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LIGHTNING

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

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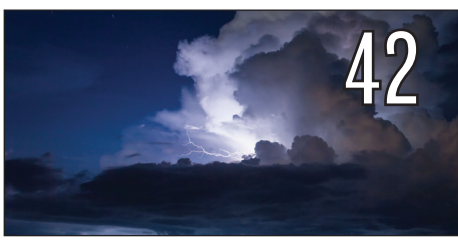

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Dear Valued **watt**now Reader

It is Spring time in South Africa and due to South Africa's high density of lightning strikes, especially in Johannesburg, I thought it apt to bring you this Lightning issue.

This issue promises to deliver informative articles, compiled and written by the SAIEE Lightning Chapter members, to whom I am deeply grateful.

Much research on lightning is conducted in High-voltage laboratories, where the effects of lightning can be simulated or approximated. Our first feature article discusses the 'Johannesburg Lightning Research Laboratory at Wits'. Read more on page 24.

In the 'Lighting Detection and Location' article, the authors share the details of the aspects of an LLS (Lightning Location System) that matter when the empirical data obtained from it will be applied to business productivity and asset management as a risk management tool. Find this on page 34.

I have often asked myself, what is the difference between a thunderstorm and lightning, and my question has been answered in the article 'Thunderstorm Warning vs Lightning Verification' – on page 42.

Please note that page 83 & 84 sports Definitions and Abbreviation related to the content in our feature articles.

From our 'ou staatmaker' – Dudley Basson, who compiled an article on the Feigenbaum Chaos, on page 70, you will learn that Mitchell Jay Feigenbaum (1944-2019) made a significant contribution to chaos theory in 1975 by studying the growth of a hypothetical population of rabbits. Fibonacci (c1170-1240+) came to his famous mathematical series of numbers by studying rabbits' breeding patterns.

The October issue features Automation, and the deadline for any articles is 17 September 2021. Please send your submissions to minx@saiee.org.za.

Herewith your September issue, enjoy the read!

Minx

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ENSURING THAT HVAC IS NOT WEAKEST OPERATIONAL LINK

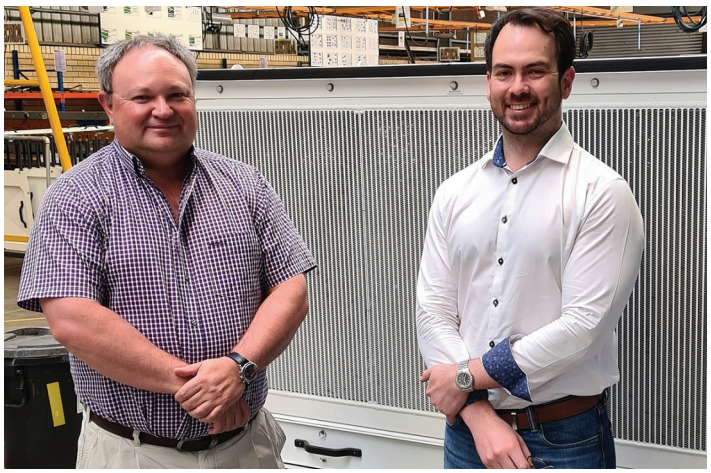
South Africa's hot climate – when combined with demanding site conditions – is often too much for standard heating, ventilation and cooling (HVAC) systems. This is where Booyco Engineering's robust solutions have built a solid name for themselves.

With over three decades of designing, manufacturing and supporting specialised HVAC systems for rail, mining and military applications, the company's depth of expertise brings a new level of health, safety and productivity to the work site.

According to Brenton Spies, managing director of Booyco Engineering, the importance of effective HVAC systems has grown significantly in recent years as companies work to improve health and safety while optimising valuable uptime.

"Businesses across a range of industrial sectors are pursuing policies of zero harm," says Spies. "Cool, comfortable working conditions are a vital part of this trend, whether in relation to rail locomotives or mining and earthmoving equipment."

"Hot and dusty site conditions, as well as factors like high vibration levels and uneven road surfaces, can undermine the performance of standard-issue HVAC equipment," he says. This invariably leads to frequent stoppages for repairs – and lost revenue due to unplanned downtime.



From left Brenton Spies, managing director of Booyco Engineering, and Grant Miller, executive director at Booyco Engineering.

The company's success is based on a detailed understanding of each application, according to Grant Miller, executive director at Booyco Engineering.

This includes considering the necessary standards for compliance, airflow, ingress protection (IP) ratings, structural and electrical requirements, corrosion and acoustic noise. wn

THE PANDEMIC, OUR ECONOMY AND THE LIGHTNING PROTECTION INDUSTRY

Bertie van Zyl
1953 - 2021

Just as with all industries, the Lightning Protection industry has had its share of tragedy and heartache.

With great sadness, we bid farewell to a stalwart of our industry and a mainstay and mentor to many young technicians.

Bertie van Zyl, Managing Director of Advanced Lightning Protection, passed away due to pneumonia complications with Covid-19 on 21 July. I feel inadequate to write a complete eulogy to Bertie at this time because no words can describe the large footprints he has left for others to fill. At this time, we take the opportunity to inform the industry at large to please take extra care as we push to revive our economy amid struggles to get vaccinations and manage Covid-19. Bertie is survived by his tower of strength wife Dirkje and daughter Sarina who is taking over the company's reins.

We stand by Sarina, Dirkje and the employees of Advanced Lightning Protection. Equally, ELPA comes alongside all LP companies and their people in this challenging time. wn

- Richard Evert, ELPA

SAIEE President's Invitational Lecture 2021

Ms Portia Derby
Transnet Group Executive

Prof Sunil Maharaj
SAIEE Presiddent

Prof Sunil Maharaj, SAIEE President, hosted his invitational lecture virtually, with nearly 400 attendees on the 24th of August 2021. He welcomed all our esteemed guests, members, and United Arab Emirates, Sweden, and various African countries.

"This evening, we are honoured to host the Transnet Group Executive, Ms Portia Derby as our keynote speaker".

Ms Portia Derby is the current Group Chief Executive of Transnet SOC Ltd, appointed February 2020. She has occupied senior positions in the South African government during a period of significant economic reform. Portia is a former Director-General of Public Enterprises (2005 - 2009) responsible for Corporate Strategy and Structure of the Investment Portfolio (2004 - 2005) and former Chief Operating Officer of the Department of Trade and Industry (2002).

Ms Portia Derby, Transnet Group Executive, engaged the attendees with an intriguing presentation on "Enhancing Manufacturing Competitiveness in South Africa: A Perspective on Supply Chains".

"We spent the last 18 months at Transnet, reviewing and relooking at ourselves and how we can become more of a collaborative player," she said in her opening statement.

She discussed the nine critical sectors of Transnet's strategic focus in the automotive (R178.88 bn), agricultural (R48.0bn) and mining (R164bn) industries, which offers a relatively high economic contribution.
"We focus on these as we it ties up with the economic recovery and reconstruction plan of government, but also, it is a massive use of our ports."

Transnet's planning framework includes Iron Ore, Manganese, Coal, Chrome and Magnetite. The objective with Auto & Containers includes an R100bn upgrade of the Port of Durban to expand the regional hub port system for clean commodities and support the Durban hub growth to 11 million TEUs.

"Our fuel & Gas objective is to use public and private partnerships to grow refined fuel import capacity and new entrant access and develop the gas infrastructure network towards a sustainable energy portfolio", she added.

Ms Derby gave an overview of Transnet's Segment Strategy Process, which developed a portfolio of initiatives affecting the whole country.

Watch the recording of the webinar here.

OBITUARY - Edward Howard Gregory - 1929 - 2021

Edward Howard Gregory (Gus) died peacefully at his home in Great Brak River on the 29th of June 2021. He would've celebrated his 92nd birthday this year.

Gus was a Police Reservist for many years in Rhodesia while working as an Electrical Engineer. Gus became a senior member of the SAIEE in 1953 and remained a member until his passing.

Our condolences go out to Gus' wife, Gay and his children, Howard, David and Louise. May he rest in peace.

Electricity Regulation Act amendment 'not perfect', but a good start

It is possible for 10 GW of new power generation capacity to be built in the next seven years, now that the amended Schedule 2 of the Electricity Regulation Act has paved the way for easier distributed generation, says Business Leadership South Africa (BLSA) CEO Busi Mavuso.

The amendment has the potential to spur major new investment in electricity generation, since companies can now go ahead with building their own generation plants of up to 100 MW without first obtaining a licence from the National Energy Regulator of South Africa (Nersa).

These companies still need to register with Nersa though, except for plants created purely as a back-up supply in the event of disruption.

It is still unclear what this registration will require, but Mavuso hopes it will be a simple process.

She explains that the amended Schedule 2 also, for the first time, allows for wheeling across the grid – meaning that companies can generate power in one place and use the electricity in another.

"That is particularly important for renewable energy generation. Where the sun shines and wind blows may not be where the electricity is needed."

The amendment also allows for companies to buy electricity from third parties.

However, Mavuso points out that these activities all require companies to deal with Eskom as the transmission operator and says much will depend on how simple and cost-effective the State-owned power utility can be in offering this service.

Municipalities will also need to play a role where their infrastructure is used for power delivery.

"The amended schedule is not perfect. There are several ambiguities that need clarification.

"The schedule seems to allow for wheeling from one producer to many end-users, but the language is unclear on this.

"It also appears to exclude municipalities as resellers of electricity – which may make it difficult for municipalities to buy power directly from private producers," Mavuso points out.

She adds that the amendment also does not specify how energy storage will be treated when producers create battery capacity to store energy produced and she welcomes further amendments to the schedule to clarify these issues.

BLSA is of the view that the ball is now in the regulator and Eskom's court. The organisation deems it important that these entities use the regulatory space to enable widespread distributed generation and sales across the grid.

Mavuso believes the amendments to electricity regulations are a clear success of Operation Vulindlela – the project set up between the National Treasury and the Presidency to drive structural reforms.

BLSA CEO Busi Mavuso

Some of Vulindlela's other priorities are the divisionalisation of Eskom, the auction of additional spectrum to improve digital broadband access, bulk water infrastructure, speeding up water-use licensing processes, the corporatisation of the Transnet National Ports Authority, third-party access to rail infrastructure and visa reforms.

Mavuso says if all these were achieved, the business operating environment in South Africa would improve significantly and make South Africa an easier place to do business. wn

Alfeco Group honour their Women of Steel

In celebration of Women's Month, the Alfeco Group celebrated their female staff and learners from their three different divisions, Pioneer Metals, Veer Aluminium and Veer Steel Mills, for being dedicated, determined, and successful women of steel at their Alrode plant on August 11.

Our staff of 125 women received luxury gift boxes and chocolates, following a motivational talk from Group Executive Siddiqca Hardev.

The celebration included learners from the Group's Training Programme spearheaded by training authority, MerSeta - which comprises learners from Imisebenzi National Development Agency, Nhlanhla P.S Holdings and the University of Johannesburg's Resolution Circle.

At the event, Siddicqa said this year, the Group decided to recognise and celebrate its women as the foundation that held their families and colleagues together due to the consequences of the Covid-19 pandemic.

"We wanted to show each one of our women how valuable they are to us and that they are appreciated," said Siddiqca.
She added that they work in a male-dominated industry - however, the number of women in our Group had grown over the last two years, and the Group is strategically driving an intention to double these numbers with the commitment of everyone, as they are expanding.

"Our women have shown true leadership, grit, determination and excel in their work. We respect and value all their contributions," said Siddiqca.
She further encouraged the audience to keep up the excellent work while encouraging them to continue showing the male-dominated steel industry that they are more than just women because they are solid and resourceful go-getters.
Samantha Qolindaba from the Group's front desk said the gifts were beautiful.

"It feels good that the company considered celebrating us with such classy gifts. I enjoyed the motivational talk as well. I do feel appreciated," said Samantha. wn

At the event, Group Executive Siddicqa Hardev presenting the motivational talk for the Women's Month Celebration at the Veer Steel Mills, Alrode.

Alfeco Group's HR department ladies Caroline Ramalamula, Eldah Nkhwashu, Selina Mkwanazi, Thabile Lukhele and Akhiwe Nokenke at the Women's Month Celebration at Veer Steel Mills, Alrode.

Kgotsofalang Mashilo and Lebogang Sekgwama at Women's Month Celebration in Veer Steel Mills, Alrode.

Chene van Niekerk and Roxanne Cawcutt received their gift boxes for the Women's Month Celebration at Veer Steel Mills, Alrode.

Welcome to the family, DEHNventil!

Since 1983, DEHNventil has been synonymous with power in the ranks of lightning current arrestors. Now, with the new slim design, combined with the original DEHNventil strength; you can save space in your switchgear cabinet, while still protecting your electrical assets with the same performance parameters.

With the slim design, the new DEHNventil has the width of four standard DIN modules and with the combined arrester it saves up to 50% of space occupied by the previous module and other devices available in the market.

It allows for easy module replacements with a spring supported plug-in module, which makes replacement quick and effortless, leaving you with more room for extra components. Maximum protection is achieved with the RAC spark gap technology, which provides more safety with minimum residual energy and maximum follow current extinguishing capabilities of up to 100 kArms. DEHNventil creates the best possible protection for assets based on downstream terminals.

PERFORMANCE THAT SAVES YOU TIME AND MONEY

The new features of DEHNventil promises savings in both time and costs, because of the easy installation and maintenance. Installation is seamless, with an entire block plug-in that can be changed with one hand. This is achieved with a spring supported ejection mechanism, providing the effortless installation and replacement which ensures a quick installation that saves time. Using a single module, DEHNventil needs less maintenance than its predecessor.

After replacement, your protection is already at optimal performance, this prevents gaps in your protection and creates longer times between maintenance intervals. It also replaces equivalent or older devices, which provides you with futureproof protection. Additionally, the new DEHNventil models now come equipped with a remote signaling contact, simplifying your product selection.

