconcept

Concepts and designs for lightning and surge protection systems

Developed concepts for lightning protection systems of complex installations in line with the IEC 62305 standard (SANS 62305) include drawings, mounting details, bills of material, specification texts (tender texts), concept descriptions and material offers. To develop a professional concept, a risk assessment must be conducted. From the risk assessment, a lightning protection level (LPL) is derived, and the applicable protection methods are then used to design a lightning protection system (LPS).

Our services include:

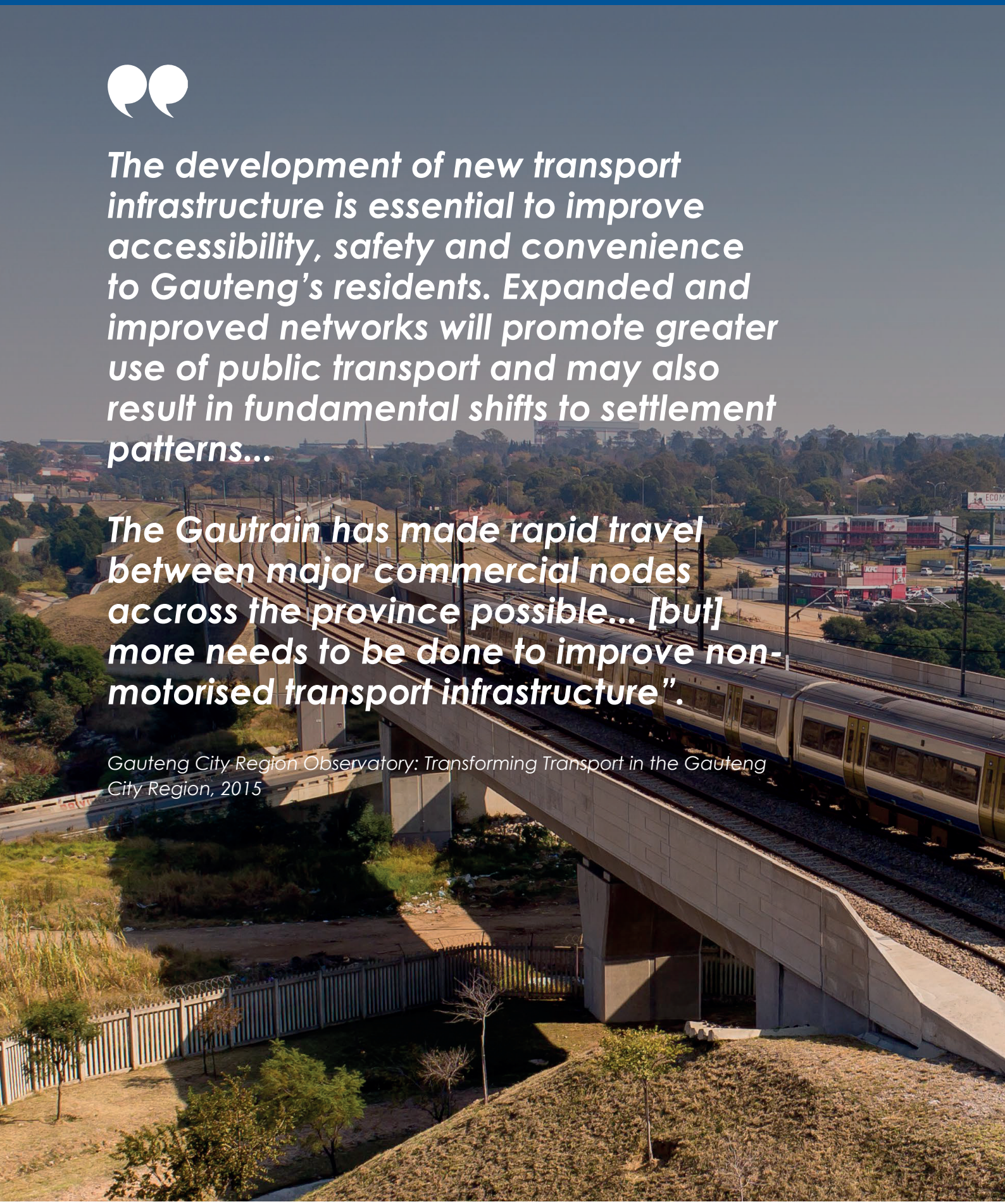
- Soil resistivity and earth resistance surveys
- Risk assessments as per IEC/SANS 62305-2
- Site assessment surveys
- In-depth 3D detailed lightning protection designs, which include detailed mounting drawings and cost-optimised bill of materials
- Basic tender concept designs with estimated Bill of materials
- Earth-termination system designs for lightning protection systems
- Earth-termination system simulations and designs for calculating safe power frequency step and touch potentials
- Calculation of separation distances as per IEC/SANS 62305
- Consulting of specification writing
- Technical engineering support of surge protection devices, external lightning protection and earthing products.

DEHN AFRICA (Pty) Ltd

+27 (0)11 704 1487 I info@ dehn-africa.com

www.dehn-africa.com

RAILWAYS continues from page 99



The development of new transport infrastructure is essential to improve accessibility, safety and convenience to Gauteng's residents. Expanded and improved networks will promote greater use of public transport and may also result in fundamental shifts to settlement patterns...

The Gautrain has made rapid travel between major commercial nodes accross the province possible... [but] more needs to be done to improve non-motorised transport infrastructure".

Gauteng City Region Observatory: Transforming Transport in the Gauteng City Region, 2015

RAILWAYS continues from page 101

Part four

SHAPING GAUTENG'S FUTURE

Shaping Gauteng's future

THE TRANSPORT CHALLENGES

Gautrain has started to shape perceptions and behaviours related to public transport in Gauteng and is encouraging more sustainable land use and development patterns which are centered around transport nodes and infrastructure. However, significant challenges persist:

18.7M PEOPLE

will be living in Gauteng by 2037 if current projected annual growth rates (+1.7%) continue

Source: Gauteng City Region Observatory

More than

TWICE AS MANY CARS ON THE ROAD

Source: Deloitte

Average road speeds could deteriorate from 48km/hr to as low as

10KM/HR BY 2037

Source: Deloitte

Negative economic impacts - traffic congestion cost South Africa

OVER R1BN

IN 2015

Source: Gauteng City Region Observatory

"By continuing with the existing trends and not intervening in the present urban structure and the manner in which land is developed, not changing people's travel patterns and travel choices and not investing in more friendly technologies, Gauteng will increasingly become a far less pleasant and healthy urban area to live in"

Gauteng Integrated Transport Master Plan, 2013

RAILWAYS continues from page 103

Shaping Gauteng's future

GAUTENG'S SUSTAINABLE FUTURE

The Gautrain Management Agency is planning to upgrade the Gautrain network to help deal with future challenges such as population growth and increasing car usage.

A key ambition is to invest an additional **R24.4bn** in improving the existing Gautrain network, though...

Unlocking Development

- New stations at Modderfontein, Samrand and Waterfall
- Commercialisation of Centurion and Marlboro

Improving Line Capacity

- New rolling stock, depot and operator facilities
- Upgrades to system capacity
- Additional new buses
- Y-link to connect northern part of system directly to O.R. Tambo International Airport

Enhancing Station Access

- Parking enhancements at Rosebank, Pretoria and Hatfield

The Gautrain Management Agency is also planning to **extend** the system through the construction of new track and stations. The network will extend further across the province and support better regional integration.

149km of new dual track and **19 new stations** are being proposed. It will involve extensions to all three existing routes and it is expected that over **R110bn** will be spent (at current prices).

Architects Impression

Shaping Gauteng's future

INCLUSIVE EMPLOYMENT FOR ALL

Planned investment into the Gautrain network will deliver additional jobs to support the Gauteng economy. These will be good quality, secure and formal jobs that will help to improve livelihoods and help to reduce poverty across the province.

Construction Phase Impacts

c.R110bn will be spent on the extension and **c.R24.4bn** will be used to improve the existing network

Spend could create up to **175,000** additional direct jobs for South African people

Around **438,000** additional jobs could be supported through supply chain and wage spend

Over **R60bn** of salary would be delivered to support this many workers

c.**R100bn** contribution to GDP over twenty years

Source: Seriti and Hatch Calculations

Operational Phase Impacts

Operation of the new complete network could deliver an additional **68,000** jobs to South African people over twenty years of operation

Around **380,000** additional jobs could be supported through supply chain and wage spend over twenty years

Around **R74bn** of salary would be delivered to support these workers over twenty years

c.**R126bn** contribution to GDP over twenty years

Source: Seriti and Hatch Calculations

**1 job = 1 full year of employment. This is a typical approach for monitoring employment impact in South Africa.*

RAILWAYS continues from page 105

Shaping Gauteng's future

AN EVEN MORE INTEGRATED REGION

Gautrain extensions will create wider and deeper connections between the cities of Johannesburg, Tshwane and Ekurhuleni.

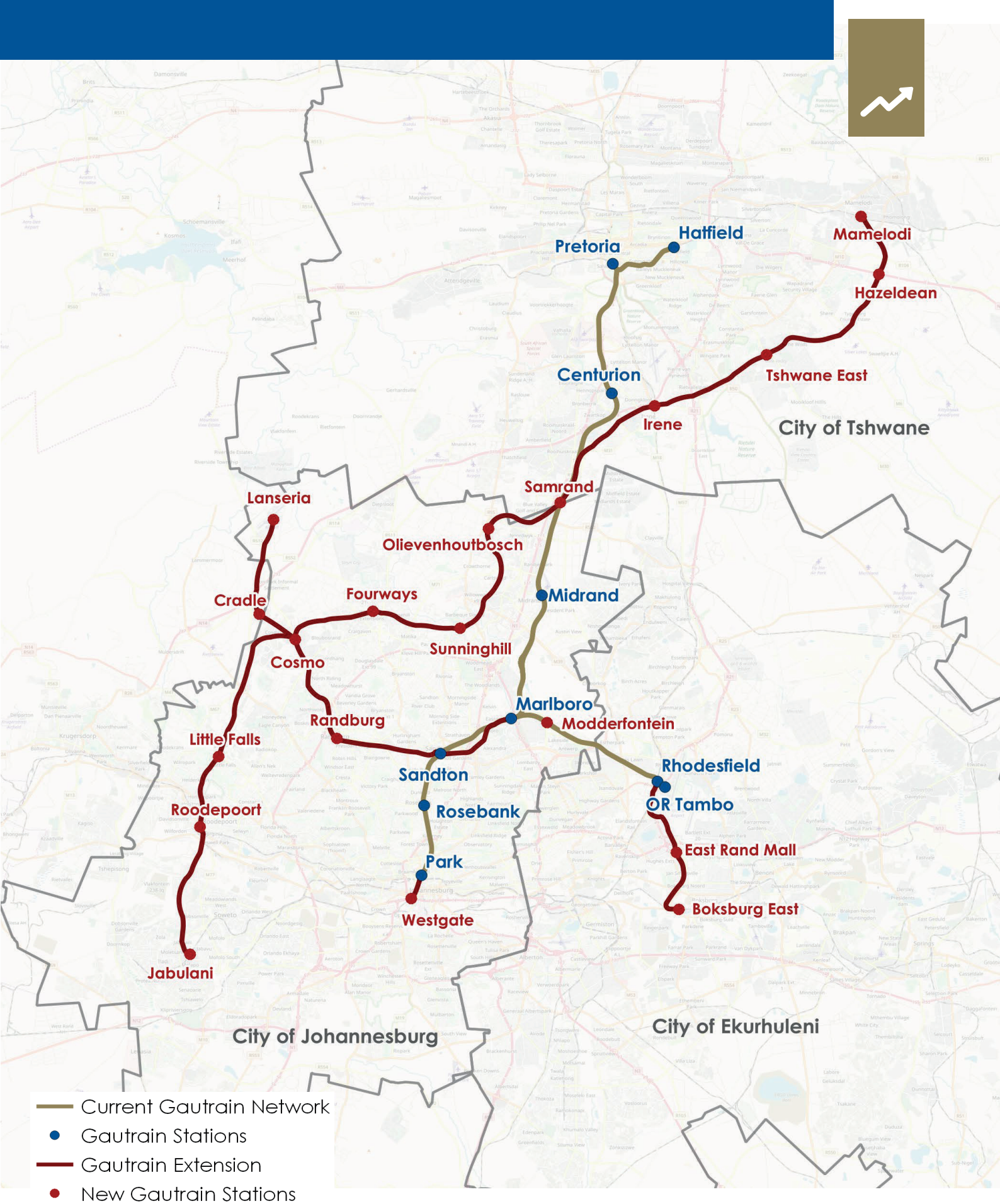
This will allow residents to access more employment, education and training opportunities, while also allowing businesses, training providers and educational insititutions to attract new workers and customers.

With this new infrastructure in place **2.2m** more people will live within 2km of the line, which is 18% of the total population of the cities of Johanesburg, Tshwane and Ekurhuleni.

It will also support economic development, diversification and increased prosperity. This is because well integrated city regions have:

- ✓ More scope for clustering and innovation
- ✓ More competitive markets which lead to greater efficiency and innovation
- ✓ Higher wages per capita
- ✓ Bigger populations which justify and attract investment in hard and soft infrastructure
- ✓ Higher levels of productivity

> *"The extension of rail services would add significantly to area-wide accessibility [in Gauteng] and should be pursued where it is economically and technically feasible..."*
>
> GCRO Mobility in the Gauteng City-Region


Hatfield
Pretoria
Mamelodi
Hazeldean
Centurion
Tshwane East
Irene
City of Tshwane
Samrand
Lanseria
Olievenhoutbosch
Midrand
Cradle
Fourways
Sunninghill
Cosmo
Marlboro
Randburg
Modderfontein
Little Falls
Sandton
Rhodesfield
OR Tambo
Roodepoort
Rosebank
East Rand Mall
Park
Boksburg East
Westgate
Jabulani
City of Johannesburg
City of Ekurhuleni
Current Gautrain Network
Gautrain Stations
Gautrain Extension
New Gautrain Stations
City Boundaries

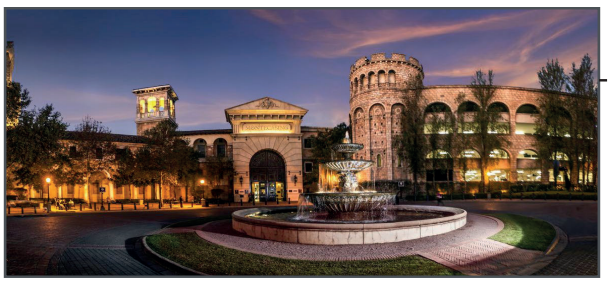
RAILWAYS continues from page 107

Shaping Gauteng's future

AN EVEN MORE INTEGRATED REGION

Gautrain extensions will link up some of the most important attractions, facilities and services across the region and will allow people to access them quickly, efficiently and safely.

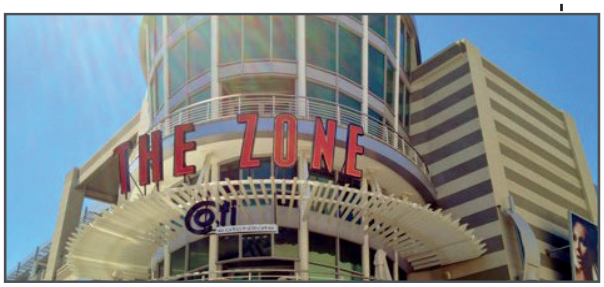
Lanseria Airport



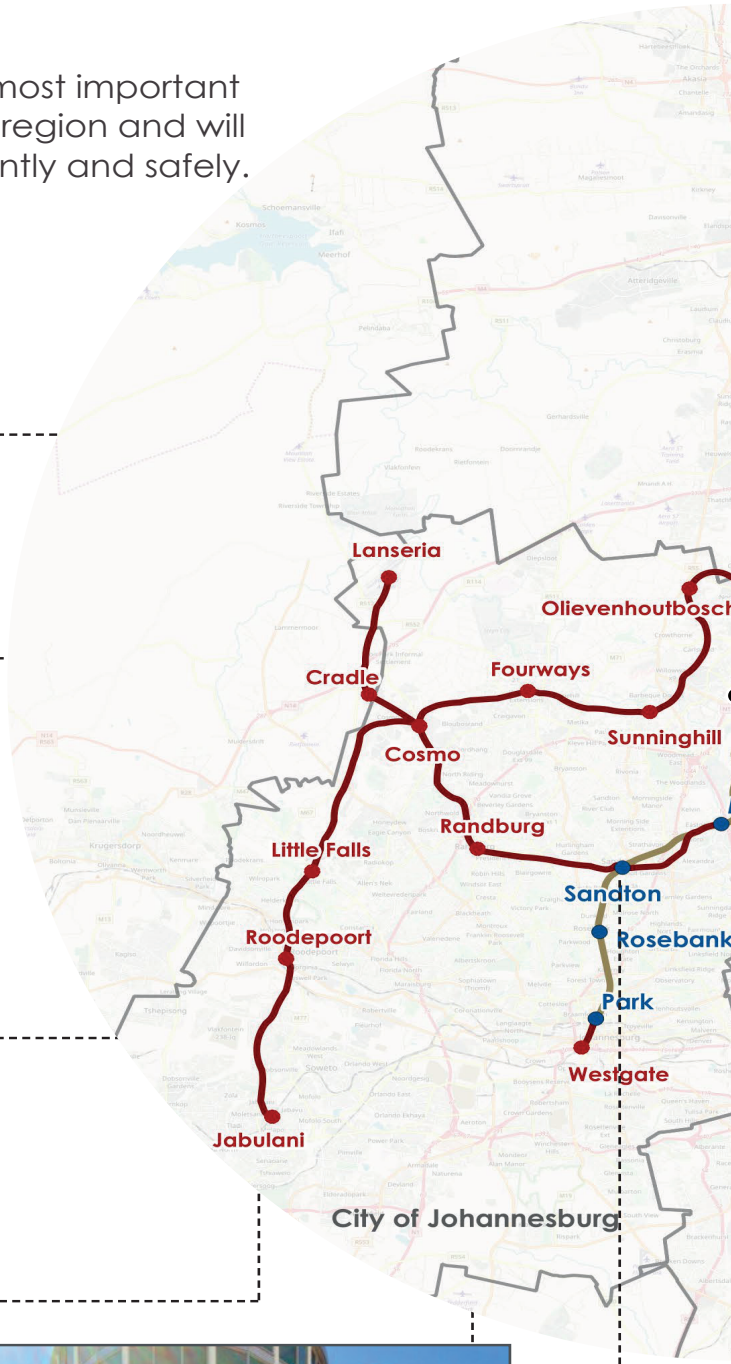
Monte Casino

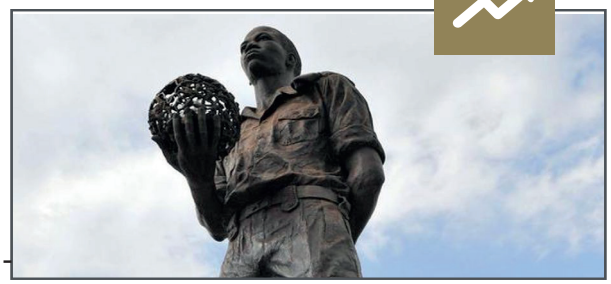
Cradle of Humankind World Heritage Site

Jabulani Mall



Rosebank Mall



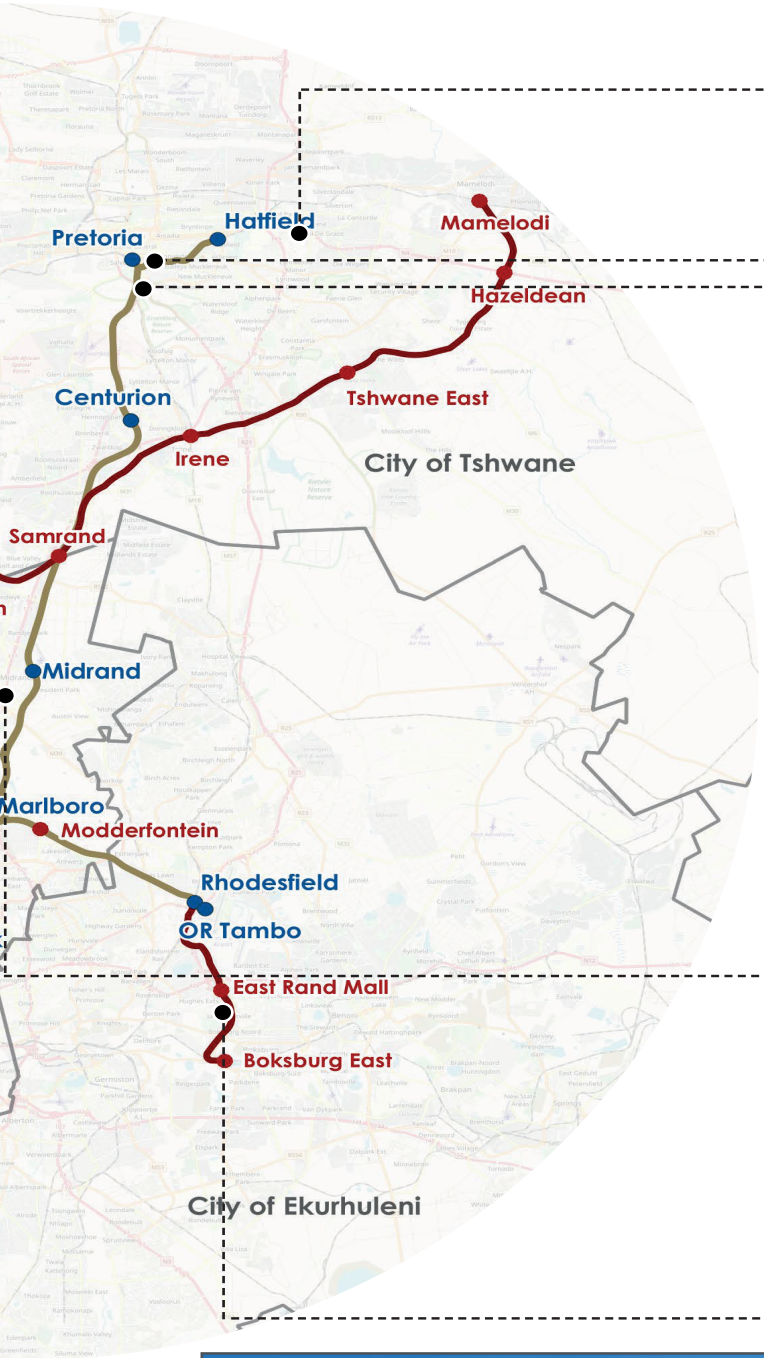


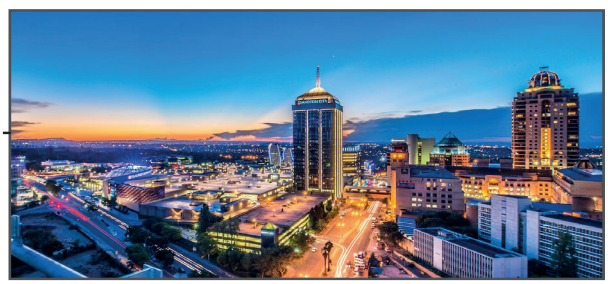
Solomon Mahlangu

Union Buildings

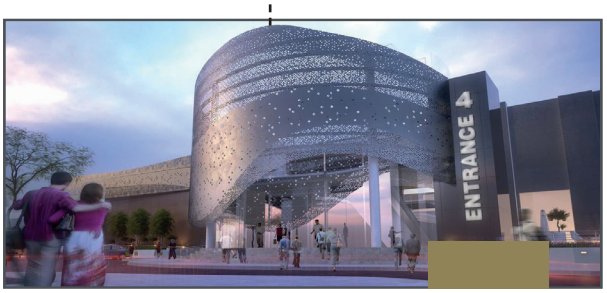
Freedom Park

Mall of Africa





Sandton City Mall



East Rand Mall

Shaping Gauteng's future

TRANSFORMING TOWNSHIPS

The extension of Gautrain will connect several important townships to the centre of Gauteng and the wider region.