With the slim design, DEHNventil lowers your additional costs with the space gained in the switchgear cabinet. As an all-in-one solution, combined type 1 + 2 + 3 arrester, in accordance with EN 61643-11, all your electrical assets within a protection range of 10 meters of cable length are protected, which does away with additional costs for additional devices and installations.

Using the expertise from spark gap technology specialists and made-in-Germany quality, the DEHNventil uses this combined type 1 + 2 + 3 arrestor to safeguard against over-voltages of transient in low-voltage switchgear and control units. Extra performance is offered by the RAC gap technology implemented with a high reaction rate, which lowers the impact on linked installations and systems with lower residual energies.

DEHNventil places your mind at ease during storms or surges with the reliability of the RAC gap technology and German design, leaving you with more time and more resources to focus on what matters most – your business!

The new DEHNventil is a worthy competitor and effortlessly replaces equivalent older devices, thus providing the maximum guarantee of future compatibility. The DEHNventil is powerful, reliable, future-proof, and space saving in design.

The new DEHNventil, half the size, all the power! It is truly the new benchmark in surge protection.

DEHN has been leading the way in lightning and surge protection for 111 years. We develop products that set new standards. Contact our team today to find out more on the newly launched DEHNventil. wn


DEHN
PROTECTS.
YOUR TRUSTED PARTNER FOR SURGE AND LIGHTNING PROTECTION

Celebrating 45 years in Lightning Protection

HHK has become the biggest lightning protection and earthing contracting company in the Southern African Sub-Saharan region. It has never changed hands nor has there been a change in company name nor logo for the past 45 years.

The Head Office is based in Johannesburg (Northcliff) with nine branches country wide and employs approximately 130 people.

HHK obtained the SABS Quality Management System listing on 16 October 1987 (Listing Number: LM/0087) and thereafter has grown from strength to strength. Helmut is also a member on various SANS/IEC committees/working groups for lightning protection, earthing and surge protection standards.

HHK provides complete turnkey solutions including design, soil resistivity surveys, installation, final commissioning and certification. We also supply 'as built' design drawings (3D) approved by SANS/ELPA for any project from simple golf/bus shelters and residential houses to major structures and mining plants, etc.

ELPA CERTIFICATION

HHK is a Class 1 member of the Earthing and Lightning Protection Association (ELPA). This certificate serves to inform the industry that the company is registered with the Earthing and Lightning Protection Association and aligns with the vision and objectives of the Association. The company undertakes to uphold the ethics of ELPA and to protect the client from the threat of lightning.

EDGE OVER COMPETITORS

HHK has three elements that give it the edge over competitors:

- SUFFICIENTLY RESOURCED
  With an employ of 130 with diverse skills, 45 light pick-up trucks and the latest equipment in the game, **HHK** is sufficiently resourced to handle projects of different scales in mining and other industries. "We tap into our capabilities to address the specific needs of our clients. We do not shy away from challenges. Each client's requirements are different, and we strive to find a unique solution to every challenge," says Helmut.

- CREDIBILITY IN THE INDUSTRY
  Underlining HHK's devotion to quality, **HHK** has undertaken processes to comply with best practices in lightning, earthing and surge protection, since 1976. It was awarded the SABS Quality Management System listing in 1987. Helmut Kanwischer serves as a member on the various SANS/IEC committees/working groups for lightning protection, earthing and surge protection standards. On implementation, **HHK** received the nationwide approval and accreditation of the Earthing and Lightning Protection Association (ELPA). Helmut says: "ELPA accreditation is important as it emphasises our reputation as a credible service provider."

- HANDS-ON MANAGEMENT
  Helmut' hands-on approach ensures that projects, from commissioning to post-installation and maintenance are all personally overseed. In true German style, he meticulously keeps track of the finer details of a project which potentially have implications on the quality of the service offered. "We do not compromise on quality. We know that our service is central to protecting people's lives in various industries that we serve,".

WELL-POSITIONED

It has been a long and eventful journey for Helmut H Kanwischer.

Today, **HHK** is a household name in lightning protection, earthing and surge industry and promises to continue serving devotedly in the future. wn

CELEBRATING 45 YEARS LIGHTNING SERVICE & EXPANDING

HHK was established by Helmut Hermann Kanwischer in 1976 (**HHK**). Helmut emigrated from Germany to South Africa in 1969 and saw the potential in South Africa, which has one of the highest ground flash density lightning discharges in the world. From the humble beginning of a simple secretarial service and garage, he developed his business plan. Through his vision, innovative thinking, unrelenting determination and will-power, the company has become what it is today, the **HHK** head office is in JHB and various branches nationwide.

HHK is proud to announce the expansion of its latest branch in Cape Town.

H.H.K.

Earthing & Lightning Protection Systems
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Blitz-Detect
HIGH PRECISION
Lightning Detection Systems

Blitz-Detect in partnership with Nowcast is proud to bring to South Africa high-precision lightning detection services by means of a completely autonomous lightning detection networks (LDN).

Nowcast is a German lightning detection expert company which is known for its strong project partnership approach. In such partnerships, nowcast sets up ultra-precise, long-range lightning detection sensor networks in countries across the world and together with local partners to jointly operate those networks. Key to such joint ventures is Nowcast's deep belief in true long-term partnerships. Acting like colleagues leads to the addition of great value to the region through technology. Celebrating mutual success as quality leaders in ultra-precise lightning detection, early thunderstorm warning and leading-edge short-term forecasting has proved to be an excellent driver for first-class services and outstanding customer satisfaction in the private and public segments.

A trusted partner

"When Nowcast deployed its first partnership lightning detection network together with a local company in Latin America many years ago, enthusiasm fueled the approach of engaging in long-lasting, professional, open-minded business partnerships across the globe." says Richard Fellner, MD of nowcast.

"Highly qualified local partners that are working closely with Nowcast enable the success of best-in-class lightning-detection technology and thus also success in the defined market. Today, Nowcast is proud to call numerous qualified and passionate private companies and national weather services its trusted partners with one goal: to provide the most reliable and precise lightning data, particularly for lightning-prone countries. Maximum safety and efficiency for people, investments and processes. Nowcast's partnership missions are based on the Nowcast LINET (LIghtning detection NETwork) technology", Richard explained.

In May 2021, a brand-new partnership LINET system was installed in South Africa. Trevor Manas, managing director of Blitz Detect, and his business partners, Alexis Barwise, Wilfried Wagner and Etienne Gerber, are bringing their vast experience in lightning and lightning protection to this endeavor and form the local core team in South Africa.

Here, the Blitz-Detect team provides deeper insight into the partnership, as well as the benefits of ultra-precise lightning detection.

NOWCAST AT A GLANCE

- German company specialized in ultra-precise lighting detection (hardware and software)
- Patented 3D total lightning detection (CG and IC, including emission height)
- Accuracy of 75m on average, detection efficiency down to 2kA strokes
- Real-time operation as well as historical lightning data
- Provides data services, complete autonomous networks and hybrid solutions
- Trusted by numerous customers and partners around the world

What made you decide to build a lightning detection network (LDN) in South Africa?

TM: As a lightning protection specialist, it has always been a challenge to confidently recommend lightning detection systems as part of the lightning safety plans drawn up for schools, golf courses and mines. Furthermore, when conducting lightning damage investigations, the procurement of accurate lightning data has always been extremely difficult and expensive.
We have found that most local systems did not meet the lightning detection accuracy and efficiency required to provide optimum operational safety for outdoor facilities nor do they provide reliable verification of historical lightning activity.
This led us to start the search for a LDN that would meet the highest possible specifications.

Why is lightning detection important in South Africa?

AB: Many parts of South Africa have high lightning stroke densities, our country also has one of the highest lightning fatality rates per capita in the world, with numerous deaths and injuries being reported every year.
At Blitz Detect, we are confident that Nowcast`s ultra-precise lightning detection system will be instrumental in saving many lives and lightning induced injuries. We also aim to provide valuable lightning data to the insurance industry, aviation industry and energy suppliers in South Africa. At Blitz Detect, we strongly believe that the our system will make a substantial contribution to lightning safety and to the effective operation of essential services to the public in Southern Africa.

What is your mission for lightning detection?

EG: First and foremost, we want to save lives. South Africa has a very strong outdoor culture. The Nowcast system provides meticulous monitoring of all types of outdoor facilities, thereby making these operations and activities much safer for everybody.
Of course, lightning data is valuable in maintaining vital operations to many other types of industries such as the insurance, energy and aviation industry. Weather service providers as well as research facilities also benefit enormously from highly accurate lightning detection information. Here at Blitz Detect we look forward to providing these customers with precise, easily accessible, cost-effective data-based lightning detection solutions.

What convinced you to partner with Nowcast and its LINET technology?

WW: Due to the fact that our team has been actively involved in the lightning protection industry for many years and have a deep understanding of the mechanisms of lightning, we knew exactly what we were searching for.
The Nowcast LINET system`s unsurpassed accuracy, efficiency and reliability without doubt sets the benchmark in lightning detection. When you add the easy to use customer interfaces of the Nowcast LINET system, this made our decision to partner with Nowcast very easy.
The partnership agreement with Nowcast has also vastly reduced the capital outlay into building the LDN, this means that we are able to offer cost effective lightning detection and lightning data packages to our customers.

> ***"The Nowcast LINET system represents the pinnacle of German engineering and has an impeccable track record around the world."***
>
> **Trevor Manas, managing director, Blitz-Detect**

What makes the Nowcast LINET system so exceptional?

TM: There are many features that make the Nowcast system unique. Most importantly, the Nowcast system provides industry leading detection accuracy and efficiency.
The Nowcast system boasts an unsurpassed lightning location average accuracy of 75m and a lightning detection efficiency of 99% of all lightning strokes.
The Nowcast system also has various patented features such as its rTNT (real Time Tracking and Nowcasting of Thunderstorms) algorithm for tracking and prediction of lightning activity as well as its 3D detection of intra-cloud lightning which is used to provide accurate severe weather and hail warnings.
The Nowcast LINET system represents the pinnacle of German engineering and has an impeccable track record around the world.

How did the rollout of the new lightning detection network go?

EG: The Nowcast team provided invaluable support throughout the entire network setup. It was only with their help that I am happy to report the rollout was seamlessly executed in only a few weeks, with all sensors functioning properly and without failure.

How important is the highest possible precision and reliability of such a service for your customers in South Africa?

AB: It is of utmost importance. Precision and reliability are key to the success of the South African network. Professional customers that require lightning data, can only profit from this data when the highest standards of quality are fulfilled.
Thunderstorms are sharply delineated events and should therefore be detected and forecast with the highest possible accuracy and reliability to achieve optimum benefit for decision making and operations.

What makes your overall business stand out in your market?

WW: Given the fact that we are able to offer the highest standard in lightning detection in cost effective packages with no capital outlay, makes Blitz Detect clearly stand out in our market.
The Blitz-Detect team also offers comprehensive lightning safety plans incorporating the Nowcast LINET system.
Most important, the user friendly, easy to access LINET system plays a vital role in providing our customers with autonomous, independent and professional lightning detection solutions.

What can customers expect from Blitz Detect's new services?

TM: All of our customers, be it for early warnings/ nowcasting or for historical lightning data, can expect the highest level of accuracy and reliability in the detection of lightning and severe storms.
They can also expect to be provided with an accessible, real-time, easy-to-use interface that is also cost-effective.

Industry Leading Lightning Detection

Real Time Tracking and Prediction

3D Detection of Lightning for Severe Storm Warning

Should you wish to find out more about Blitz-Detect lightning detection and early warning systems, please feel free to contact us:
www.blitz-detect.com
info@blitz-detect.com

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Hybrid Working: Profits, People And The Planet

Hybrid working has become the 'new normal', says IWG founder and CEO Mark Dixon. Here, he explains why – and what it means for the future of the office. With Covid-19 restrictions starting to ease, businesses of all kinds embrace the hybrid approach, locking in its benefits for people, profits and the planet.

As the restrictions associated with Covid-19 begin to ease in many countries, government advice is changing. The 'stay-at-home' mandates that have seen many of us based in spare bedrooms or kitchen tables are finally being lifted over the past year. But with businesses of all stripes now awake to the benefits of hybrid working, it seems unlikely we'll go back to our pre-pandemic routines.

"People can now return to the office," IWG Founder and CEO Mark Dixon said recently, "but with the right infrastructure and technology, employees can be productive no matter where they are."

"Now, as a result of the pandemic, we're seeing businesses of all sizes recognise the benefits of this model," says Dixon. "We've seen record demand full network deals, where clients' employees have access to any of our locations globally. This has already driven an increase of more than a million people using our network over the last year, with another million committed to doing so in the months ahead."

According to Dixon, "We've been witnessing the decline of full-time office work right across the world since long before the Covid-19 pandemic began." In his view, there are three critical reasons for this shift to the hybrid model.

BETTER FOR PEOPLE

First and foremost, Dixon argues, hybrid working has clear benefits for people. "For employees, the time saved on commuting to and from work every day is better spent seeing friends and family, exercising, or covering childcare. As a result, workforces have the potential to be healthier and happier."

A work base closer to home is a long-term priority for workers, Dixon says: "They want to continue with the reduced commute, and increased family time they have experienced in 2020 and into 2021."

It's no surprise, then, that IWG's latest research found 77% of employees say a base closer to home is a must-have benefit that will inform future job applications. Around half of all employees went even further, saying they would look for another job if asked to return to the office five days a week.

Many businesses are already reconfiguring their use of real estate, with firms such as HSBC, BP and JP Morgan planning to shrink their office footprints significantly. Dixon predicts that, in tandem with this, businesses will bring workspaces closer to where their employees live, empowering them to work flexibly. "High-quality local workspaces will spring up in communities across the world – not only in city centres but also in the suburbs and rural areas." These will allow workers to work near home ('WNH'), rather than from home when it suits them.