Gautrain will eventually link an additional **2m** township residents to better employment, training and education opportunities in nodes in the centre of the province (e.g. Sandton and Rosebank). Examples include:

- ✓ **1.27m** in Soweto
- ✓ **334,600** in Mamelodi
- ✓ **138,000** in Diepsloot
- ✓ **115,800** in Kagiso
- ✓ **70,800** in Olievenhoutbosch

Source: Census, 2011

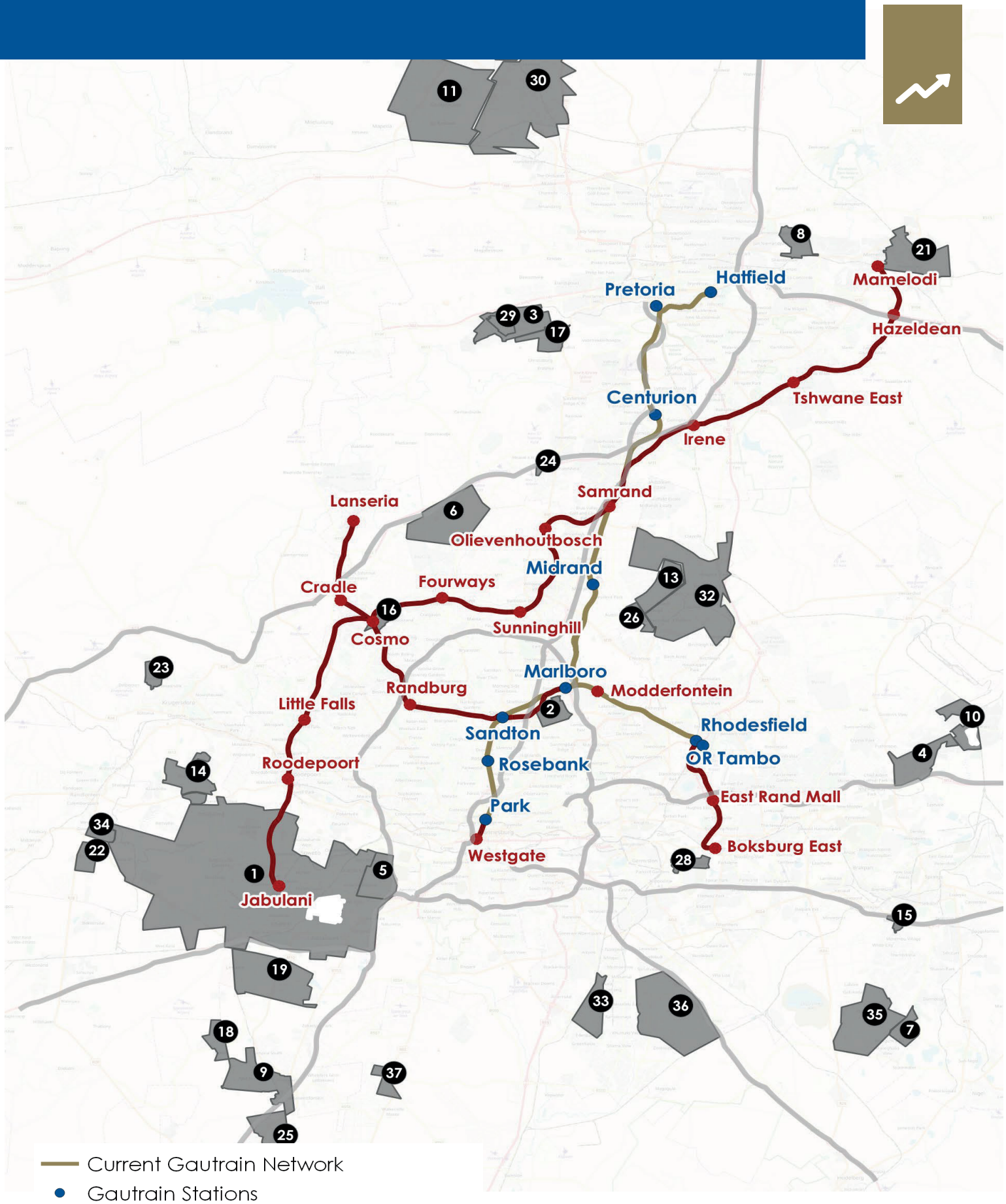
It will also provide township residents with a **safer, faster and more reliable transport option**. Currently over **52%** of people use informal modes of transport or walk as their primary mode of transport in Gauteng.

Commercial and residential development will also be stimulated in and around new stations, which will provide opportunities for job and business growth.

If trends observed at Marlboro station over the last five years are reflected across all of new stations, around **3m m² of new commercial floorspace** could be created in the 2km radius around stations supporting up to **182,000 new jobs** for local people.

Sources: Gauteng City Region Observatory, Geoterra and Homes and Communities Agency

Key: **1** Soweto, **2** Alexandra, **3** Atteridgeville, **4** Daveyton, **5** Diepkloof, **6** Diepsloot, **7** Duduza, **8** Eersterust, **9** Ennerdale, **10** Etwatwa, **11** Ga-Rankuwa, **12** Hammanskraal, **13** Ivory Park, **14** Kagiso, **15** Kwa-Thema, **16** Kya Sand, **17** Laudium, **18** Lawley, **19** Lenasia, **20** Mabopane, **21** Mamelodi, **22** Mohlakeng, **23** Munsieville, **24** Olievenhoutbosch, **25** Orange Farm, **26** Rabie Ridge, **27** Refilwe, **28** Reiger Park, **29** Saulsville, **30** Soshanguve, **31** Temba, **32** Tembisa, **33** Thokoza, **34** Toekomsrus, **35** Tsakane, **36** Vosloorus, **37** Walkerville, **38** Winterveld, **39** Ekangala, **40** Zithobeni


Pretoria
Hatfield
Mamelodi
Hazeldean
Centurion
Tshwane East
Irene
Samrand
Lanseria
Olievenhoutbosch
Midrand
Cradle
Fourways
Sunninghill
Cosmo
Randburg
Marlboro
Modderfontein
Little Falls
Sandton
Rhodesfield
OR Tambo
Roodepoort
Rosebank
East Rand Mall
Park
Westgate
Boksburg East
Jabulani
Current Gautrain Network
Gautrain Stations
Gautrain Extension (delivered in phases)
New Gautrain Stations
Townships
Highways (N & M roads)

RAILWAYS continues from page 111

Shaping Gauteng's future

AN INTEGRATED TRANSPORT NETWORK

Investment in Gautrain will help to create a better-integrated transport network by linking together the BRT, new bus networks and existing bus and rail systems. Gautrain will become the lynchpin that augments and ultimately enhances these services.

Evidence demonstrates that integrated, multi-modal transport systems have a number of benefits, including:

- ✓ Increased patronage from modal shift
- ✓ More reliable and faster journeys
- ✓ Increased revenue and reduced administrative costs
- ✓ Increased passenger satisfaction
- ✓ Greater economic benefits

Source: Booz&Co, 2011

Gauteng's public transport network at 2037 will embrace:

- ✓ A 28 station Gautrain system
- ✓ A more extensive feeder bus system
- ✓ Links with MetroRail at eight of these stations
- ✓ Integration with BRT across the region
- ✓ A world class public transport system that residents are proud of


Pretoria
Hatfield
Centurion
Midrand
Marlboro
Sandton
Rosebank
Rhodesfield
OR Tambo
Park
Gautrain network
Gautrain stations
MetroRail
Major highways

RAILWAYS continues from page 113

KEY PERFORMANCE METRICS

Further investment in Gautrain will continue to drive economic growth in Gauteng.

Current annual GDP in Gauteng is around:
R1,507bn
Source: StatsSA

Average GDP growth over the last ten years has been:
2.4% per year
Source: StatsSA

ADDING TO ANNUAL GDP

During a *typical future year* the construction phase is expected to add:
Source: Sereti and Hatch Calculations

R5.01bn
to GDP per annum → **0.33% per year**
to GDP of province
Source: Hatch Calculations

A *typical future year* post-construction is expected to add:

Direct, supply chain and wage spend jobs *Source: Sereti and Hatch Calculations*	**R6.29bn** to GDP per annum	**Around 0.42%** to annual GDP of province
Employment supported within catalysed developments *Source: GeoTerra and Hatch Calculations*	**R5.20bn** to GDP per annum	**Around 0.35%** to annual GDP of province
Construction jobs associated with new developments *Source: GeoTerra and Hatch Calculations*	**R0.95bn** to GDP per annum	**Around 0.06%** to annual GDP of province
	R12.44bn to GDP per annum, in total	**0.83%** to GDP of province, in total *Source: Hatch Calculations*

Future year estimations are based on scaling up existing impacts. It is likely that the intensity of impacts at/around each station will grow and the subsequent impact numbers will be greater than set out here.

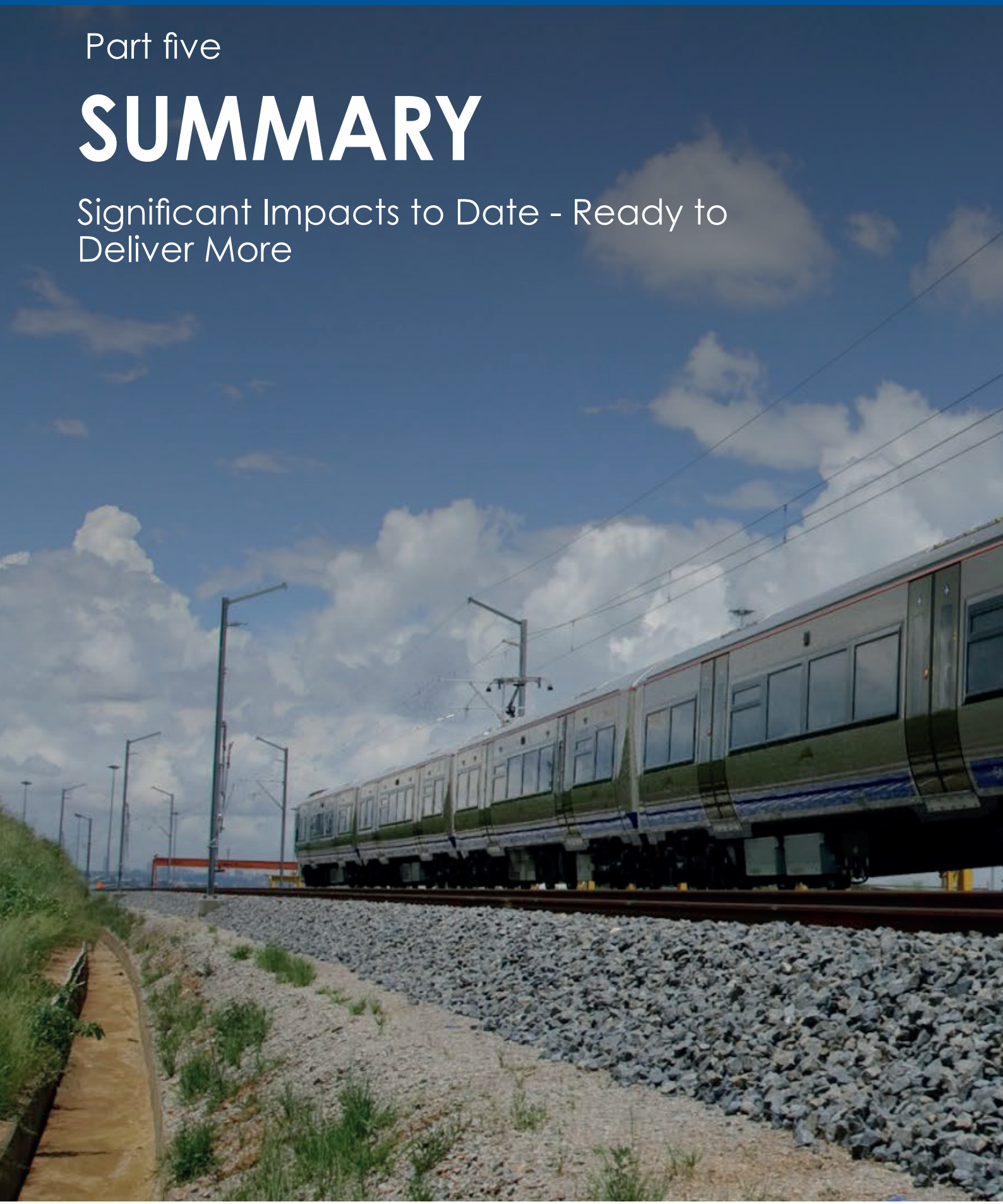
Note: Analysis excludes economic assessment of travel time savings

RAILWAYS continues from page 115

Part five

SUMMARY

Significant Impacts to Date - Ready to Deliver More



RAILWAYS continues from page 117

Summary

GAUTENG FACES PROFOUND ECONOMIC AND SOCIAL CHALLENGES

Severe congestion in Gauteng is damaging the economy and environment

- The number of cars on the road will more than double by 2037 without action
- Average **road speeds could deteriorate from 48km/hr to 10km/hr** by 2037
- Since 2006 the concentration of PM10 in Gauteng's atmosphere has increased by c.20%

Gauteng has extremely high rates of poverty and inequality

- Gauteng's **unemployment rate is high at 29%,** which is above the South African rate of 27%
- Employment in the formal sector declined from 85% in 1997 to around 77% today
- Unemployment is highest among women and young people

Gauteng urgently needs more sustainable patterns of land use development

- Around the world, city regions are prioritising transit related development around public transport nodes
- Gauteng needs to be part of this process - without transit related development **land use patterns will damage the environment, absorb much needed public investment and miss out on the benefits of agglomeration**

Gauteng must compete better on the international stage

- Johannesburg **is ranked 42nd out of 44 cities on the Global Power City Index (2018)** - this ranking is too low
- Gauteng needs to invest in infrastructure to better compete on the global stage

Gautrain has responded to these challenges and delivered an impressive range of socio-economic benefits...