While the corporate HQ still has a part to play in the new world of work, its role will change. "Hybrid working means that when colleagues do come together, it will be for collaboration," Dixon says. "So it's important to design spaces that are inviting and flexible, where people can be creative. In short," Dixon explains, employees' demand for hybrid working means "fewer and fewer companies need office space that is just a sea of desks."

BETTER FOR PROFITS

In itself, this change in companies' needs could yield significant savings in the long term. "Companies rapidly

realise the benefits of the 'hub-and-spoke' model for office space," says Dixon. "Instead of one large and expensive city-centre space, we are seeing more clients looking for a smaller central HQ that's supported by other offices located closer to where employees live."

Partnering with flexible workspace provider IWG involves less commitment and less expense than leasing a local office network bit by bit. The scalability of flex space is another critical benefit: businesses can increase or decrease their space at short notice, depending on how much is needed.

"Some companies are currently locked into leases," Dixon explains. "But when these expire, these clients are increasingly set to make the shift into more flexible hybrid space."

Hybrid working also empowers employers to recruit and retain the best people regardless of geographic location, Dixon says. This broadening of the talent pool will make firms more competitive and thriving in the long term.

Finally, says Dixon, there's a question of "enlightened self-interest" at play when it comes to the relationship between hybrid working and the bottom line: "A better work-life balance makes for happier, more engaged and productive employees who will stay with a company for longer."

Furthermore, a study by EY shows that companies can save about ZAR 165 000 for each employee that works in a hybrid manner. Not only are cost savings promised by a reduction in staff turnover, but having fewer people at the HQ every day and cutting overheads accordingly can pay dividends.

BETTER FOR THE PLANET

The third reason the hybrid approach is being widely adopted – with firms as diverse as Google and Barclays Bank now committed to it – is that it's a sure-fire way to bolster a business's sustainability goals.

That hybrid working is better for the environment is "an obvious fact," insists Dixon. "Commuting is the single biggest contributor to carbon emissions globally, so cutting long commutes by car or train [can make a significant difference]."

However, he argues, "This doesn't mean that people should be restricted to working from home. The key is to reduce the commute by ensuring people have everything they need closer to home. Hybrid working can help to deliver this concept.

It's an approach to planning that involves ensuring offices, retail, and other facilities are close to residences so that interlocking, self-sustaining neighbourhoods can be formed – enabling people to access whatever they need on foot in a quarter of an hour or less.

"IWG has already seen record growth this year," says Dixon. "Importantly, this growth includes rapidly increasing demand for workspaces in the heart of communities, close to where employees live."

He adds that "2020 hit the accelerator" on CEOs' readiness to embrace the hybrid model and argues that the pandemic will have lasting effects on the way we live and work. "Hybrid working is the future," Dixon concludes. "And it's coming to life around us right now." wn

About IWG

Sustainable energy is about more than just power

Government's progressive stance towards the use of alternative energy sources, which aims to have 25% of the country's electricity provided through renewables by 2030, promises a far-reaching impact on the sustainability, not only of power supply but also in the areas of social and environmental sustainability.

As part of South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), a 30% weighting of government's consideration of Independent Power Producers (IPPs) hinges on the bidder's contribution to local socio-economic development over a 20-year timeline.

Jan Fourie, General Manager in Sub-Saharan Africa of Norwegian renewables giant and recent Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP) tender award winner, Scatec, explains the development of their comprehensive sustainability strategy is both well-rounded and holistic.

"It is also congruent with the 17 key sustainable development goals (SDGs) outlined in the UN's 2030 Agenda," he says.

To achieve this, Scatec engages in collaborative visioning, working closely with their host communities to create a lasting positive impact over the long term.

"We're part of something that's good for everyone", Fourie expands,

"IPPs and our host communities are bringing about a socially just transition to cleaner energy, which is also resulting in a fairer distribution of skills and jobs in the country."

Scatec employed approximately 1 900 people directly in SA during the peak construction period of the Round 4 Upington Solar Complex, whose surrounding towns and communities benefit from the knock-on economic effects of these jobs.

Fourie articulates the company's take on employment as a sustainability-oriented IPP: "We want people from our host communities as part of our operations at every level. We run internship programs in the areas where we operate to upskill and empower people and have local people in our offices in highly skilled technical and leadership positions. When we understand each other better, we all operate better.

"For example, a plant manager who is from the local community understands the nuances of the particular context and can manage operations more fluidly at an inter-personal level," he says.

IPPs like Scatec also assist with indirect employment by outsourcing various roles - like maintenance and vegetation control - to small local companies based in project site areas.

Fourie adds that Scatec also ensures the sustainability of their suppliers in terms of raw-material sources, carbon intensity and labour practices.

"An ethical supply chain is paramount, and we will not support unsound environmental practices or structural violence against marginalized people in the form of unjust working conditions."

Scatec's strategic goals for integrated community development over the next 20 years revolve around five key pillars: education, youth development, local economy, well-being, and community visioning.

To achieve these goals, they're partnering with various experts, government representatives, and leaders within the communities, such as principals, pastors, and CEOs.

In every sense, people from the project areas are stakeholders, having partial ownership of the company in the form of shares held by community trusts.

Fourie elaborates, "We want to help solve whatever particular problems and challenges our host communities face. Revenue generated through the community trust's shareholding and the project's socio-economic development contribution, which is a percentage of revenue, is used for a variety of social-benefit programmes like clinics, construction of community facilities, co-ops to create jobs, and efforts to assist schools with specific challenges in education."

Fourie explains that Scatec's role within communities as conscientious custodians is not motivated simply by a desire to comply and adhere to regulations.

"It makes strategic business sense too. We're going to be a part of the social fabric of these communities for decades to come, and in many ways, the fates of IPPs and their host communities are intertwined. Thriving, sustainable communities are what we need and what we work towards, both for the social development of our people and to succeed as a company," concludes Fourie. wn

New hope for renewables to ease SA's energy woes

There is a new urgency in South Africa's energy sector following the lifting of the threshold for companies to produce their electricity – and it could breathe new life into the renewable energy sector.

BYI GRAHAM ABRAHAMS
SENIOR VICE PRESIDENT
ELECTRIFICATION PRODUCTS DIVISION
AT ABB SOUTH AFRICA

President Ramaphosa's recent lifting of the threshold for companies to produce their electricity without a licence to 100MW has changed the game for renewable energy – and indeed, the entire energy sector - in South Africa.

It's an essential step towards establishing energy security, critical for our country's economic recovery.

It will enable companies to build their energy facilities to cater to their own needs. These projects will also be able to 'wheel' surplus energy to the grid, which will help ease a prevailing supply deficit estimated to be in the region of 5,000MW.

How much of a difference can 100MW make to the broader energy landscape? More than you may think. According to the national power producer, 1MW of electricity can power 650 average homes - which means 100MW can power the entire residential power needs of a city the size of Kimberley, which has a population of 140,000.

While the announcement of the new threshold isn't explicitly aimed at renewables, it's clear that it will provide fresh impetus to South Africa's renewable energy sector.

This is at a time when our power grid is facing a significant transformation driven by the need to integrate renewable energy, improve energy efficiency and allow consumers more control over their energy consumption.

Earlier this year, the South African Department of Energy launched the long-awaited fifth round of the Renewable Energy Independent Power Producer Procurement Program (REIPPPP), seeing it procure 1,600MW

of onshore wind 1,000MW of solar photovoltaic capacity.

The IPP (Independent Power Producer) Office is also set to open bidding for 3,000MW of gas-to-power, 1,500MW of new coal and 513 MW of battery energy storage in the coming months.

The country's biggest challenge isn't necessarily creating new sources of power, though. It's how to move as much electricity as possible from new generation sites, whether renewable or not, without impairing the function of the power network that needs it.

ENERGY STORAGE

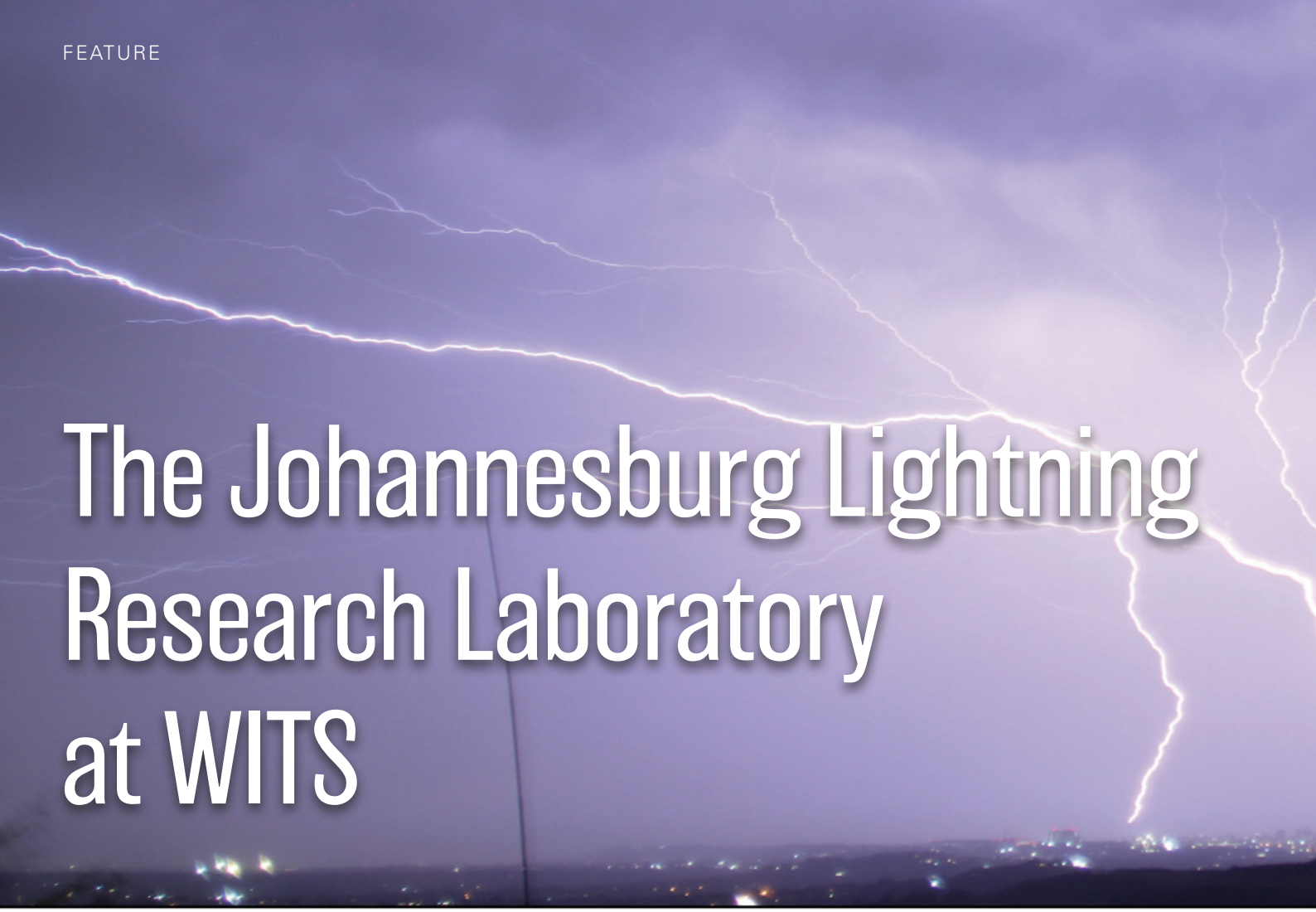
That's where modern battery energy storage systems (BESS) play an essential part in transforming the energy grid by driving wider adoption of renewable energy solutions and helping to improve grid stability. BESS solutions level out load peaks and connect more renewable energy to existing electrical networks by balancing the sometimes inconsistent renewable power supply.

South Africa intends to decommission several coal-fired power plants by 2030 as it diversifies its energy mix to include solar and wind projects. In addition to voltage control, it also stores surplus energy from wind and solar farms, which can later be used to level out peaks in grid loading.

This way, renewable power can be put to the most efficient use possible. This doesn't just increase grid reliability but supports a longer-term vision of decarbonising energy generation and making sure more of South Africa's coal-dominated energy mix comes from renewables in the coming decades.

Ultimately, the key to realising the new power grids of the future is the digital solutions that enable it. ABB Ability ™ offerings can help with remote management of energy storage. In recent months the ABB Ability™ team in Italy installed an Electrical Distribution Solution System (EDCS) – now renamed, Energy and Asset Management system - that can monitor electrical distribution points; this system is available globally. This can be done via a cloud-computing platform that allows managers access to an ecosystem of features that used advanced algorithms and machine learning to continuously improve the site's energy efficiency and power asset management.

With safe, smart and sustainable solutions available to transform how we manage energy efficiency, the future is indeed now. wn



The Johannesburg Lightning Research Laboratory at WITS

Johannesburg is a unique city – it has a lightning flash density between 11 – 18 flashes/km^2/year which, while significant, is not the highest (this is reserved for locations such as the Democratic Republic of Congo and Venezuela).

BY I H.G.P. HUNT
C. SCHUMANN
J.R. SMIT

However, it is rare to find a country's main economic and industrial centre in such a high lightning flash density area. This not only makes it a location where lightning protection is imperative, but also a location ideal for studying lightning – both the physics of the natural phenomenon and the practical effects.

Much research on lightning is conducted in High-voltage laboratories, where the effects of lightning can be simulated or approximated, but the achievable distances (lightning travels kilometres from the clouds to the ground) mean generating and studying real lightning in a high-voltage laboratory is not possible.

The Johannesburg Lightning Research Laboratory (JLRL) project aims to turn Johannesburg into a laboratory where lightning events can be measured and characterised through the use of high-speed cameras, direct current measurements, fast electric field measurements, field mill measurements and comparison with lightning location systems (such as the South African Lightning Detection Network (SALDN)).

In comparison, other locations around the world where well-known lightning studies take place are:

- Tokyo has 5 flashes/km^2/year [1],
- Austria has 2-4 flashes/km^2/year,
- Germany 2-3 has flashes/km^2/year,
- Switzerland has 1-1.5 flashes/km^2/year [2],
- Rapid City 6-10 flashes/km^2/year,
- Toronto has 1.5-3 flashes/km^2/year [3]
- São Paulo has 10 flashes/km^2/year and

Figure 1: Johannesburg city profile, with the Sentech and Telkom tower visible.

- Belo Horizonte has 7 flashes/km^2/year [4].

Johannesburg also has two tall communication towers - the Sentech tower and the Telkom tower. Figure 1 shows a photograph of the Johannesburg city centre taken from the North looking South-East through the city. Both the Sentech tower and the Telkom tower can be seen. The towers are both approximately 250 m tall and are about 4 km apart. Tall towers are often sought after for studying lightning, as they are struck often. They also resemble the type of lightning (upward lightning) wind turbines are susceptible to.

HISTORY

As many readers of this article will know, South Africa has an incredibly strong history of lightning research. Beginning with some of the first camera observations of lightning events and subsequent strokes by Sir Basil Schonland (who founded the Bernard Price Institute at the University of the Witwatersrand) to the lightning current measurements performed by Dr Andrew Erikkson and team on the CSIR tower and the early electric field measurements by Proctor et al. [1-6]. In more recent years, the work done by Professor Ian Jandrell and Professor John Van Coller and the broader Lightning/EMC research group at the University of Witwatersrand, Johannesburg has

Figure 2: Dr Carina Schumann and her high-speed camera setup. Cameras pointing South-East through Johannesburg city.

covered many lightning research areas such as: lightning protection, earthing, surge protection, lightning detection networks, lightning forensics, injury mechanisms, keraunopathology and the physics of lightning.

It is out of this research group that The Johannesburg Lightning Research Laboratory has grown. Based in the School of Electrical and Information Engineering at the University of Witwatersrand and forming one of the laboratories in the Centre of Excellence on High Voltage Engineering (CEHVE) the JLRL team hopes to continue the strong legacy of ground-breaking lightning research of not only the University of the Witwatersrand, but of South Africa as a whole.

HIGH-SPEED VIDEO FOOTAGE

The JLRL project began with high-speed video observations over Johannesburg during the 2017 to 2018 summer thunderstorm season. These were conducted by Dr Carina Schumann, Brazil, who had joined the research team as a post-doctoral fellow. Dr Schumann was already an emerging researcher with experience of filming high-speed videos of lightning in Brazil and the USA. High-speed studies of lightning are incredibly useful as they allow the whole phenomenon to be characterized, as has been shown by Saba et al., Warner et al., Mazur et al. and Jiang et al. show this for example [16-19]. In 2017, she made the first high-speed video captures of lightning in South Africa since Sir Basil Schonland capture a lightning event with his Boys camera in the 1930s! Some of these images of which were published in the September 2018 WattNow lightning issue. Dr Schumann is shown in figure 2, along with the high-speed camera setup and view over Johannesburg. Johannesburg has shown itself to be an ideal location for lightning observations, as the thundercloud base is high, allowing cameras to capture the complete channel of lightning events.

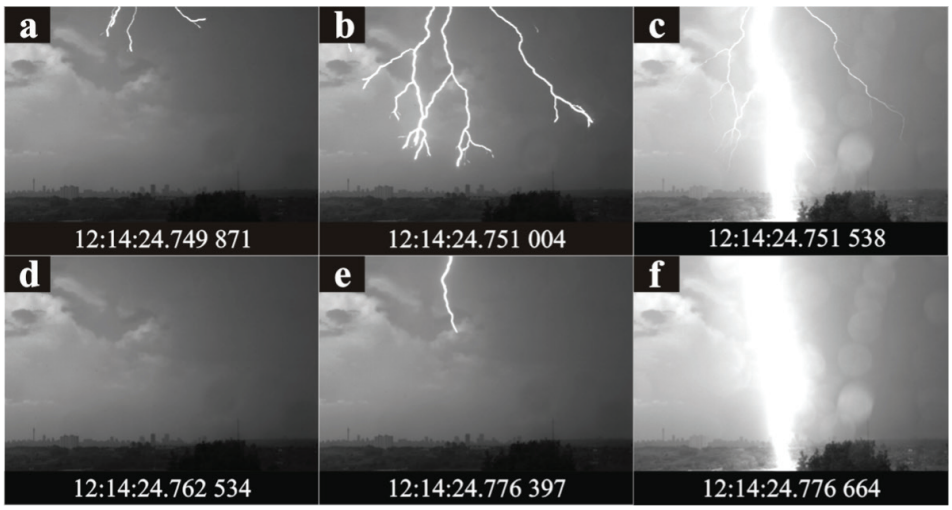


Figure 3: High-speed image of a downward negative lightning flash over Johannesburg, South Africa.

Figure 3 (a-f) shows an example of a high-speed video capture of lightning over Johannesburg, South Africa. The lightning flash captured is a downward negative cloud-to-ground flash. We can tell it is a downward negative flash from the branching seen in the leader propagation in frames (a) and (b) (notice the time difference between frame (a) and (b) is only 33 microseconds!). A positive event would typically have

far less branching and an upward event would branching towards the clouds. The return stroke – the actual connection to ground, where electrical current flows – is seen in frame (c). This current then dies in frame (d) after about 10 milliseconds but activity begins in the channel again in frame (e). Then, in frame (f), we have another stroke, referred to as a subsequent stroke. These multiple strokes are what cause the 'flickering' effect one might notice in a lightning flash when observed with the naked eye.

LIGHTNING CURRENT MEASUREMENTS AT THE SENTECH TOWER

A key part of the JLRL is the recently installed current measurement system on the Sentech tower – this allows us to make direct measurements of the lightning currents when the tower is struck. The system is a custom designed DEHNdetect measurement coil system as described by Birkl et al. [9]. The system consists of two coils to measure both peak currents and lower magnitude continuing currents - particularly important for ICC found in upward lightning events. A similar system has been installed at the Gaisberg and Peissenberg towers.

Unlike many instrumented towers in other locations around the world, the Sentech tower does not penetrate the cloud base making the whole lightning event visible - invaluable for correlation between high-speed video and direct current measurements.

Figure 4 shows the first current measurement made at the tower on 5 October 2020 at 13:07:21 UTC - The full clip can be viewed here. This was a rare downward negative flash to the tower (with 50 kiloamp peak current!), which usually has upward events. More than 50 lightning current measurements have been made over the 2020 to 2021 thunderstorm season.

More common, however, are upward lightning events with current waveforms as shown in figure 5. Here, we can see the flash began with an initial slow rising current typical of upward lightning events.

Soon after, pulses on top of the slow rising current occurred (referred to as ICC pulses or ICCP). Once the slow rising current has died, subsequent Return Strokes (RS) followed. Table 1 summarises these events over the 2020 to 2021 thunderstorm season. A total of 32 flashes to Sentech tower had both subsequent return strokes and ICC pulses. The other events were all just slow rising initial continuing current without any pulses.

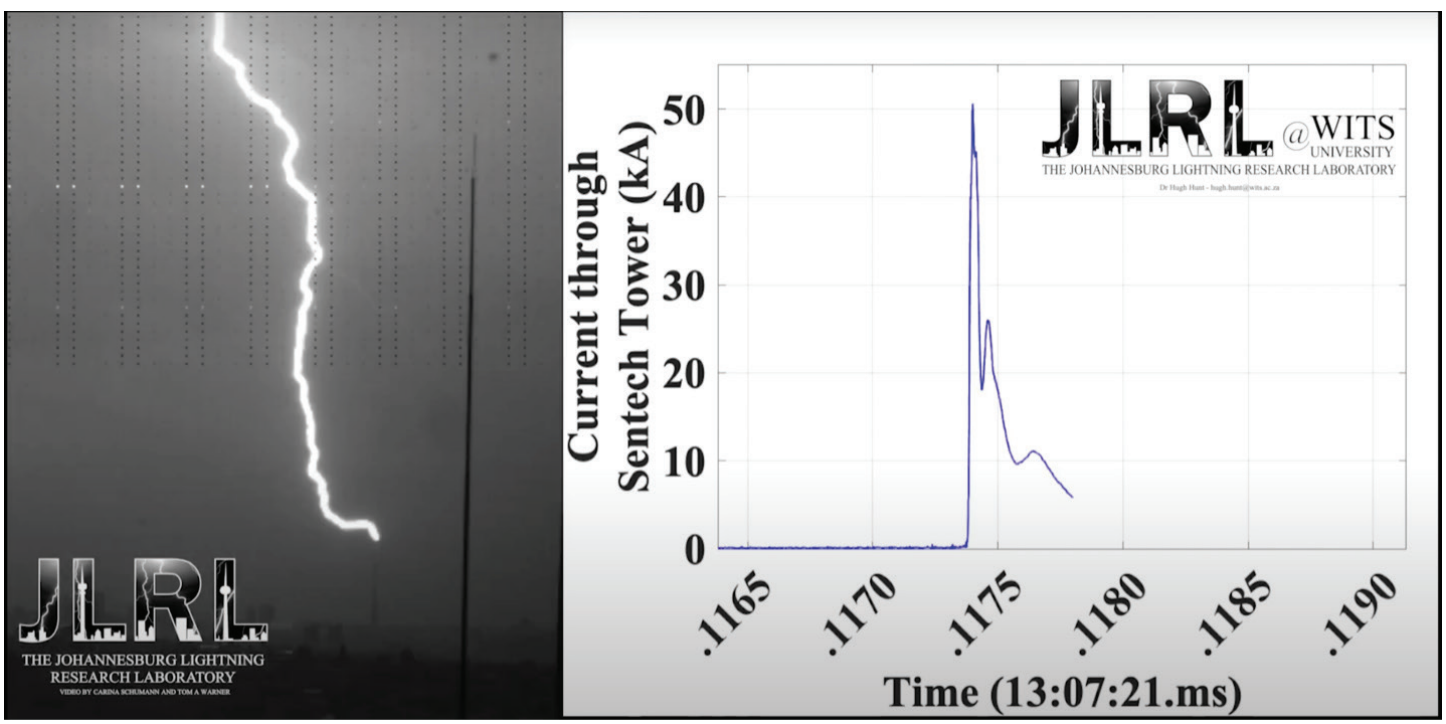


Figure 4: The first lightning current measurement made at the Sentech tower on 5 October 2020 at 13:07:21 UTC. A rare case of a downward lightning event to the tower. The full clip can be viewed here.

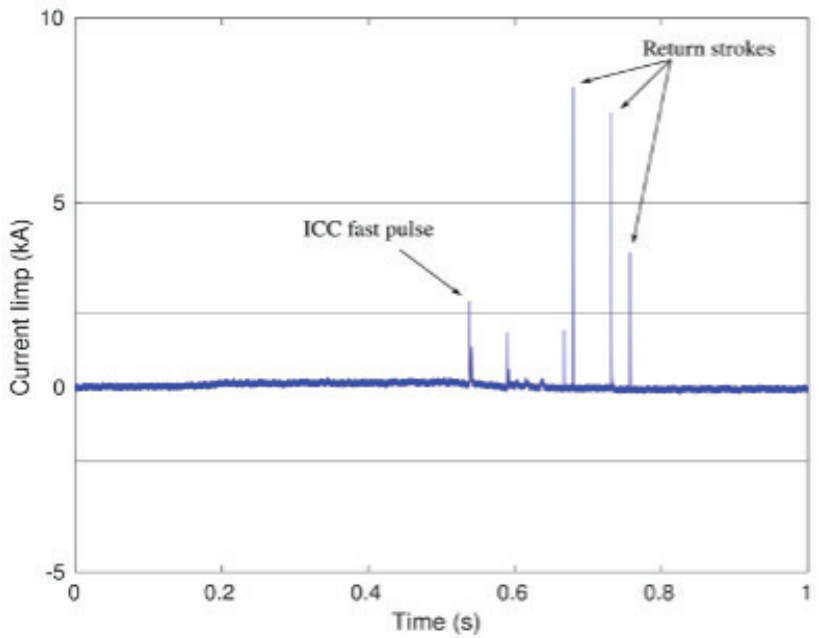


Figure 5: A typical upward lightning current waveform measured at Sentech tower during the 2020 to 2021 thunderstorm season.

SAFETY AND AWARENESS

The JLRL also aims to distribute the knowledge and research gained to the broader South African (and African) community. This is done through a number of key partnerships specifically, the South African Institute of Electrical Engineers (SAIEE), the African Centre for Lightning and Electromagnetics Network (ACLENet), the Earthing and Lightning Protection Association (ELPA) of South Africa and the South African Weather Service, whom which the JLRL team works closely. The JLRL team also regularly speaks to schools and students in the Johannesburg area, as well as sports groups and other communities. We hope to expand this to other regions of the country going forward.

IN SUMMARY

While still under development, a number of future plans are in consideration for the Johannesburg Lightning Research Laboratory. With the support of Telkom, we hope to install a second current measurement on the Telkom tower in Hillbrow, Johannesburg, allowing for two direct current measurements to be made in the same region. Plans are also underway for installation on Wits University campus, with particular focus on studying upward initiating leaders in collaboration with Dr Marcelo Saba from the Brazilian National Institute for Space Research.

THANKS

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CARINA SCHUMANN has been studying the physics of lightning around the world through high-speed cameras for over 10 years. Originally in Brazil, she has observed lighting in the United States of America, Austria and South Africa. She graduated from the Federal University of Itajubá with a degree in Physics and completed her PhD and MSc in Atmospheric Electricity at the Brazilian National Institute for

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JASON R SMIT is an electrical engineer and completed his BSc. Eng (Electrical and Informational Engineering) at the University of the Witwatersrand, South Africa. He also has BSc. Eng in Biomedical Engineering. He is currently completing his Masters of Science in Engineering through the University of the Witwatersrand and evaluating the lightning return stroke models at mid-range distances specifically for Johannesburg. He is also laboratory manager at the Johannesburg Lightning Research Laboratory.