Summary

GAUTRAIN HAS ALREADY DELIVERED SIGNIFICANT ECONOMIC AND SOCIAL BENEFITS

Gautrain has directly delivered employment and is helping to reduce poverty and inequality

- Provided **35,000 direct jobs during construction** and c.87,300 were supported via supply chain and wage spend
- Over **10,900 direct jobs operational jobs** have been created to date and c.61,000 have been supported through supply chain and wage spend
- Around **7,600 direct construction jobs** and **7,000 direct operational jobs** held by **lower income residents**
- A significant number of operational jobs are held by women (3,000), young people (5,800) and HDIs (10,100)

Gautrain has fundamentally improved perceptions of public transport

- Over **98m** trips have been made on Gautrain since 2010
- **87%** of Gauteng residents think it is a good idea
- Each person who has taken a trip on Gautrain instead of a car has delivered **R74 in economic value**

Gautrain is helping to make the city region far more integrated

- Around **70% of trips on Gautrain cross a city boundary**
- Shifting from car to Gautrain saves a significant amount of time traveling between cities (e.g. 43 minutes saved between Pretoria and Sandton at 7am peak)

Gautrain has begun to shape far more efficient land use patterns

- **Commercial floorspace has increased by over 1.6m m²** around stations since 2010 which provides space to support **66,000 jobs**
- Median sales values per m² have increased for office (45%) and retail (32%) space around stations
- Residential floorspace has grown by over 138,000 m² around stations

New patterns of development are benefiting township residents

- Over **50% of the workforce** at Raddison Blu live in Alexandra
- It is estimated that around **30-40%** of the 150 staff at Saint Restaurant are from Alexandra
- There are many more examples of this

Gautrain is improving the image of Gauteng and is helping to attract investment

- Over **R44bn FDI** into the region in 2016, which is the highest recorded amount since 2003
- Around **4.3m visitors** came to Gauteng in 2016 which was 43% of all visitors to the country
- Gautrain is driving these numbers - around 50% of visitors to Sandton Convention Centre use Gautrain

Gautrain has made a significant contribution to Gauteng's economy

- During a typical year the construction phase added **R3.33bn** to GDP, which added **0.28%** to Gauteng's annual GDP
- During a typical year the operation of Gautrain adds **R6.64bn** to GDP, which adds around **0.56%** to Gauteng's annual GDP
- For every Rand spent on Gautrain's original construction, around **R2.6** of economic benefit has been delivered to Gauteng over ten years

RAILWAYS continues from page 89

Summary

IN THE FUTURE GAUTRAIN WILL HAVE A TRANSFORMATIVE IMPACT

Future Gautrain investments will create thousands of new jobs

- c.**175,000 new direct construction jobs** will be created and c.438,000 should be supported through wider spend if all future investments are made
- c.**68,000 new direct operational jobs** will be created over twenty years and c.380,000 should be supported through wider spend when all investments are made
- If future impacts reflect current operations, around 21,000 operational jobs will be held by township residents over ten years

Future Gautrain investments will help to transform township economies

- Over **2m township residents** will be linked to better employment, training and education opportunities to nodes in the centre of the province (e.g. Sandton and Rosebank)
- Currently over 52% of people use informal modes of transport or walking as their primary mode of transport in Gauteng - linking them into Gautrain will provide them with a safer, faster and more reliable option

Future Gautrain investments will build a truly integrated city region

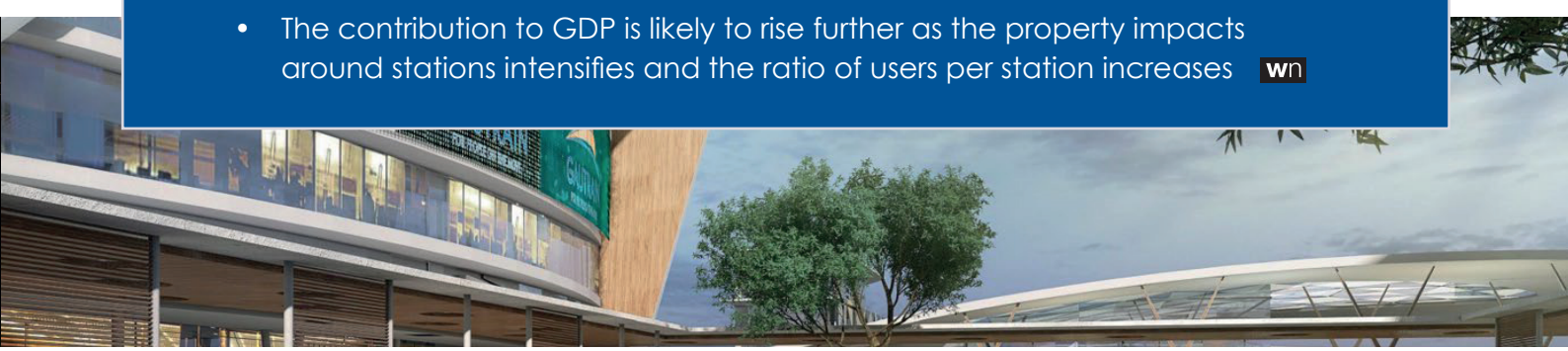
- With new infrastructure in place **2.2m more people will live within 2km of the line**, which is **18% of the total population** of the cities of Johannesburg, Tshwane and Ekurhuleni
- The new Gautrain infrastructure will allow residents to access more employment, education and training opportunities, while also allowing businesses, training providers and educational institutions to attract new workers and customers

Future Gautrain investments will anchor a fundamentally better public transport network by 2037

- Gauteng's transport networks will become more integrated and accessible which should increase patronage, reduce journey times and deliver economic benefits
- It is proposed that the Gautrain network will expand by **149km** and **19 new stations**
- The expanded Gautrain network will link extensively with MetroRail and BRT across the province

Future investment will continue to drive the Gauteng economy

- During a typical year it is expected that the future construction phase will add **R5.01n** to GDP, which will add **0.33%** to Gauteng's annual GDP
- During a typical year it is expected that future operations will add **R12.44bn** to GDP, which will add c.**0.83%** to Gauteng's annual GDP
- The contribution to GDP is likely to rise further as the property impacts around stations intensifies and the ratio of users per station increases wn



The Brunels - 250 Years

Sir Marc Isambard Brunel (1769-1849) and his son Isambard Kingdom Brunel (1806-1859) stand as giants in the annals of engineering. This was a time before engineering became split into several different fields of specialisation.

BY DUDLEY BASSON

Isambard Kingdom Brunel (1806-1859)

Sir Marc Isambard Brunel was born in Hacqueville, Normandy, to Jean Charles Brunel and Marie Victoire Lefebvre. He showed proficiency in draughtsmanship, mathematics and music at an early age. A family friend tutored him in naval matters which led to his becoming a naval cadet on a French frigate, and during his service visited the West Indies several times. He made an octant for himself from brass and ivory which he used while at sea.

In January 1792 Brunel's frigate paid off its crew, and Brunel returned to live with his relatives in Rouen. He was a Royalist sympathiser, as were most of the inhabitants of Normandy, and it soon became evident that he would have to leave France. During his stay in Rouen, Brunel had met Sophia Kingdom, a young English woman who was working as a governess. He was forced to leave her behind when he fled to New York. Sophia was the daughter of William Kingdom, a Plymouth naval contractor.

Brunel got involved in a scheme to link the Hudson River by canal with Lake Champlain and also submitted a design for the new Capitol Building to be built in Washington. The judges were very impressed with the design, but it was not selected.

In 1796, after taking American citizenship, Brunel was appointed Chief Engineer of the city of New York. He designed various houses, docks, commercial buildings, an arsenal, and a cannon factory.

In 1798, during a dinner conversation, Brunel learnt of the difficulties that the Royal Navy had in obtaining the 100 000 pulley blocks that it needed each year, which were made by hand. Brunel quickly produced an outline design of a set of machines that would automate their production. He decided to sail to England and put his invention before the Admiralty. He left for England on 7 February 1799 with a letter of introduction to the Navy Minister.

While Brunel was in the United States, Sophia Kingdom had remained in

Sir Marc Isambard Brunel (1769-1849)

Rouen, and during the Reign of Terror, she was arrested as an English spy and daily expected to be executed. She was only saved by the fall of Robespierre in June 1794. In April 1795 she was able to leave France and travel to London.

When Brunel arrived from the United States, he immediately travelled to London and made contact with Sophia. They were married on 1 November 1799. In 1802 she gave birth to their first child, a daughter, Sophie; in 1804 their second daughter Emma; and in 1806 their son Isambard Kingdom.

From an early age Isambard demonstrated his talent for draughtsmanship and mathematics, mastering the elements of Euclid at the age of six. He was educated in England and France, passing through the Lycée Henri IV in Paris and being apprenticed to the great English engineer Henry Maudslay and the French horologist, Abraham Louis Breguet.

In 1799 Marc Brunel contacted Maudslay who was able to make the pulley block manufacturing machines, which were installed at the Portsmouth Block Mills, and which could be operated by unskilled workers producing blocks at ten times the previous rate. By 1808 the plant was producing 130 000 blocks per year.

Brunel was a talented mechanical engineer doing much to developing sawmill machinery. He also developed machinery for mass-producing soldiers' boots but this enterprise failed due to the end of the Napoleonic wars.

Marc Brunel was made a Fellow of the Royal Society in 1814 and in 1828, he was elected a foreign member of the Royal Swedish Academy of Sciences. He was also elected a Foreign Honorary Member of the American Academy of Arts and Sciences in 1834. In 1845 he was elected an Honorary Fellow of the Royal Society of Edinburgh.

Due to several unprofitable projects, Brunel became deeply in debt, and in 1821 was incarcerated at the Southwark debtors prison. Sophia accompanied him as the prisoners were allowed to have their family with them.

Brunel began to correspond with Alexander I of Russia about the possibility of moving with his family to St Petersburg to work for the Tsar. As soon as it was learnt that Britain was likely to lose such an eminent engineer as Brunel, influential figures, such as the Duke of Wellington, began to press for government intervention. The government granted £5000 to clear Brunel's debts on condition that he abandon any plans to go to Russia, resulting in his release.

In 1805 the Thames Archway Company was formed for driving a tunnel beneath the Thames between Rotherhithe and Limehouse. Richard Trevithick was engaged to construct the tunnel but the work was abandoned when conditions became difficult and dangerous. Brunel designed a tunnelling shield in which 36 miners could work in separate compartments. As the tunnel progressed the shield would be jacked forward and bricklayers would then line the new surface.

Brunel was so confident that he could build the tunnel that at a meeting of the Thames Tunnel Company in February 1824, 2128 shares of £50 each were subscribed for.

Work began in February 1825 by sinking a 50-foot diameter iron drum on which a circular brick tower was built. The weight of the tower forced the drum into the earth while workmen excavated the interior. This vertical shaft was completed in November 1825. The huge tunnelling shield was then assembled at the base of the shaft.

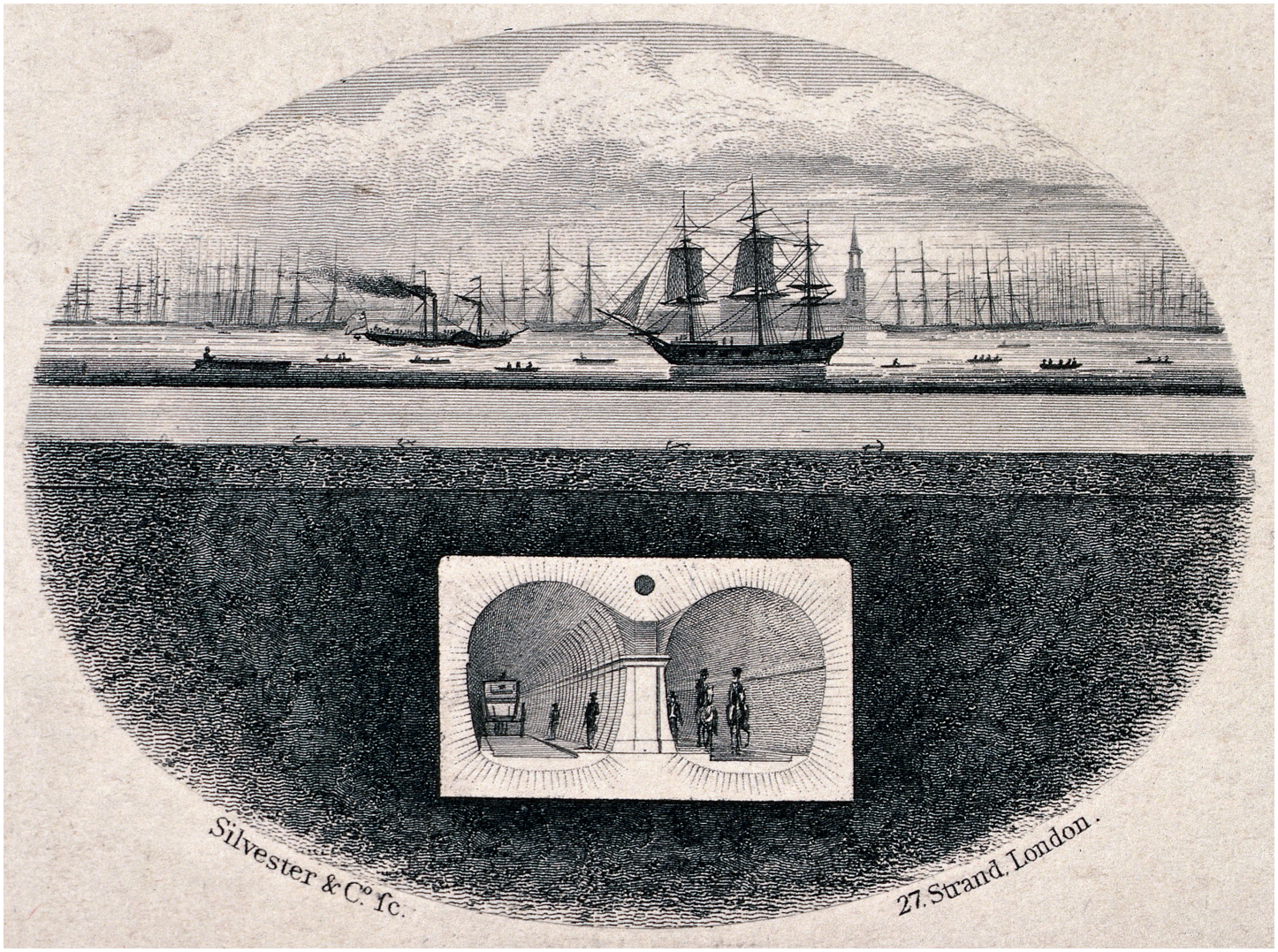
Brunel's son Isambard was by this time 18 years old and assisted with the project. Marc Brunel suffered ill health causing Isambard to bear the full burden of the work. There were several instances of flooding due to the close proximity to the river bed. The leaks from the river had to be sealed with clay by workmen in diving bells. Isambard would himself inspect the river bed in a diving bell. The Brunels had been badly misled by the surveyors who did not notice that the tunnel would pass through treacherous loose shale. Disaster came in May 1827 when the water broke through, flooding the entire excavation.

Isambard was quite capable of enjoying the good things of life, and in November 1827 hosted a sumptuous banquet in the tunnel, to which 200 guests were invited.

In January 1828 the water broke through again nearly claiming the life of the young Isambard. The project was halted in August 1828 due to lack of funds, not to be reopened for seven years. Isambard was so overstrained that he went to Bristol to convalesce.

After his recovery Isambard toured the country taking various contracts.

The most important of these was the hugely ambitious bridge over the river Avon at Clifton. The Avon Gorge was a wild site with towering cliffs at either side. Isambard's brilliant and beautiful



Cross section throug the Brunel tunnel.

solution was a single span suspension bridge, which has since become one of the world's most famous bridges. The contract was only won after hard competition in which he triumphed even over the great but ageing Telford, who produced an unusual gothic design.

Work started on 20 June 1831. Isambard's father was sceptical about the long span and thought that the bridge should have a central pier. Isambard was dogged by bad luck - capital failed due to the Bristol Riots and the work had to be abandoned – the great project only being completed in 1864, five years after his death. Much

Thames tunnel orginally used for pedestrian traffic.

I K Brunel's famous Clifton suspension bridge started in 1851. At this time, plate-chains were used for catenaries. Some of the chains were salvaged from the demolished London Hungerford Bridge over the Thames.

of the wrought iron was repurposed for the construction of the Royal Albert bridge. On 8 December 1864, the bridge was illuminated by magnesium flares for its ceremonial opening parade, but they were unfortunately blown out by the wind. The bridge has an overall length of 1352 feet and span of 702 feet.

In 1834 the government agreed to a loan of £246 000 to the Thames Tunnel Company. The old 80-ton tunnelling shield was removed and replaced by a new improved 140-ton shield consisting of 9 000 parts that had to be assembled underground. Tunnelling was resumed but there were still instances of flooding in which the pumps were overwhelmed. Miners were affected by the constant influx of polluted water, and many fell ill. As the tunnel approached the Wapping shore, work began on sinking a vertical shaft similar to the one at Rotherhithe. This began in 1840 and took thirteen months to complete.

The pollution of the Thames came to a head in July and August of 1858 in a crisis which came to be known as the "Great Stink". This was due to untreated sewage and industrial effluent being dumped into the river. The authorities accepted proposals from civil engineer Sir Joseph Bazalgette for a system of drainage, sewers and pumping stations which remain effective to this day, with a vastly increased population. Punch magazine of 21 July 1858 published a cartoon of Michael Faraday handing his card to Father Thames with the caption: *"… we hope the Dirty Fellow will consult the learned Professor".* (In addition to his phenomenal contributions to electrical science, Faraday was also Fullerian Professor of Chemistry at the Royal Institution).

London's unhealthy "Great Stink" aroused even more public concern than the 1853-1856 Crimean War. Following a plea from Florence Nightingale to the government, Isambard in 1855, designed a prefabricated military hospital for use at Renkioi in the

FARADAY GIVING HIS CARD TO FATHER THAMES;
And we hope the Dirty Fellow will consult the learned Professor.

Crimea. Tennyson's poem – "The Charge of the Light Brigade" refers to a British military blunder in the Crimean War.

On the suggestion of Prince Albert, Queen Victoria offered Tennyson the laureateship which he accepted Victoria said of Tennyson: *"He was a great poet and his ideas were ever grand, noble and elevating"*.

On 24 March 1841 Marc Brunel was knighted by the young Queen Victoria. This was at the suggestion of Prince Albert who had shown a keen interest in the progress of the tunnel. The tunnel opened on the Wapping side of the river on 1 August 1842. On 7 November 1842 Marc Brunel suffered a stroke that paralysed his right side for a time. The Thames Tunnel finally officially opened on 25 March 1843 and Marc Brunel, despite ill health, took part in the opening ceremony. One million people visited the tunnel within 15 weeks of opening. On 26 July 1843 Queen Victoria and Prince Albert visited. Although intended for horse-drawn traffic, the tunnel was initially for pedestrian use only, until roadway access could be provided.

The tunnel was used by the London Underground from 1933 to 2007 and became part of the London Overground railway in 2010, and remains in daily use. The engine house in Rotherhithe was transformed into the Brunel Museum in 2006.

Marc Brunel died at the age of 80 on 12 December 1849.

In 1830 Isambard Kingdom Brunel was elected as a Fellow of the Royal Society.

On 5 July 1836 he married Mary Elizabeth Horsley, daughter of the renowned composer and organist William Horsley. In addition to orchestral works he is well known for the hymn tune 'Horsley' which is used with the Easter words *"There is a green hill far away…"* written by the renowned hymn writer Cecil Frances Alexander.

Mary Horsley and Felix Mendelssohn would play music together at her home.

Isambard took Mendelssohn to see the tunnel workings at Wapping. Following his 1829 visit to England, Mendelssohn wrote many letters to the Horsley family.

In 1830 Isambard was engaged as chief engineer by a committee of London and Bristol businessmen, which had been formed to link the two cities by rail which would become the Great Western Railway. Isambard immediately recognised the great possibilities of this venture, but also insisted that he should have sole responsibility in all matters relating to the surveying and building of the line. Isambard was highly skilled in dealing with politicians, lawyers and investors. His appointment was confirmed in March 1830 and the committee demanded the preliminary survey of the whole line by May. In two months of astonishingly hard work and travelling by stagecoach and on horseback, the deadline was met.

Isambard was determined that the railway would be both fast and comfortable. The route surveyed would keep gradients and curvature to a minimum. The only steep gradient (1:100) would be in the tunnel at the town Box. This level railway became known as Brunel's billiard table. Isambard made extensive recordings of the jolting in trains to strengthen his case for comfortable travel. He approached Charles Babbage of mechanical computer fame to provide a multi-trace chart recorder to record the severe jolting in existing trains. Many rolls of wallpaper were used with the recorder. Prince Albert took a keen interest in Babbage's computers. Babbage obtained his precision computer parts from Sir Joseph Whitworth, who was also renowned for his well-designed BSW screw thread, which had excellent strength and locking properties for steel bolts.

Isambard introduced a broad gauge (7 feet, ¼ inch) railway track. The track gauge in use at the time was 4 feet 8 ½ inches. This had simply been adopted from the carts and tramways used at collieries. It has been claimed that the standard gauge can be traced all the way back to the wheel spacing of the Roman two-horse chariot. The wheel ruts formed in unmade roads provided an incentive for standardising wheel spacing, as non-conforming wheels could easily be damaged by the ruts.

Brunel's broad gauge track was however doomed. It would be necessary to standardise the tracks countrywide and it would have been prohibitively expensive to convert all the standard gauge tracks and rolling stock to broad gauge, and the limited curvature of broad gauge would have been hugely problematic. The broad gauge tracks were later provided with an extra rail to make the tracks available to standard rolling stock and to facilitate the gradual phasing out of the broad gauge rolling stock.

The construction of the GWR required the building of a large number of stations, bridges, cuttings etc. An enormously challenging project was the construction of the Box Tunnel. This was a two-mile tunnel through rock. Several 25-foot diameter shafts were dug from above the tunnel down to track level to provide access to several work-faces, as well as ventilation and removal of spoil. Work was done in appalling conditions using hand tools by candle light. The work required a weekly supply of a ton of candles and a ton of black powder. The blasting was detonated by means of burning fuses and the workmen had to find shelter as best they could.