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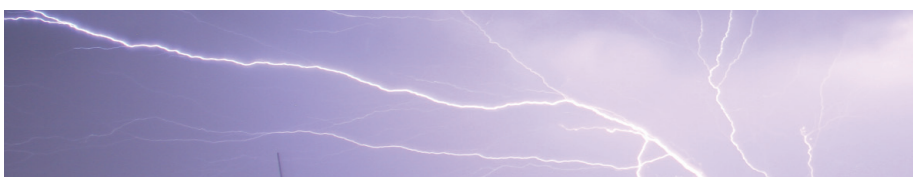

Billions of lightning bolts may have jump-started life on Earth, study suggests

How did Earth get the phosphorus it needed to make the first DNA and RNA molecules? The answer may be crackling through the sky.

BY | BRANDON SPECKTOR

Life on Earth may have begun with a flash of lightning.

No, an errant thunderbolt didn't literally animate the world's first microbes (sorry, Dr Frankenstein). But according to a new study published in March 2021 in the journal Nature Communications, trillions of lightning strikes over a billion years of Earth's early history may have helped unlock crucial phosphorus compounds that paved the way for life on Earth.

"In our study, we show for the first time that lightning strikes were likely a significant source of reactive phosphorus on Earth around the time that life formed [3.5 billion to 4.5 billion years ago]," lead study author Benjamin Hess, a graduate student at Yale University's Department of Earth and Planetary Sciences, told Live Science. "Lightning strikes may have therefore played a role in providing phosphorus for the emergence of life on Earth."

BOMBARDED WITH LIFE?

How does a bolt from the blue lead to terrestrial life? It's all about the phosphorus — or rather, the organic materials that phosphorus atoms can make when combined with other bio-essential elements.

For example, phosphates are composed of three oxygen atoms and one phosphorus atom, which are crucial to all known forms of life.

Pic 1: An artist's rendition of the early Earth environment. Lightning generated by storms and volcanic plumes frequently strikes volcanic rocks. The lightning strikes create fulgurites that contain phosphorus in a form that can be dissolved in water and concentrate in waters like volcanic ponds. Here, phosphorus can form biomolecules that help lead to the emergence of life. (Image credit: Lucy Entwisle)

Phosphates form the backbones of DNA, RNA and ATP (the chief energy source for cells) and are significant components of bones, teeth and cell membranes.

But about 4 billion years ago, while there was likely plenty of water and carbon dioxide in the atmosphere to work with, which are also essential for life's fundamental molecules, most of the planet's natural phosphorus was bound up in insoluble rock, and impossible to combine into organic phosphates. How, then, did Earth acquire these critical compounds?

One theory holds that early Earth got its phosphorous from meteors carrying a mineral called schreibersite, which is made partly of phosphorous and is soluble in water. Suppose loads of schreibersite meteorites crashed into Earth over millions or billions of years. In that case, enough phosphorus could be released into a concentrated area to create the right conditions for biological life, according to the new study.

However, about 3.5 billion to 4.5 billion years ago, when life on Earth emerged, the rate of meteor strikes on Earth dropped "exponentially" as most of our solar system's planets and moons had primarily taken shape, Hess said. This fact complicates the interstellar phosphorus theory.

However, there is another way to make schreibersite, right here on Earth, Hess said. All it takes is some land, a cloud and a few trillion jolts of lightning.

BILLIONS OF BOLTS

Lightning strikes can heat surfaces to nearly 5,000 degrees Fahrenheit (2,760 degrees Celsius), forging new minerals that weren't there before. In the new study, Hess and his colleagues examined a lightning-blasted clump of rock, called fulgurite, which was previously excavated from a site in Illinois (See pic 2). The team found that little balls of schreibersite had formed within the rock, along with a host of other glassy minerals.

With tentative proof in hand that lightning strikes can create phosphorus-rich schreibersite, the team next had

Pic 2: The main body or "trunk" of the studied fulgurite or glass is created from a lightning strike. The team found traces of schreibersite inside, suggesting lightning could have delivered crucial phosphorus compounds to early Earth. (Image credit: Benjamin Hess)

to calculate whether enough lightning could have struck early Earth to release a significant amount of the element into the environment. Using models of Earth's early atmosphere, the researchers estimated how many lightning strikes might have fallen over the planet each year.

Today, about 560 million lightning bolts flash over the planet a year. Four billion years ago, when Earth's atmosphere was significantly richer in the greenhouse gas CO_2 (and therefore hotter and more prone to storms), it's likely that anywhere from 1 billion to 5 billion bolts flashed each year, the team calculated. Of those bolts, the team estimated that between 100 million and 1 billion bolts struck land each year (the rest discharged above the oceans).

And, over a billion years, up to a quintillion (a one followed by 18 zeros) lightning strikes may have hit our young planet, each one releasing a bit of usable phosphorus, Hess said. The team calculated that, between 4.5 billion and 3.5 billion years ago, lightning strikes alone could have given Earth anywhere from 250 to 25,000 pounds of phosphorus (110 to 11,000 kilograms) per year.

That's a vast range, with a lot of uncertainty about the conditions of early Earth built into it. But Hess said that even the lowest quantity of phosphorus could have made a difference in the emergence of life.

"For life to form, there just needs to be one location that has the right ingredients," Hess told Live Science. "If [250 lbs.] of phosphorus a year were concentrated in a single tropical island arc, then yes, it may well have been enough. But it's more likely that will happen if there are many such locations."

Whether lightning did strike enough exposed land on early Earth to impact life is a question that can never be fully answered. However, the new study shows that, mathematically, it was at least possible.

It may be that a combination of asteroid impacts and lightning strikes ultimately gave Earth the phosphorus it needed to weave the first bio-essential molecules, such as DNA and RNA, the researchers concluded. But further studies of early terrestrial life should take care not to strike lightning from the record. wn

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Lightning Detection and Location
- Quality parameters that matter and why

This article sets out to share the details of the aspects of an LLS (Lightning Location System) that matter when the empirical data obtained from it will be applied to business productivity and asset management as a risk management tool. IEC 62858: "The performance characteristics of an LLS determine the quality of the lightning data available"

** Earthing and Lightning Protection Association ** Johannesburg Lightning Research Laboratory, School: Electrical and Information Engineering*

Our understanding of lightning has developed with our ability to detect it and observe its behaviour. In the early 1740's, Benjamin Franklin discovered some experiments from other scientists and initiated an experiment with a kite (1752) being lucky enough not to kill himself. With these scientific experimental "close-encounters", he realised the dangers and set about trying to prove that lightning was electricity. A Swedish scientist, Georg Wilhelm Richmann wasn't so fortunate when he attempted (1753) to repeat the experiments and was fatally wounded from a side-flash.

To adequately protect ourselves from the threat of lightning, we need to understand the inherent details of each lightning stroke. With the advance in technology, scientists have managed to extract increasing "snippets" of information. In the "laboratory", the discharge was dissected using safer techniques than that used by Franklin and Richmann – using Boys camera amongst others, and insulated towers, identifying and characterising different parts of the discharge. The study of lightning for applied protection, concentrated on identifying the frequency with which lightning occurred and where, then combining this knowledge with the laboratory studies. To accomplish this task more effectively, lightning detectors were developed that could measure the electromagnetic surge from a lightning discharge.

Fig 1: Detecting lightning can be fatal - Georg Richmann, Petersburg, 1753

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With lightning occurring every minute of every day, in approximately 2,000 thunderstorms at any one time covering at least 10% of the earth's surface, technological advances remain focused on improving our ability to detect the lightning.

Before proceeding, familiarise yourself with or cross-reference to the list of definitions and abbreviations applicable to the subject matter of this article.

LIGHTNING LOCATION SYSTEMS (LLS)

Single detectors were used to characterise localised lightning trends.

Over time, technology has allowed us to establish a matrix of lightning sensors that produce information that can collectively be analysed to report the position of a lightning stroke, the time when it occurred and the approximate peak current, globally.

An LLS with many sensors, covering a large geographical area, is also commonly referred to as a Lightning Detection Network (LDN).

Such networks are usually of a modular nature where additional sensors can be added to the network to improve the performance parameters of an existing coverage area (CA) or to expand the CA to include more end-users or more target areas (TA).

In South Africa, the SALDN (Southern African Lightning Detection Network), owned and operated by the South African Weather Service (SAWS) is such an example and currently has 25 sensors. See figure 2.

CG (CLOUD TO GROUND) LIGHTNING FLASH AND STROKES

A CG lightning flash is made up of one or more lightning strokes where a stroke is by definition a lightning discharge between cloud and ground. The CG flash will contain at least one lightning stroke (known as a "first return stroke") which has managed to breach the gap between cloud and ground. Intra-cloud or inter-cloud lightning (IC) may be linked to the CG flash but for the purposes of applying empirical data from an LLS as a risk management tool, we will concentrate only on the detected stroke components of the CG flash.

Where a CG flash has more than one stroke (known as "subsequent return strokes") these utilise the same path or part of the path of the first stroke. The nett result is that the group of strokes, also containing other lightning elements, may transfer a sustained burst of energy into the ground.

A successful LLS will detect individual lightning strokes and geolocate the point at which they terminated.

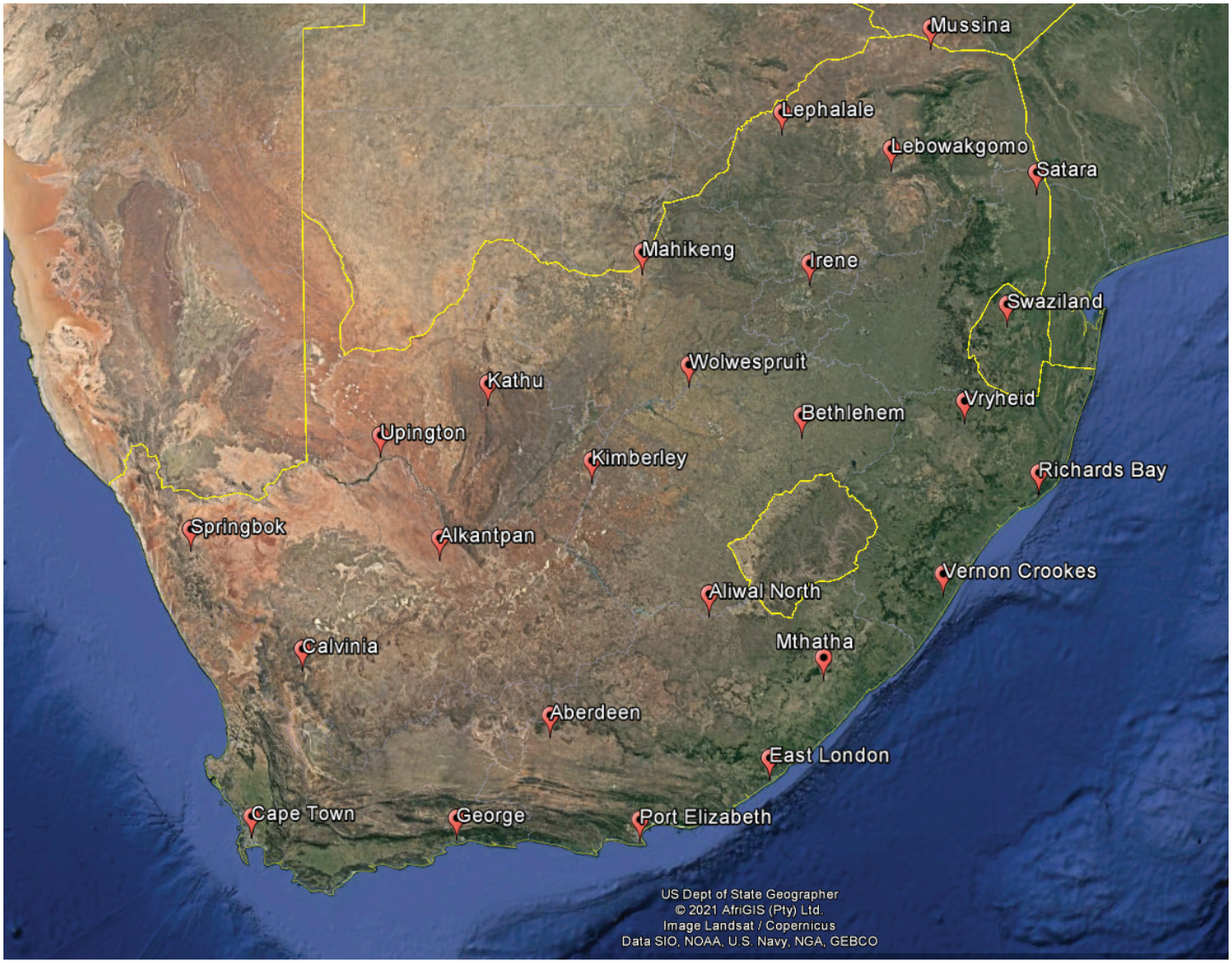

Fig 2: SALDN LLS network of sensors
Modern-day LLS are implemented world-wide with varying degrees of success.

Mathematical criteria have been stipulated in IEC 62858 by which individual strokes are identified as part of a CG flash.

LIGHTNING RISK MANAGEMENT

The lightning current of a single flash may transfer an enormous amount of energy into a structure resulting in severe or catastrophic damage.

Effective long term asset management requires sound risk management strategies to reduce the damage caused by lightning.

Lightning protection to eliminate damage to buildings and equipment requires an inherent understanding of the withstand levels required to sustain available life and value of assets.

Therefore, the frequency of lightning discharges, where they occur, and lightning peak current magnitude are all extremely important to understanding which preventative measures are necessary.