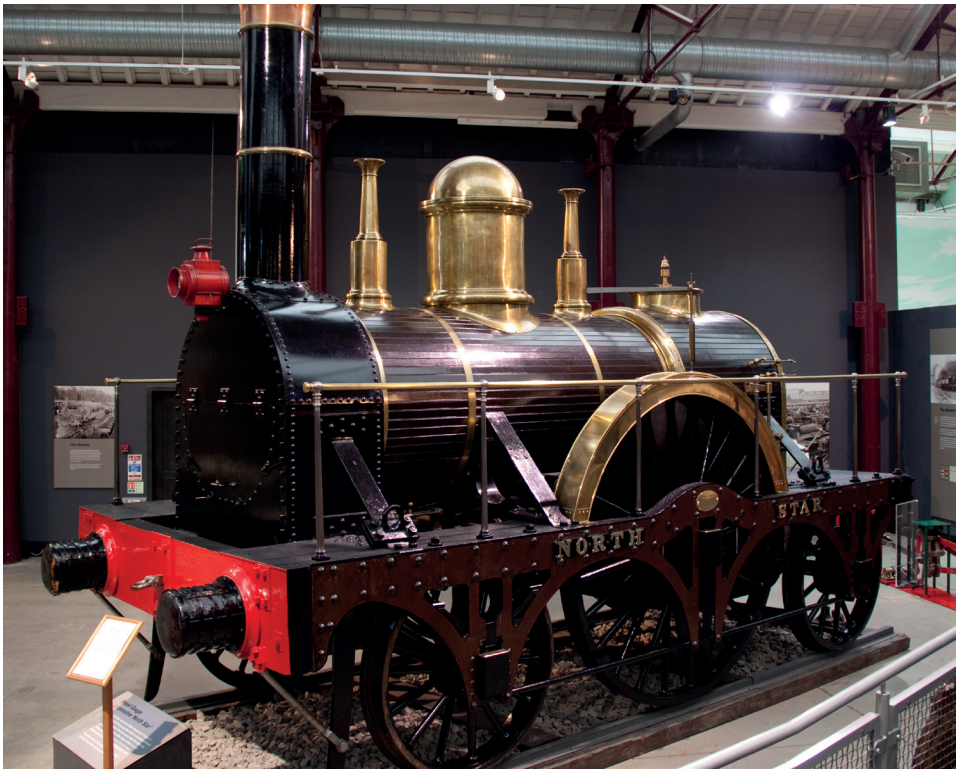
For more info on the Box Tunnel.

Watch a tribute to I K Brunel *"Pushing the Boundaries"* written and narrated by Eileen Colburn (20 min).

Watch: Men of iron steam and fire - 48 minutes (must see).

For a list of the number and variety of locomotives used on the GWR is astonishing.

Nearly 600 broad gauge locos were used on the GWR from 1837 to 1892.



A 2-2-2 locomotive "North Star" with 7-foot driving wheels used from 1837 to 1871. Twelve of these were in operation.

The most popular was an 0-6-0 of which 102 were used from 1852 to 1892.

A recently found letter from 1869 reveals how the Great Western Railway was responsible for the famous English writer Charles Dickens losing his Christmas turkey.

The unfortunate episode took place in Christmas week 1869, when a horsebox with parcels from Hereford caught fire, destroying the contents, near Hanwell railway station in west London. Dickens wrote:
Sir, in reply to your letter I beg to say that I have no doubt my Christmas fare was destroyed by an unavoidable accident, and that I bore the loss with an unbroken good humour towards the Great Western Railway Company. Faithfully Yours, Charles Dickens.

When the GWR from Bristol reached Exeter in 1844, there was a requirement to extend towards Plymouth. Due to the gradients of the terrain, Isambard was keen to try the atmospheric powered train that he had seen when visiting Dalkey in Ireland in 1843. The atmospheric train dispenses with a locomotive and uses a piston affixed to the leading coach which is drawn by a partial vacuum in a pipe between the rails. The pipe has a slit at the top through which the piston is connected to the train and the slit is sealed by a leather flap. Pumping stations were built at three mile intervals to maintain the suction.

By 1847 the atmospheric infrastructure was in place, and a full timetable worked by atmospheric trains was introduced over the 20-mile section between Exeter and Newton Abbot early in 1848. This worked quite well once the winter was over, with trains travelling at speeds of up to 70 mph.

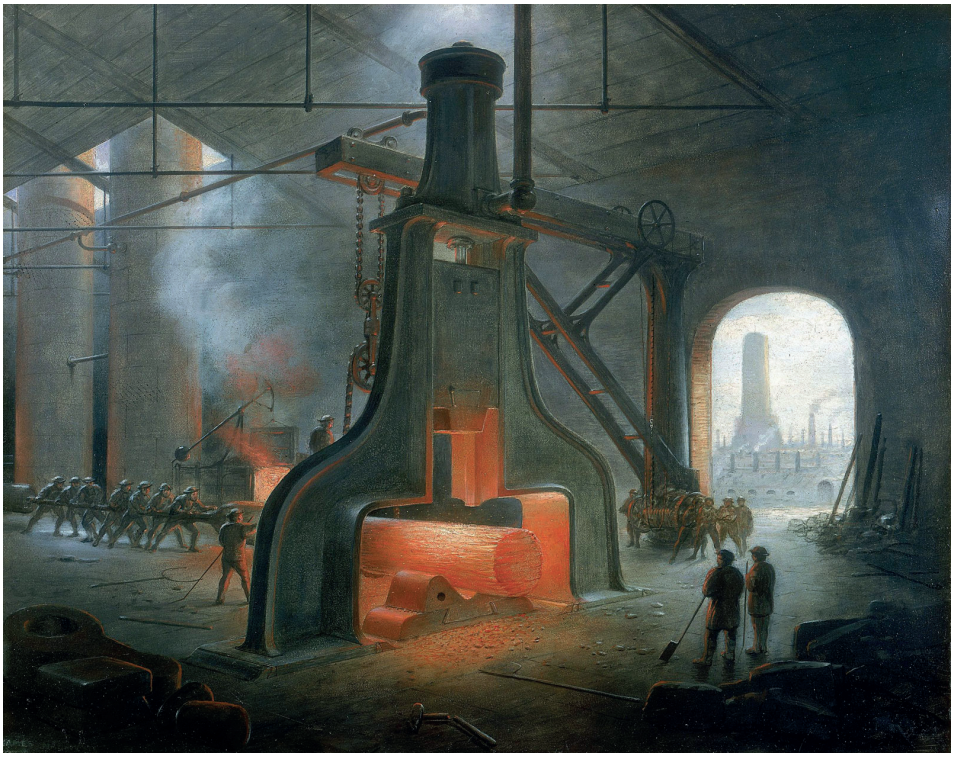
The system, however, experienced recurrent difficulties. By far the worst problem was the leather flap which degraded under working conditions losing its seal and eventually tearing despite attempts at lubrication. By September Brunel recommended that atmospheric power should be abandoned and after less than a year the line reverted to locomotive working.

A similar form of propulsion can be found on modern aircraft carriers for launching aircraft. Instead of a partial vacuum, these use high pressure steam which produces phenomenal acceleration to launch aircraft over a few hundred metres.

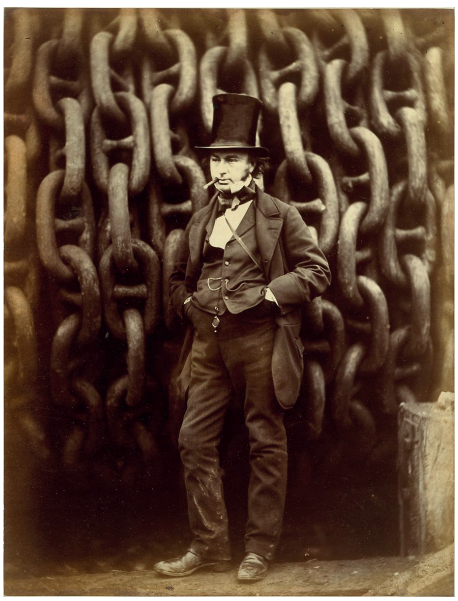
Isambard's vision for the GWR did not end at Bristol. He would extend the railway to Penzance, but he set his sights on continuing the service to New York.

In 1836, Brunel, his friend Thomas Guppy and a group of Bristol investors formed the Great Western Steamship Company to build a line of steamships for the Bristol to New York route. Brunel built three gigantic ships which were each in turn the largest ship that had ever put to sea. The SS Great Western, launched in 1837; the SS Great Britain, launched in 1843 and the SS Great Eastern, launched in 1858.

The huge size of Brunel's ships presented a problem with obtaining drive and paddle shafts of exceptional size. This challenge was met by James Nasmyth (1808-1890) who designed his huge but finely controllable steam hammer. Nasmyth demonstrated the precise control of the hammer by letting it break an egg in a wineglass without breaking the glass. As a schoolboy he built successful model steam engines. He worked for two years at Henry Maudslay's machine shop in London and later built his own foundry and made machine tools of all kinds along with a variety of steam powered machines. In his retirement he became a renowned astronomer. He devised the Nasmyth focal point arrangement which is now used on very large modern telescopes.



Nasmyth's famous steam hammer.



Iconic photo of I K Brunel standing in front of a drum of stud link cable chain used for launching the Great Eastern.

SS Great Western was an iron-strapped, wooden, side-wheel paddle steamer, with four masts to hoist the auxiliary sails. The sails were not just to provide auxiliary propulsion, but were also used in rough seas to keep the ship on an even keel and ensure that both paddle wheels remained in the water, driving the ship in a straight line. The hull was built of oak by traditional methods. Built in Bristol, Great Western was launched on 19 July 1837 and then sailed to London, where she was fitted with two side-lever steam engines from the firm of Maudslay, Sons and Field, producing 750 horsepower between them.

On 31 March 1838 The Great Western sailed for Bristol to start her maiden voyage to New York. Before arriving at Bristol, a fire broke out in the engine

HISTORY continues from page 131

The launch of the Great Britian, 1843.

room. The fire was extinguished but in the confusion Brunel fell 20 feet and was injured. As a result of the accident, 50 passengers cancelled their bookings leaving only 7 to complete their journey. On completing her maiden voyage she arrived at New York with 200 tons of coal to spare.

The Great Western worked the Bristol to New York route for 8 years and after 45 crossings was sold to the Royal Mail Steam Packet Company to be used on the West Indies run. She was scrapped in 1856 after serving as a troop ship during the Crimean War. The Great Western achieved a speed of 8,66 knots. She had a length of 252 feet and a displacement of 1700 tons.

LAUNCHING OF THE GREAT BRITAIN

The SS Great Britain was a revolutionary ship which set the trend for future shipping design.

She was the first iron hulled screw propeller driven vessel which could carry sufficient coal for the Atlantic crossing.

The ship was launched by Prince Albert on 19 July 1843. The launching was actually a 'floating' as the ship had been built in a dry dock. The Prince was taken to Bristol on the Royal Train by the GWR with Brunel driving on the footplate.

The ship had a total length of 322 feet and a displacement of 3400 tons.

She initially had a 6-bladed propeller but a four bladed propeller was later found to work better. A three bladed propeller was also tried. Propeller design was further improved after blades were being lost on the Atlantic crossing. Propellers and turbines cannot be designed intuitively – this requires some serious mathematics and experimentation. In the first issue of the Scientific American magazine of

28 August 1845, an article suggested that the screw propeller be scrapped and paddle wheels fitted.

Click here for a highly detailed account of the construction, operation and history of the SS Great Britain.

Have a guided tour of the SS Great Britain with Isambard Brunel himself forsooth - 7 minutes. *(Please disregard comments on the six bladed propeller efficiency).*

Watch fascinating accounts of life aboard the ship and comments by passengers of their experiences.
http://www.ssgreatbritain.org/story

Watch: SS Great Britain – a fascinating historical account - 13 minutes

In 1852, Great Britain made her first voyage to Melbourne, Australia, carrying 30 emigrants.

She earned a reputation as the most reliable of the emigrant ships to Australia.

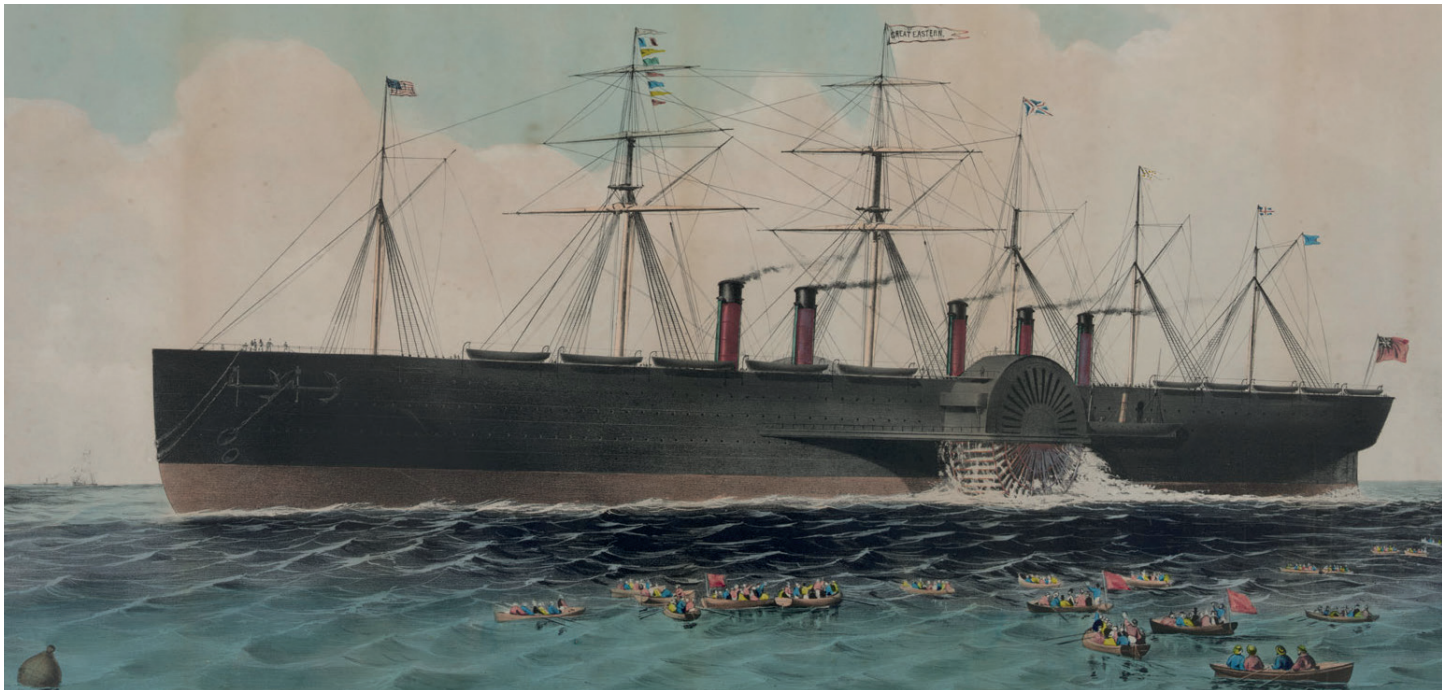
The luxurious meals served to the first class passengers required copious supplies of fresh foodstuffs, but there was no refrigeration readily available at the time. Supplies of milk, eggs and meat were from a Noah's Ark farmyard which would typically contain one dairy cow, 133 sheep, 2 bullocks, 38 pigs, 420 chickens, 300 ducks, 400 geese and 30 turkeys. On the Australia run more animals would be taken on board, including goats.

There were usually several cats on board, resident cats and pets of passengers, which would help to keep the rat population in check.

The Great Britain was fitted with a removable screw propeller which could be removed to reduce drag when conditions were favourable for sail-only propulsion. She was later converted to a sailing vessel.

Once her days of transporting passengers to America and Australia had ended, the Great Britain was used to transport Welsh coal to America. In 1886 on what was to be her final voyage, a fire on board en route to Panama put an end to her sailing days and she was used as a floating coal bunker, and eventually scuttled and abandoned at the Falkland Islands.

HISTORY continues from page 132



The Great Eastern

The story has a happy ending. In the 1970s, a rescue project was arranged, thanks to several large donations. The great ship was placed on pontoons and transported back across the Atlantic one last time, and returned to her birthplace in Bristol's Great Western Dockyard.

The SS Great Britain, after being salvaged and painstakingly restored to her former glory, is now a museum piece in the dry dock in Bristol where she was constructed.

Watch: SS Great Britain Salvage – 51 minutes

The Great Eastern was launched in 1858 into the Thames at Millwall between London and Greenwich. This is across the river from Rotherhithe, not far from the Brunel tunnel. The ship was launched sideways on two slipways due to the ship being too long for the width of the river. Remains of the slipways can still be seen on the river bank.

The Great Eastern was by far the largest vessel that had ever been built. Originally designed as a passenger ship for the Australia route, she had a passenger capacity of 4000 and crew of 418. The ship was however only used on the transatlantic route.

Other vital statistics are:
Length 692 feet; Beam 82 feet; Keel to deck height 58 feet; Displacement 32 160 tons; Speed 14 knots; Engine power 8000 horsepower.

Propulsion was by means of side paddle wheels, screw propeller and sails.

The gigantic paddles were driven by four steam engines and the propeller driven by a fifth steam engine. Seven masts were provided for the sails – these were named after the days of the week.

The ship was laid down on 1 May 1854, launched on 31 January 1858 and completed in 1859.

Her maiden voyage began on 30 August 1859.

The ship builder was J. Scott Russel & co., Millwall.

The ship was designed with a double hull and transverse bulkheads at 60 feet intervals and two longitudinal bulkheads spaced 36 feet apart and running the full 350 feet of the two engine rooms, greatly improving the safety of the ship. Thick plates were attached to the underside of the hull to enable the ship to be beached as there was no dry-dock able to accept the ship. All of the surfaces between the hulls were painted to reduce corrosion – one can only wonder how this could have been done in the confined space. The ship has a very complex 30-year history and was scrapped in 1889.

Watch: video describing the launch of the Great Eastern - 47 minutes.

Three attempts had been made to lay a transatlantic telegraph cable between

Ireland and Newfoundland but with little success. A fourth attempt in 1865 was made using the Great Eastern which had been modified and refitted to carry 500 crew, 8000 tons of coal and over 2700 miles of cable weighing 5000 tons. The new cable was based on design changes recommended by William Thomson (later Lord Kelvin) and the Chief Engineer Charles Bright. The 1865 cable broke in mid-ocean but a further attempt in 1866 succeeded in laying a fresh cable, and also recovered the broken cable, which was spliced to new cable to complete a second line. The 1866 cable operated successfully until 1872 and the repaired cable until 1877.

From 1866 to 1878 the Great Eastern laid 30 000 miles of submarine cable in various parts of the world.

On 16th August 1858, Queen Victoria sent the first transatlantic telegram, to President James Buchanan of the United States. The 99-word message took 16 hours to send - two minutes per character. The message, sent in Morse code, was received using a mirror galvanometer invented by Thomson.

Queen Victoria knighted Thomson in 1866, for his contribution to the transatlantic cable project. Thomson was honoured in 1892 with the title 'First Baron Kelvin of Largs' for his contributions to thermodynamics. Kelvin is the name of a river flowing close to Glasgow University.

Watch: A brief description of the Great Eastern – 2 minutes:

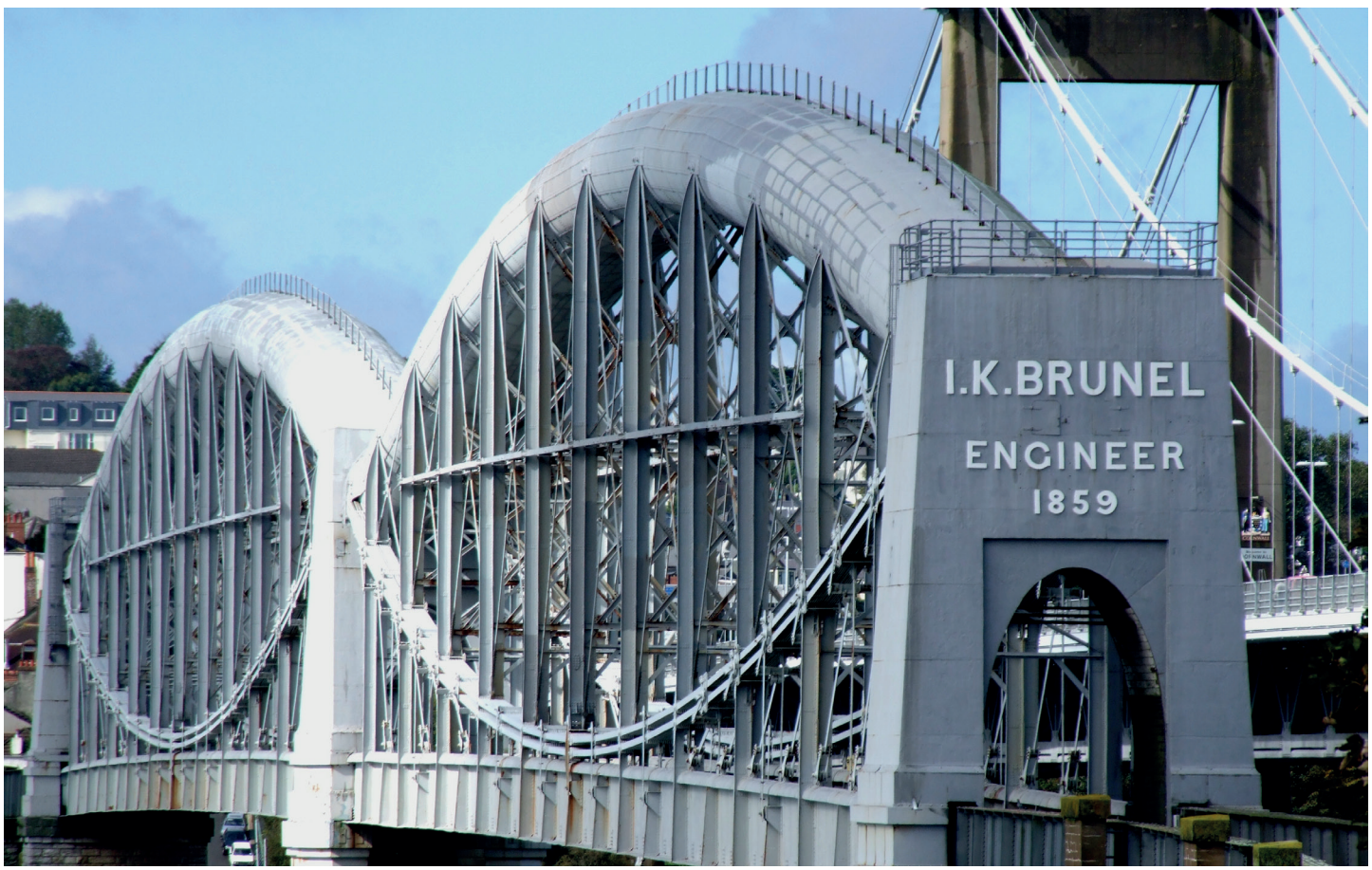
Watch: An excellent account of the construction, operation and history of the Great Eastern (must see).

Click here for an excellent description and history of the Great Eastern.

Watch: Great Eastern – photos – 6 minutes.

Brunel's final great work was a railway bridge over the Tamar river at Saltash, linking Devon and Cornwall and providing the final link to the Great Western Railway from Paddington to Penzance.

When seeing the Royal Albert Bridge for the first time, one may think that the graceful and pleasing lines are the result of a purely aesthetic design – but this is not the case.



The Royal Albert Bridge

The design is the brilliant engineering solution to practical constraints. The railway track is required to curve away from the crossing at both ends. This made a suspension bridge unviable as it would have required excessively long catenary extensions which would not support the approach bridges and would require anchor points far removed from the bridge. A cantilever girder bridge would have required an excessively heavy construction. The Admiralty required that the bridge should have only one pier in the navigable part of the river and must have a clearance of at least 100 feet above high water.

Brunel's solution was two 455 foot spans of a combined bowstring and suspension bridge (lenticular truss) which would not require catenary extensions and would not exert any horizontal thrust on the piers. The tensile forces at the ends of the catenary plate chains are resisted by the compressive force on the tubular arch. The railway deck is suspended by vertical tensile members attached to both the catenary chains and the tubular arches. The structure is also provided with sway bracing to deal with windy conditions. Brunel's 1852 'Great Tubular Bridge' over the river Wye at Chepstow was a forerunner to the Royal Albert Bridge.

The three pier foundations in the river were constructed using caissons. It was found that river bed conditions made it impossible to exclude water from the caissons. The caissons were then closed at the top and pressurised so that the workmen could expose and prepare suitable foundation bedrock. This was perilous work as at this time nothing was known about the danger of quickly moving from a higher pressure environment to one of lower pressure. The work in the caissons was done by candle light. This was not a romantic setting – the appalling working conditions would never have been condoned by modern safety standards, however there was no shortage of willing labour. All the work had to be done using hand tools as compressed air and pneumatic power tools were not available at this time.

The central pier was of iron construction and the outer piers of masonry.