The central element to quantifying the appropriate risk treatment for the threat of lightning is the lightning ground flash density (GFD or NG) values which describe the severity of lightning at the site where the risk has to be managed. Lightning data from an LLS compliant with international standards, can be used to compile GFD data for this purpose.

In a perfect world, an LLS should

- detect every lightning stroke that occurs,
- at the correct location,
- at the correct time, and
- report the correct peak current magnitude.

The IEC has established two standards for lightning detection:

- IEC 62858 as the standard for LLS (Lightning density based on lightning location systems (LLS) - General principles) for purposes of risk management.
- IEC 62793, as a secondary standard (Protection against lightning - Thunderstorm warning systems) provides additional supporting detail pertaining to LLS.

LLS PERFORMANCE PARAMETERS

In advanced modern LLS, the sensors will detect aspects of the radiated magnetic and electric fields, employing timing techniques and wave-frontal analysis to the detected signal to qualify the location, time, and peak current of each lightning stroke.

As with all measuring systems, a degree of error is inherent to the process and these errors must be acknowledged and factored into the risk analysis.
The following concepts are therefore central to a qualifying lightning location system:

- Detection efficiency (DE) – Ideal = 100%:
- Location accuracy (LA) – Ideal = error to be less than size of smallest asset;
- Peak current (measured in kA).

IEC 62858 defines detection efficiency as the "percentage of strokes or flashes detected as a percentage of the total number of strokes or flashes occurring in reality".

There is no purpose in discussing the location of a lightning stroke or the peak current if the lightning stroke has not been detected.

IEC 62858 defines Location accuracy (LA) as the "distance between the real stroke location and the stroke location given by the lightning location system".

DETECTION EFFICIENCY (DE)

A minimum lightning detection efficiency requirement for an LLS to generate lightning data for the purposes of lightning threat risk management as stipulated in SANS 62305-2, is defined in IEC 62858 as:

- Annual average flash detection efficiency of an LLS for CG (cloud to ground) lightning shall be at least 80 % in the region over which NG has to be computed
- Lightning Flash DE ≥ 80%
- (N_G is the symbol for lightning ground flash density GFD in CG flashes per km^2 per year).

Two factors that will influence detection efficiency are:
1. False detection; and
2. Redundancy.

FALSE DETECTION

The methods applied in different LLS to locate the lightning stroke termination point on the ground will influence the required number of sensors that must be simultaneously operational to detect the lightning.

The different technologies used in LLS fall outside the scope of this discussion but suffice to say that advanced modern LLS that utilise both electric and magnetic fields have more permutations available to discern between lightning and non-lightning sources.

REDUNDANCY

To detect lightning, sensors capable of responding to and measuring electromagnetic waves are required. To obtain a positive confirmation that the source of the measured electromagnetic waves is lightning, the signatures and behaviour must comply to predefined criteria.

Consider these minimum requirements to be an eyewitness, detecting and locating the lightning stroke.

Where more than one eyewitness detects and locates the same lightning stroke, one may argue that the second eyewitness is not required. In truth the second eyewitness is "redundant" (meaning: strictly not required).

In high risk production facilities with critical path processes, "a high degree of redundancy" means greater security of the production line. If a critical part fails, there is immediate backup in place.

In an LLS, increased redundancy, decreases the probability that a lightning stroke will not be detected.
In an LLS, detection redundancy however, is not solely a backup detection strategy. The additional lightning sensors serve a duel purpose of also improving the location accuracy.

LOCATION ACCURACY (LA)

A maximum lightning location error requirement for an LLS to generate lightning data for the purposes of lightning threat risk management as stipulated in SANS 62305-2, is defined in IEC 62858:

- The value of the median location accuracy of an LLS for CG strokes shall be better than 500 m in the region over which NG has to be computed.
- Lightning Stroke median LA < 500m

Two primary methods of correlation are used in LLS technologies to quantify the point of origin of a lightning stroke. Using different electromagnetic field detection technologies, they also have differing minimum requirements.

- Difference of timing delay for the measured signal to reach each sensor and is known as "Time of Arrival" or ToA.
  A minimum of 4 sensors must report this signal if only this technique is applied;
- Angle of incidence of the radiated wave that reaches each sensor and is known as "Magnetic Direction Finding" or MDF.
  A minimum of 2 sensors must report this signal if only this technique is applied.
- Combining ToA and MDF offers additional permutations to achieve both the DE and LA objectives.

LIGHTNING PEAK CURRENT ESTIMATION

For the purposes of lightning threat risk management as stipulated in SANS 62305-2, lightning current parameters are predefined from extended research studies as revised and approved by CIGRE (the International Council on Large Electric Systems) and adopted by the IEC.

While the empirical lightning current values do not procedurally contribute to the design considerations in 2021, they will be relevant in the national risk management strategies to reduce lightning related fatalities, damage to properties and disruption to services.

SANS 62305 addresses lightning current in generalised terms qualified in the lightning protection level (LPL) understanding that the associated maximum and minimum lightning current design values for the applied lightning protection measures will not be exceeded in naturally occurring lightning.

The radiated electromagnetic wave in a lightning stroke is a function of the lightning current in the channel. Therefore, the magnitude of the raw signal received by each lightning sensor in an LLS conveys some perspective of the original lightning current of the stroke it has detected.

The signal arriving at the sensor is not a constant value but rises and falls just as any wave does – visualise the tsunami wave at sea as it passes through any point.

By capturing peak value of that wave, a reference point exists that can be cross-correlated to distance, final calculation of location, speed of wave, etc. With appropriate application of the science of physics, it is possible to determine a theoretical value of lightning current.

An advanced LLS will be able to deliver consistent values of lightning peak current (in kA) for lightning strokes anywhere within the boundaries of the CA. Modern-day LLS should also be able to retrospectively re-assess lightning solutions as more accurate approximations are discovered through the study of new empirical data.

Those outcomes will in turn improve risk management strategies and our SANS. It is for this reason it is considered a requirement when the validation reports of an LLS are considered.

TIMING ACCURACY

Alongside lightning peak current, accurate timing of lightning strokes does not form part of the IEC 62858.

However, modern-day LLS equipped with GPS synchronisation, should be able to report lightning stroke contact times in nanosecond resolution and therefore should be able to distinguish between lightning strokes that occur nanoseconds apart from different flashes.

In addition, LLS with ToA rely on accurate timing to improve location accuracy.

LIGHTNING CLASSIFICATION

We briefly mentioned, IC lightning, known as intra-cloud or inter-cloud lightning where an "electric discharge of atmospheric origin occurs within or among thunderclouds or between thunderclouds and air and which does not have a ground termination".

LLS do detect IC and together CG flashes make up total lightning. Discussion about the detection and location of total lightning is not part of the scope of this article.

An LLS must correctly classify CG and IC flashes. Misclassification of IC as CG lightning and vice versa will adversely influence the statistical exposure reports reporting false values of N_G.

A minimum lightning flash classification requirement for an LLS to generate lightning data for the purposes of lightning threat risk management as stipulated in SANS 62305-2, is defined in IEC 62858:

- A classification accuracy (CG flashes not misclassified as IC) of at least 85% is required.;
- Lightning Flash Classification ≥ 85%

LLS VALIDATION

The performance characteristics of an LLS determine the quality of the lightning data produced and can be evaluated using techniques explained in IEC 62858:

a) Network self-reference.
b) Rocket-triggered (or triggered) lightning and tall object studies.
c) Video camera studies.
d) Intercomparison among networks.

It is important to recognise that theoretical assessments or modelling

simulations of the LLS configuration of installed sensors in a network do not constitute validation of the performance of the LLS.

NETWORK SELF-REFERENCE

Direct description from IEC 62858 "In this technique, statistical analysis of parameters such as

- standard deviation of sensor timing error,
- semi-major axis length of the 50 % confidence ellipse, and
- the number of reporting sensors, is used to infer the LA and DE of an LLS.

- This method requires data collected by the network after it has been properly calibrated.
- It can provide a good estimate of the network's performance in a cost-effective, practical manner".

ROCKET-TRIGGERED (OR TRIGGERED) LIGHTNING AND TALL OBJECT STUDIES

Direct description from IEC 62858 "This method uses data from rocket-triggered lightning experiments or lightning strikes to tall objects (e.g. instrumented towers) as ground-truth to evaluate the performance characteristics of an LLS within whose coverage area the triggered lightning facility or the tall object is located".

The process is uncomplicated but requires considerable investment in time, finances, and skilled resources to facilitate safe measurement systems so as to not repeat the outcome of Georg Reichmann's compromised experiment in 1753 in Petersburg. Controlled hi-resolution lightning direct measurements in both studies provide known values for reported lightning

- Contact point of strokes;
- Detected CG flashes and strokes
- Peak current estimation; and
- Lightning classification.

Fig 3: Upward lightning flash to the Sentech tower captured by the JLRL - 14 October 2015 at 10:08pm

Fig 4: SALDN LLS CG flash report - 4 detected strokes - reported locations not on tower

While such data does not guarantee the same performance elsewhere in the CA of the LLS, it creates an indisputable record of performance by which to progressively improve our lightning threat management strategies.

IEC 62858 declares "These methods provide the best ground-truth data for performance characteristics validation for CG lightning."

EXAMPLE OF STUDY IN SOUTH AFRICA: WITS UNIVERSITY – JOHANNESBURG LIGHTNING RESEARCH LABORATORY (JLRL)

The JLRL undertook such a validation of the SALDN LLS, at the Johannesburg Sentech Tower in the manner as referenced in IEC 62858.

An example of results obtained from the exercise are illustrated in figures 3 and 4.

The SALDN provides the means by which to include built-in calibration data that asserts the possible area within which a known lightning stroke terminated on the ground. In effect, the SALDN pre-emptively reports a degree of location uncertainty and therefore "location error".

The reported results from the SALDN have been superimposed on an aerial image of the tower in figure 4 with the following details for each reported lightning stroke:

- Reported location denoted by the pink dot, and
- Uncertainty location error illustrated by the yellow ellipses around each pink dot.

The manufacturers of the SALDN LLS proclaim the reported location to be a single point location validated with an associated area of uncertainty. Every lightning stroke produced by the LLS is accompanied by these "confidence ellipses". With the submission of such a confidence ellipse, a risk assessor is afforded the opportunity to visually understand the area within which the lightning stroke occurred.

Several facts are evident from this ground-truth exercise by the JLRL using a tall structure:

1. Location accuracy is immediately documented per lightning stroke – with reference to the reported location point (pink dot);
2. The reported latitude and longitude of all 4 strokes in the CG flash do not align directly on the Sentech tower which was the known point of contact and therefore the principle of "location accuracy" is visually evident and cannot be ignored nor diplomatically redefined;
3. Over an extended period, the variance of the LLS can be monitored for stability through this exercise;
4. Over time, the median location accuracy can be compared to average location accuracy to be considered as a more effective engineering solution to effective lightning risk management;
5. The four results obtained here suggest a 100% reported success rate for "possible contact area" of the 4 lightning strokes.
   However, the size of the confidence ellipse must comply with the IEC 62858. The concession that a median LA limit is set at 500m also means that many individual results may not be less than 500m.
   (The median location accuracy limit aligns with the measured semi-major axis values of the 50% confidence ellipse obtained from some LLS such as the SALDN).
   Over time this may need to be reconsidered for purposes of legislation and national safety strategies. Increasing the parameter to address 99% confidence ellipse would increase the semi-major axis distance and potentially considerably higher LA values as a network performance characteristic.

6. The SALDN LLS lightning stroke reporting mechanism provides an opportunity for an internal strategy for the network owners to implement progressive network improvement simply be striving to achieve a shorter "semi-major axis" distance on reported lightning solutions.
   Doing so would realise significant remedial long term savings to the South African community.

VIDEO CAMERA STUDIES

Direct description from IEC 62858 "Lightning data obtained using video cameras can be used as ground-truth to evaluate the performance characteristics of an LLS within whose coverage area the lightning discharges occur. The LA, DE, and lightning classification accuracy of an LLS can generally be estimated using this method."

EXAMPLE OF STUDY IN SOUTH AFRICA: WITS UNIVERSITY – JOHANNESBURG LIGHTNING RESEARCH LABORATORY (JLRL)

The JLRL undertook ground truth evaluations using high speed cameras with a field of view including both the Sentech Tower and the Telkom Tower as a validation exercise in the manner as referenced in IEC 62858.

A paper was presented at the ICLP 2018 publishing the findings [Ref:]

1) Overall Flash DE: 88.3%;
2) Overall Stroke DE: 72.1%;
3) Downward flash DE: 94%
4) Upward flash DE: 66.7%
5) Overall median location accuracy: 68.5m for 71 lightning events.

These results provide international benchmark audit findings of what the SALDN LLS can deliver to South Africans. Without audits of this nature, the lightning data from any and all LLS cannot unilaterally be accepted and applied to risk management strategies.

CONCLUSION

Any LLS implemented in South Africa must be validated in the manner described in this article.

Whenever enquiring for lightning data as consulting engineer, insurance assessor, power utility asset manager, or lightning protection risk advisors, the request for due diligence reports from the LLS network owners wanting to offer the service, should be made.

Rydall Jardine, SAIEE member and Unit Manager, Technical Services, SAWS, gave a presentation at the

SAIEE Lightning Chapter meeting on the SALDN and other weather related developments that SAWS are engaged in. The purpose was to share the background of where the new South African lightning Ground Flash Density (GFD) map came from and the systems that SAWS as a management team have committed to on behalf of the South African government, committing to advancing safety for South Africans. This article has provided the framework for responsible lightning risk management which starts with qualified lightning risk exposure.

Without doubt South African engineers and asset managers, short term insurance financial service providers and industry leaders will recognise the annual risk imposed upon us in our thunderstorm season and the financial consequences of failing to apply due diligence to the risk.

IEC/SANS 62793 lays out the operations of thunderstorm warning systems (TWS) and it should be clear that TWS do not by default qualify as LLS for the purposes of risk management and accurate lightning data.

IEC/SANS 62793 asserts the following regarding performance evaluation of an LLS being applied as a TWS: "For a LLS or network of detectors based on single detectors, the performance evaluation is the responsibility of the network operator".

This has been true of the SAWS who have applied their efforts in a difficult economic climate to meeting the needs of major corporates such as Eskom and have delivered a full keraunic cycle/solar cycle of data (2006 to 2017) and audited results to deliver to South Africa an updated GFD map consistent with the inspired work delivered by the CSIR scientists of Dr Ralph Anderson, Dr Andrew Eriksson, and Dr Hendri Geldenhuys with the data set of 1975 to 1986.

The independent validation results reported by the JLRL is extremely encouraging and a scope of new development lies ahead with the South African community as primary beneficiaries. wn

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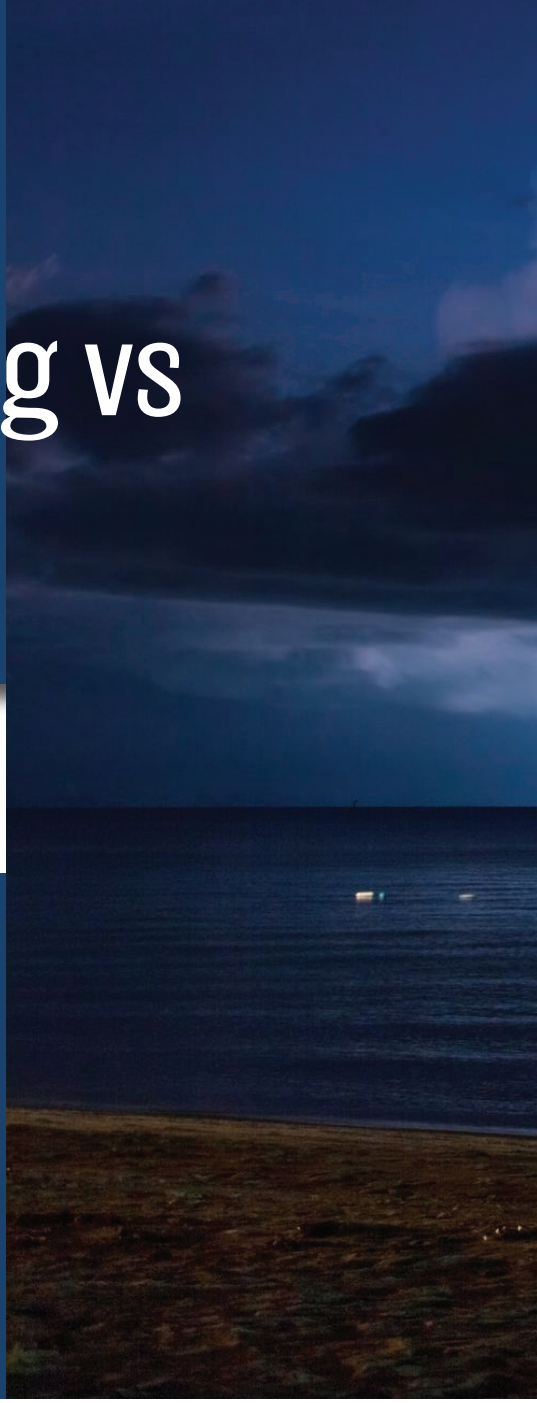
Thunderstorm Warning vs Lightning Verification



THUNDERSTORM AND LIGHTNING – IS THERE A DIFFERENCE?

Britannica defines a thunderstorm as a violent short-lived weather disturbance almost always associated with lightning, thunder, dense clouds, heavy rain or hail, and strong gusty winds (contributor: Philip Krider, Professor of Atmospheric Physics, University of Arizona). Severe thunderstorms bring with it extreme rainfall or hail and high winds, wreaking havoc on any infrastructure not prepared for the conditions.

Lightning detection has advanced to the point that the technology is available to anticipate the storm threat and take the necessary avoiding actions to prevent injury and damage.

Early warning systems' success measures differ from those required to issue lightning verification of contact incidents, and South African stakeholders must recognise those differences.

There are apparent role responsibilities for success, both the end-user and the service providers (network operators).

LIGHTNING AND STORM RISK PREPARATION

Lightning, in any thunderstorm, poses a threat to people, properties, assets, and productive processes.

Lightning acts as the electric generator in the global electric circuit, maintaining the electric charge required to sustain the global electrical balance.

A brief discussion on the global electric circuit can be found on page 64 in this issue of **watt**now.

Before proceeding, familiarise yourself with, or cross-reference to the list of definitions and abbreviations applicable to the subject matter of this article - tables are available here.

Lightning between cloud and ground, on a global scale, cannot be avoided. Continued commercialisation of claims to the contrary (diffusing the global electric circuit by human intervention) does not form part of the scope of this article.

Solutions to minimising that lightning threat are twofold:

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a. Manage the threat of thunderstorms in real-time by following a safety management plan with required lead times (LT) and a thunderstorm warning system (TWS); and
b. Implement lightning protection measures with the necessary lightning protection systems (LPS) and surge protection measures (SPM) commensurate with the risk of loss of life, permanent injury, possible disruption to services to the public, possible damage to cultural heritage sites (loss of assets can be extended to the personal historical value attached by the asset owners) and potential economic losses.

The former requires an acute awareness amongst all parties involved to act promptly upon receiving warnings and to continuously review the procedures and effectiveness of the plan and the early warning solutions.

The latter is a permanent implementation of strategies that safely facilitate the unimpeded transfer of lightning current within the global electric circuit, protecting lives and avoiding damage to property and assets.

This article sets out to clarify the concepts of contingency plans in the face of imminent storm threat on the one hand and asset management and contact incident investigations on the other.

THUNDERSTORM WARNING SYSTEMS (TWS)

Thunderstorm warning systems (TWS) provide valuable early warning information in real-time about

thunderstorm movement. Systems that constitute a TWS are described in the South African National Standard SANS 62793, adopted from IEC 62793 (Protection against lightning - Thunderstorm warning systems).

A TWS monitors natural atmospheric electric activity and lightning, providing valuable early warning information in real-time with enough time (lead time, LT) to implement "temporary lightning hazard preventive measures" – the safety management plan.

Central to the application of thunderstorm warning systems are the following:

1. Effective delivery of warnings (alarm) before the thunderstorm arrives;
2. A safety management plan with planned procedures (temporary lightning hazard preventive measures) to respond to the imminent threat;
3. The minimum semi-permanent and permanent infrastructure required within which temporary lightning hazard preventive measures can be implemented;
4. Lead Time (LT) – The warning must be received with adequate time in which to implement the safety management plan;
5. Time to Clear (TTC) – The notification that declares that the thunderstorm risk has ended, and the temporary measures can be rescinded, normal operations can resume;
6. Target or Target Area (TA) – the area, buildings or operations that will be at risk during the thunderstorm;
7. Surrounding Area (SA) – the area in which lightning can introduce damage or life risk at the TA due to (example) connected services such as electrical power lines.
8. Monitoring Area (MA) - The geographical area over which thunderstorm activity must be monitored to be able to timeously issue the warnings required at the SA and the TA;
9. Detection Efficiency (DE) - the percentage of lightning discharges detected by a sensor or a network.

TEMPORARY LIGHTNING HAZARD PREVENTIVE MEASURES

The South African Technical Report SATR 62713, adopted from IEC TR62713 (Safety procedures for reducing risk outside a structure), is a rudimentary safety procedure including the application of TWS, applicable to temporary lightning hazard preventive measures.

The role of the end-user is vital. In SANS 62793, it is the end-user who is expected to qualify the temporary preventive measures and not the TWS service provider (network operators): "The effectiveness will depend to a large extent on the risk involved and the planned decisions to be taken".

Risks may vary from

(a) people exposed to lightning in open areas. Examples are informal structures in rural communities, school grounds, open-air sporting facilities and temporary recreational facilities; to

(b) Industrial production and maintenance processes severely disrupted by lightning can lead to fatalities and permanent injury. Examples are mining operations where sudden blasts would cause fatalities and structural collapse. Electricity utility maintenance of power transformers where uncontrolled moisture ingress would cause accelerated ageing of the oil insulation. Paper production where an unplanned interruption in electrical supply would severely disrupt the control sequence leading to loss of raw materials and production time.

Therefore, the required alarms, lead times, and temporary lightning hazard preventive measures are determined according to the circumstances within the surrounding area (SA) and target (TA).

A cautionary note is issued in the SANS 62793 – Managing human safety and applying production security rests with the end-user and not the TWS service provider (network operators):

"Although this information allows the user to adopt anticipated temporary preventive measures, it should be noted that all the measures to be taken based on monitoring information are the responsibility of the system user according to the relevant regulations".

EFFECTIVE ALARMS, FAILURE TO WARN AND FALSE ALARMS

An effective alarm (EA) is a warning delivered where lightning does occur in the surrounding area (SA) during the time between when the warning was issued and the Time to Clear (TTC) notification. In other words, the TWS successfully issued a warning within the required LT.

Factors that would impede the effectiveness of a TWS are:

- Failure to warn (FTW) - where lightning does occur in the surrounding area (SA) and no warning was issued; and
- False alarms (FA) – when a warning is issued when there is no storm activity in the monitoring area (MA);

There are many reasons why a TWS service provider (network operator) may fail to issue a warning within the LT or may issue a false alarm. Detection efficiency (DE) and location accuracy (LA) are amongst several reasons and

therefore should not be confused with the other critical aspects of a TWS as being more critical.

DETECTION EFFICIENCY (DE) AND LOCATION ACCURACY (LA)

The success of a TWS whose purpose has been defined in SANS 62793 is not measured by the detection efficiency of the TWS.

Thunderstorms, by their definition, contain many lightning discharges. A thunderstorm will typically contain "clusters" of lightning flashes, each made up of one or more lightning strokes. Global lightning activity occurs every minute of every day, in approximately 2,000 thunderstorms at any one time covering at least 10% of the earth's surface.

In South Africa, the SALDN (Southern African Lightning Detection Network) detects approximately 25 million lightning strokes and a determined 10 million lightning CG flashes annually.

A TWS does not need to detect and report every lightning discharge to be deemed successful. The correct parameters must be measured and managed for that success.

SUCCESSFUL EARLY WARNING AND SAFETY MANAGEMENT

To address the real-time threats that require temporary lightning hazard preventive measures, success is measured by (a) the number of effective alarms, (b) the actual lead times (LT), (c) the number of incidents in which the TWS failed to issue a warning (FTW) and (d) the number of false alarms (FA).

The exact number of lightning strokes, number of lightning CG flashes and number of lightning IC flashes, where they occurred in high resolution to within meters or tens of meters of their real geolocations (location accuracy), are not required for successful early warnings to the end-user.

As stated in SANS 62793, the TWS service providers (network operators) do not quantify the risk involved, nor does the TWS service provider have the authority to implement the planned decisions to be made.

A higher degree of DE and LA will only be required if the TWS cannot provide the required lead time (LT) for an imminent storm. A high DE will improve the probability that the first lightning activity will be detected when it occurs within the MA and the SA.

SANS 62793 does not stipulate minimum criteria for a TWS in terms of detection efficiency and location accuracy. Therefore, the TWS service provider is not compelled to fulfil the validation criteria that applies to an LLS (Lightning Location System) where the empirical lightning data will be applied to business productivity and asset management as a risk management tool as described in IEC 62858 (Lightning density based on lightning location systems (LLS) - General principles).

TWS PERFORMANCE – INSTALLATION, MAINTENANCE AND EVALUATION

The TWS service providers (network operators) are solely responsible for managing and proving the valid performance of the TWS services being provided.

SANS 62793 is clear on these matters:
Installation: *"For LLS or a network of detectors, the installation is the responsibility of the network operator",*
Maintenance: *"For LLS or a network of detectors based on single detectors, the maintenance is the responsibility of the network operator",*
Performance: *"For an LLS or network of detectors based on single detectors, the performance evaluation is the responsibility of the network operator".*

Since the performance of a TWS will reflect the installation and maintenance, it goes without saying that the performance of the TWS in use needs to be well documented when commencing with a safety management plan involving the lightning safety of people, valuable property, and assets.

SANS 62793 guides what evaluation processes can be deemed acceptable.

The detection and location aspects of an LLS being used as a TWS can be evaluated using "cross-correlation", where the comparative data is obtained from an independent LLS. SANS 62793 is evident on the conditions when undertaking such an exercise: "When an LLS is used for evaluation, the detection efficiency and location accuracy should be a minimum on the same values as given in IEC 62858". The network operators of the reference LLS must be able to produce evidence of achieving the minimum values as stated in IEC 62858.

LIGHTNING VERIFICATION

The starting point to overcoming the threat of lightning is to quantify the threat – how often is the site exposed to lightning, how severe is the lightning – answering questions such as multiple events? Peak current magnitudes during charge transfer? Value (in any form necessary to the property owner) at risk? Contingency plans?

Once a solution has been determined, it must be understood that a sound and relevant lightning protection

solution must be expected to protect people, property, and livelihoods. Therefore, South African stakeholders should not assume that "nothing can be done about lightning" in certain circumstances. Nor should you accept the argument that soil conditions keep changing or that lightning has too many unknowns, or that lightning can break any system.

The corollary to the above, aggressive expectation is that when lightning does cause damage with or without a lightning protection scheme in place, the owner and whoever has taken responsibility for the financial loss protection cover should expect some form of explanation as to the nature of the compromised buildings and assets.

The performance of lightning protection solutions can be measured by the subsequent resilience of a structure fitted with a lightning protection system (LPS) and surge protection measures (SPM).