Watch the pier construction - 6 minutes,

The two bridge spans were manufactured and tested on the Devon shore and brought on pontoons to the partially built piers where they were installed at low level. Brunel himself stood on the 1000 ton span to direct installation to the signallers, to the delight of the throngs who had come to witness the spectacle. The bridge spans were progressively raised by jacks as the construction of the piers progressed. Only half of the central pier was constructed during the raising of the first bridge span as the second bridge span was only installed after the first had been completed. The 17 approach spans were of plate girder construction supported on masonry piers.

Brunel was delighted when testing of the fully loaded spans showed deflections of only 1,14 and 1,20 inches. The bridge that Brunel claimed would last more than 50 years remains in daily use after 160 years and used by very much heavier rolling stock.

The bridge was opened by Prince Albert at a ceremony on 2 May 1859. Brunel was too ill at the time to attend the ceremony. He was at a later date taken slowly over the bridge for the first and last time and died in that same year.

The other significant work, completed two months before his death, was the 'Three Bridges' or 'Windmill Bridge' near Hanwell in west London. This is a crossing of three routes: The Brentford Railway at the bottom; the Grand Junction canal over the railway and Windmill Lane roadway over the top. The structure is a scheduled monument.

In a 2002 public poll of *"The 100 Greatest Britons"*, I K Brunel was ranked in 2nd place. Public perceptions and sentiments seem to have played a large part in the poll.

Other rankings were: (1) Winston Churchill, (4) Charles Darwin, (5) Shakespeare, (6) Isaac Newton, (9) Horatio Nelson, (21) Alan Turing, (22) Michael Faraday, (25) Stephen Hawking, (41) Charles Dickens, (80) Charles Babbage, (84) James Watt, (91) James Clerk Maxwell.

If the survey had been split into various categories and ranked by specialists in each category the result would have been quite different.

In Alfred, Lord Tennyson's well known but very long poem *"Locksley Hall"*, he mentions the railway as *"… the ringing grooves of change …"*. Apparently the poet laureate thought that trains ran in grooves along the track.

A memorial window was erected in Westminster Abbey in 1868 to commemorate Isambard Kingdom Brunel. Originally sited on the north side of the nave it was moved to south side and slightly altered in 1952. wn

ACTOM HIGH VOLTAGE EQUIPMENT COMPLETES R22-MILLION GENERATION TRANSMISSION INTERFACE CONTRACT FOR ESKOM'S KUSILE POWER STATION.

ACTOM High Voltage Equipment was awarded a R22-million contract for the generation transmission interface for all six generation units at Eskom's new Kusile power station currently under construction near Emalahleni in Mpumalanga.

The contract, involving the supply and erection of 400 kV transmission lines from each of the six generation units to the nearby transmission substation that will link the new power station to the national electricity grid, was awarded to the division in mid-2015.

The contract also included supplying and erecting galvanised steel cross-beams, which are to be installed between each of the generation units to support the transmission lines strung across to the transmission substation.

The contract follows the award to ACTOM High Voltage Equipment in mid-2012 of the generation transmission interface contract for Medupi, Eskom's other new coal-fired power station, near Lephalale, Limpopo Province.

ACTOM High Voltage Equipment has successfully completed erection of the transmission lines and associated equipment linking Kusile's Generation Units to the transmission substation. It was completed as scheduled.

HIGH VOLTAGE EQUIPMENT
A division of ACTOM (Pty) Ltd

1st in sector TOP 500 South Africa's best managed companies 2018/2019

LEVEL 1 BBBEE

PROUDLY SOUTH AFRICAN

ACTOM

ACTOM (Pty) Ltd: 2 Magnet Road, Knights, 1413 | PO Box 13024, Knights, 1413
Tel: +27 (0) 11 820 5369 | www.actom.co.za

SAIEE 2020 COUNCIL

GRADE	NAME & SURNAME	CONTACT DETAILS	EMAIL ADDRESS
President	Sy Gourrah	083 321 5526	sgourrah@gmail.com
Deputy President	Prof Sunil Maharaj	012 420 4636	Sunil.maharaj@up.ac.za
Senior Vice President	Prince Moyo	011 800 4659	prince.moyo@eskom.co.za
Junior Vice President	Prof Jan de Kock	018 299 1970	Jan.DeKock@nwu.ac.za
Immediate Past President	George Debbo	012 991 3748	george.debbo@gdtelecom.co.za
Honorary Treasurer	Stan Bridgens		bridgens34@gmail.com
Honorary Vice President	Roger Cormack		rogercormack1949@gmail.com
Past President	Stan Bridgens	011 487 9048	s.bridgens@saiee.org.za
Past President	Viv Crone		vivcrone@gmail.com
Past President	Mike Crouch	011 440 7944	michaelc@telkomsa.net
Past President	John Gosling	011 487 3003	gosling@worldonline.co.za
Past President	Dr Hendri Geldenhuys	084 625 5522	GeldenHJ@eskom.co.za
Past President	Dr Angus Hay	011 585 0490	angus.hay@liquidtelecom.co.za
Past President	Jacob Macjinjike	011 800 5329	machinJ@eskom.co.za
Past President	T.C. Madikane	031 536 7300	tc@igoda.co.za
Past President	Ian McKechnie	012 663 4804	ianmac@gafrica.com
Past President	Andries Mthethwa	011 820 5094	andries.mthethwa@actom.co.za
Past President	Prof Pat Naidoo	071 312 0111	pat@patnaidoo.co.za
Past President	Paul van Niekerk		paulvn@telkomsa.net
Fellow	Jane-Anne Buisson-Street		buisson@mweb.co.za
Fellow	Max Clarke	011 285 0940	mppc@mweb.co.za
Fellow	Tom Eichbaum	011 652 2226	thomas.eichbaum.pvt@gmail.com
Fellow	Dr F Manganye		
Fellow	Collin Matlala	011 997 8900	matlalac@global.co.za
Fellow	Pascal Motsoasele	083 642 5921	pascal.motsoasele@gmail.com
Fellow	Amelia Mtshali	011 871 2625	MtshalHA@eskom.co.za
Fellow	Prof Jan-Harm Pretorius	011 559 3377	jhcpretorius@uj.ac.za
Fellow	Veer Ramnarain		
Fellow	Prof Jerry Walker	016 421 5190	jerrywalker@walmet.co.za

GRADE	NAME & SURNAME	CONTACT DETAILS	EMAIL ADDRESS
Senior Member	Mike Barker	083 627 7673	mike@mikebarker.co.za
Senior Member	Prudence Madiba	011 800 4212	Prudence.madiba@eskom.co.za
Senior Member	James Motladiile	011 629 5172	james.motladiile@eskom.co.za
Senior Member	Patrick O'Halloran	011 490 7485	pohalloran@citypower.co.za
Senior Member	Kgomotso Setlhapelo	011 871 2228	SetlhaK@eskom.co.za
Senior Member	Monde Soni	012 421 4743	sonim@eskom.co.za
Senior Member	V Shikoana		
Senior Member	Prof M Sumbwanyambe		
Senior Member	Dr Nicholas West	011 717 7278	njwplasma@gmail.com
Member	Dr Clinton Carter-Brown	083 630 0626	clintoncarterbrown@gmail.com
Member	Tshego Cornelius	011 871 3063	corneltg@eskom.co.za
Member	A Mamayuha		
Member	Dr Lesedi Masisi	011 717 7212	lesedi.masisi@wits.ac.za
Member	Prof Fulufhelo Nelwamondo	083 978 1988	fnelwamon@gmail.com
Member	S Vhulondo		

SECTION CHAIRPERSONS:	
Chairman Rotating Machines Section:	J Bembe
Chairman Power & Energy Section:	S Ntombela
Chairman Electronic And Software Section:	W Stucke
Chairman Historical Section:	M Clarke
Chairman Earthing & Lightning Protection Chapter:	
Chairman Load Research Chapter:	M Soni

SAIEE CENTRES

Eastern Cape Centre
Chairman | Simphiwe Mbanga
T|083 777 7916 **E**|MbangaS@eskom.co.za

Free State Centre
Chairman | Joseph George
T|082 263 1213 **E**|joseph.george22@gmail.com

Gauteng Central Centre
Chairman | Nduduzo Khumalo
E|nsp.khumalo@gmail.com

Kwa-Zulu Natal Centre
Chairman | Jay Kalichuran
T|082 569 7013 **E**|KalichuranJ@elec.durban.gov.za

Mpumalanga Centre
Chairman | Nicholas Smit
T| +27 72 341 9891 **E**| Nicholas.Smit@sasol.com

Northern Cape Centre
Chairman | Ben Mabizela
T| 073 708 0179 **E**| MabizeBG@eskom.co.za

Southern Cape Centre
Chairman | Steyn van der Merwe
E|steynvdm@gmail.com

Vaal Centre
Chairman | Carlisle Sampson
T|083 397 8021 **E**|Carlisle.Sampson@sasol.com

Western Cape Centre
Chairman | Heinrich Rudman
E| admin.wcape@saiee.org.za

SAIEE CALENDAR

MAY 2020

1	Workers day
5	President's Inaugural Lecture - Bloemfontein
6	President's Inaugural Lecture - Kimberley
7	Centre Chairman's Workshop
14	AM Series - ISO55k: A General Overview - G Fogel, Gaussian, R Davies - UK
19	President's Inaugural Lecture - Secunda
20	President's Inaugural Lecture - Vanderbijl Park
21	**ST-TALK - Railways - Webinar**
22	AM Series ISO55k: Sample Artefacts G Fogel, Gaussian
26	Power & Energy Section - Webinar "Impact of 5G on our health"
28	Centre Chairs Meeting
29	Load Research Chapter - Webinar "Working with Demand response"

JUNE 2020

4	AM Series - ISO55k: Maintenance Strategies - T Mokwana
11	AM Series - ISO55k: Expansion & Operations Strategies - L Naidoo/M Kopa
18	AM Series - ISO55k: Asset Condition Assessment P Moyo/G Fogel
22	President's Invitation Lecture, UJ
23	President's Invitation Lecture - UP
	ST-TALK: Biomedical Webinar
	AM Series ISO55k: Project Portfolio Optimisation - B Neijens
25	Centre Chairs Meeting

Notices and invitations to events will be circulated to members in due course.

Visit www.saiee.org.za for more information.

JULY 2020

2	Power & Energy Section Monthly Meeting "Opportunities in the energy storage space"
15	Power & Energy Section - Webinar - Electric vehicles
21	Load Research Chapter - Electrification planning case studies and tools"
23	**ST-TALK - Power Engineering Webinar**
30	Centre Chairs Meeting
31	Load Research Chapter - Webinar "National & Regional electricity planning models"

AUGUST 2020

6	Women's breakfast
7	COUNCIL
9	Womans day
10	Public holiday
18	Load Research Chapter - Monthly Meeting Standards under review NRS034, NRS048, 097"
20	**ST-TALK - Communications Webinar**
27	Centre Chairs Meeting

SEPTEMBER 2020

9	Power & Energy Section - Webinar Socio-economic aspects of procuring energy from a range of energy source technologies"
14	BP Lecture WITS
15	BP Lecture Durban
16	BP Lecture Port Elizabeth
17	BP Lecture Cape Town
22	**ST TALK - Lightning Webinar**
23	Centre Chairs Meeting
30	Load Research Capter - Webinar "Database and wharehoue schemes"

Section & Chapter Webinars

ST-TALKS Webinar - exclusively members only

MAINTENANCE

DISTRIBUTION

MANUFACTURING

PROJECTS

SERVICE & REPAIRS

Key sectors served by ACTOM's equipment supply and solutions offering include:

Power Generation	Construction	Healthcare	Paper & Pulp	Renewable Energy
Transmission	Energy	Industrial Processing	Petro-chemical	Sugar
Distribution	Environmental	Mining	Rail Transport	Textile
Utilities	Food & Beverage	Oil & Gas	Signalling	Water & Sanitation

ACTOM, offering a winning and balanced combination of manufacturing, service, repairs, maintenance, projects and distribution of electro-mechanical equipment through its 35 outlets throughout Sub-Saharan Africa.

ACTOM

ACTOM (Pty) Ltd: 2 Magnet Road, Knights, 1413 | PO Box 13024, Knights, 1413
Tel: +27 (0) 11 820-5111 | Fax: +27 (0) 11 820-5044 | www.actom.co.za