On the one hand, lightning verification may be required by the insurance industry to confirm potential lightning damage claimed by a policyholder. As a major stakeholder, the insurance industry is entitled to receive more than a yes/no response. In this example, the decision to pursue a case or settle will always be considered against the financial consequences. By sheer volume, with little clarity on procedures, some insurance houses would elect to settle and recoup costs via increased premiums. The subtle irony should not be lost on us. Nothing is for free, and each industry must pursue its tasks with excellence in the best interests of our country.

On the other hand, lightning verification provides a detailed set of empirical data that can quantify the exact nature of the risk and pinpoint the exact remedial action required. Detailed lightning verification constitutes all the parameters required to isolate specific portions of power lines for mitigation measures. One such example is the application to electric power utilities such as Eskom. The same processes apply to telecommunications networks, rail transport, mining infrastructure, and chemical and industrial plants over a large area.

So too, then, the stakeholder must demand excellence from the lightning protection industry and industries that relate to and improve our lightning safe measures.

On page 34 in this edition of **watt**now, the processes of lightning detection and lightning location is discussed. This includes the effort required to provide reliable lightning data for the specific purpose of determining the root cause of a failure or for planning an appropriate lightning protection solution to prevent failure.

CONSUMER PROTECTION ACT 68 OF 2008

In South Africa, false, misleading, or deceptive representations in marketing products and services to the South African consumer violate the laws of South Africa. The Consumer Protection Act lays out which violations will be handled in criminal proceedings and the terms of imprisonment and administrative fines that can be levelled against offenders.

While the consumer is generally perceived to be private South African citizens, the service principles apply to all clients who purchase commodities and services in South Africa. South African legislation packages numerous protection processes in the best interests of our society. It includes the Companies Act that, in many instances, communicates the same consistent message to South African society.

The flip side of that message is transparency "to promote a fair, accessible and sustainable marketplace for consumer products and services". This article serves to provide "information that is necessary so that consumers can make informed choices according to their individual wishes and needs".

The purpose of the Consumer Protection Act is, amongst others, *"improving consumer awareness and information and encouraging responsible and informed consumer choice and behaviour", "promoting consumer confidence, empowerment, and the development of a culture of consumer responsibility, through individual and group education, vigilance, advocacy and activism".*

Therefore, this technical article carries with it a call to all leadership, key decision-makers and service providers to consider the current complex socio-economic challenges we face and recognise that irresponsible marketing and consumer exploitation is inevitable. We all have a choice to make, either lose more confidence in our structures or become stalwarts upholding our structures.

A market for poor quality products, grey products, and illegal products only flourish when consumers buy them. The Consumer Protection Act is therefore equally geared towards consumers behaving responsibly.

LIGHTNING RISK MANAGEMENT

In another article in this issue of WattNow, the application of lightning protection is reasoned to be a risk management task. Unlike rules and legislation such as "keep to the

left side of the road", which are implemented to facilitate citizens going about their business in an organised fashion, allowing the economy to grow at a pace set by the citizens, lightning protection serves the property owner and asset owner first and foremost.

The compromise occurs when the property owner and asset owner delegate that responsibility to financial risk managers through insurance financial service providers, who must then consider the most effective way to offer the financial surety they require.

Such delegated responsibility does not automatically confer technical, scientific and commercial wisdom upon the insurance industry, and they, in turn, seek specialist advice from the scientific, engineering and legal communities.

As new technologies develop, as scientific research discover new and improved strategies, the solutions to a stochastic, unpredictable, and violent threat to our society, namely lightning, will become less rudimentary. The risk management process will become more repeatable and controllable, adding actuarial value to analysing the risk.

Dealing with the threat of lightning is an everyday exercise in South African summers. The fantastic and dazzling phenomenon of a lightning flash across the sky, turning night into day, is sobered by hundreds of unnecessary fatalities and economic losses running into hundreds of millions of rands each year.

The SAIEE established the SAIEE Lightning Chapter by engineers who believe in our country and want to advance lightning safety through lightning awareness. Be sure to visit the SAIEE website to get more details.

If you are an electrical engineer and have not joined the Institute, we encourage you to consider doing so. wn
Click here to join the SAIEE.

SOUTHERN AFRICAN LIGHTNING DETECTION NETWORK (SALDN):

The source of South African Risk Management Lightning Data

The South African Lightning Ground Flash Density (GFD) map was first published in 1986 by Eriksson, Geldenhuys and Kröninger of the CSIR.

BY | MORNE GIJBEN | LEAD SCIENTIST | REMOTE SENSING | SAWS*
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RICHARD EVERT | NATIONAL DIRECTOR | ELPA**

** South African Weather Service ** Earthing and Lightning Protection Association*

To protect our people, our property, and our way of life, we have to be aware of our exposure to lightning.

In 2017, an updated GFD map was published by the South African Weather Service (SAWS), with an auditable track record addressing reliability, accuracy, and consistency.

This article sets out to share the details of this risk parameter with South African lightning risk managers and the electrical engineering community.

Before proceeding, familiarise yourself with or cross-reference to the list of definitions applicable to the subject matter of this article that is contained here in this edition of **watt**now.

LIGHTNING GROUND FLASH DENSITY (GFD)

Lightning ground flash density is the international benchmark measure of lightning exposure and can provide an independent unbiased confirmation of whether any lightning protection measures are required on a property or complex. Failing to implement the appropriate lightning protection measures is costing South African industry millions of rands per annum.

In conventional knee-jerk response, many property owners and asset managers find themselves obliged to implement lightning protection solutions running into hundreds of thousands of rands without substantial assurance that the investment is worthwhile or really necessary.

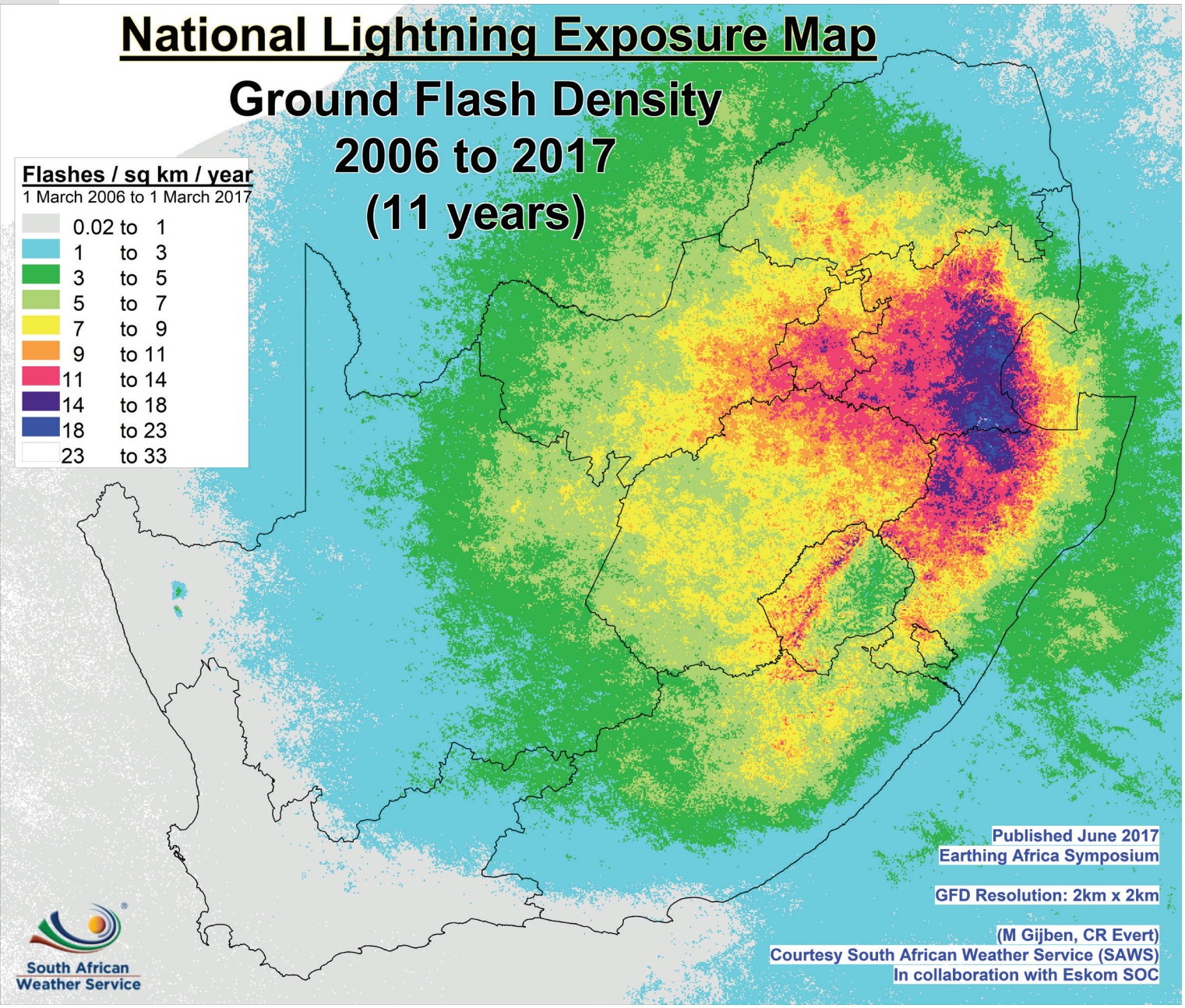

Figure 1: : Lightning GFD for South Africa

With skilled resources as described in the SANS 62305 series of lightning protection standards, none of this should be necessary. A qualified risk assessment with secure and stable risk related information and adequate consultation as recommended in SANS 63205, will determine whether Lightning Protection Systems (LPS) or Surge Protection Measures (SPM) are required, and the results should be supported by the necessary LP design report.

The South African National Standard SANS 62305-1 (Protection Against Lightning – Part 1: General principles) defines:

- a lightning flash to earth as an "electrical discharge of atmospheric origin between cloud and earth consisting of one or more strokes" and
- a lightning stroke as a "single electrical discharge in a lightning flash to earth"

The IEC International Standard IEC 62858 (Lightning density based on Lightning Location Systems (LLS) - General principles) defines lightning ground flash density (GFD) as a "mean number of cloud-to-ground flashes per unit area per unit time (flashes per km^2 per year)"

LIGHTNING RISK – GFD FOR RSA

The map (figure 1) contains high resolution detail of the GFD values applicable across South Africa obtained over a full keraunic or solar cycle of 11 years (in a gridded 2km x 2km array).

RELIABILITY OF GFD RESULTS

IEC 62858 "Lightning density based on Lightning Location Systems (LLS) - General principles" provides the basis to determine the validity of an LLS to contribute to usable GFD values upon which a reliable lightning risk management strategy can be based.

VALIDATING LIGHTNING DATA

Section 5 of IEC 62858 describes the 4 possible methods by which to validate the quality of the lightning data produced by an LLS in order to be deemed acceptable:

a) Network self-reference;
b) Rocket-triggered lightning and tall object studies;
c) Video camera studies; and
d) Inter-comparison among networks.

Of the 4 methods, SAWS have secured 3 in South Africa and await the availability of audited LLS systems that fulfil the criteria stipulated in IEC 62858.

The SAWS SALDN utilises components that have been characterised independently and in South Africa, the network performance has also been characterised independently.

Now it is time for South Africans to pool our resources and build on the validated risk management parameters of lightning ground flash density.

PERFORMANCE CHARACTERISTICS OF AN LLS

Section 4 of IEC 62858 quantifies the performance characteristics of an LLS required to produce a reliable GFD value throughout the coverage area (CA):

- Flash Detection Efficiency: Min. 80%;
- Median Location Accuracy: CG stroke minimum 500m (maximum error);
- Classification accuracy: Min. 85%.

A minimum observation period of ten years is stipulated although we recognise that the average interval between peaks in the solar cycle since 1750 is 11 years.

The solar cycle incorporates influences such as meteorological cycles of La Nina and El Nino. Therefore, SAWS have aspired to maintain an 11-year cyclic discipline of lightning data to support the national requirements for reliable lightning GFD data in accordance with the SAWS Act 8 of 2001.

SALDN VALIDATION – TALL OBJECT AND VIDEO CAMERA STUDIES - 2018

A recent study by the Johannesburg Lightning Research Laboratory (JLRL), from the Engineering faculty of the University of the Witwatersrand fulfilled 2 of the 4 validation requirements listed above.

The study included two tall structures by way of the Telkom and Sentech towers in Johannesburg and high-speed video cameras.

During the 12-month period of study, from February 2017 to February 2018, 71 lightning strokes that attached to the towers, were reported by the SALDN with a median LA of 68.5 meters.

Separately, the strokes to the Sentech tower had a median LA of 80.5m and to the Telkom tower, a median LA of 60.1m.

These results are understood to be applicable to the area under investigation and SAWS support further endeavours to verify "ground-truth" performance elsewhere across the country.

SALDN VALIDATION – SELF-REFERENCE ONGOING

To understand the localised performance of the LLS, IEC 62858 quantifies how the CA should be analysed as a gridded array of cells.

The GFD is then determined from all the flashes recorded within each cell.

Minimum permissible cell dimensions shall not be less than double the median location accuracy.

For overall performance validation, SAWS have adopted the gridded array shown in figure 2 with approximate cell size of 100km x 100km in accordance with the IEC 62858 principles mentioned above.

The sample data shown, reflects reported conservative statistics for the year 2020, with rounded up median LA (km), number of strokes detected, calculated percentage CG Flash Detection Efficiency and number of CG Flashes detected.

STATISTICAL CONSTRAINTS ON THE LLS – EMPIRICAL DATA AT LOW GFD

The criteria listed in IEC 62858 may not be entirely sufficient to record the location accuracy (LA) of an LLS in areas with a very low GFD since the LA values are statistically defined by the number of strokes detected by the LLS.

A low GFD in any of the cells in the gridded array, will translate to a lower volume of detected lightning strokes in the same given period, upon which to assess location accuracy. The West Coast of South Africa would be such an example.

For these reasons, the SAWS undertake to uphold an open dialogue and engage

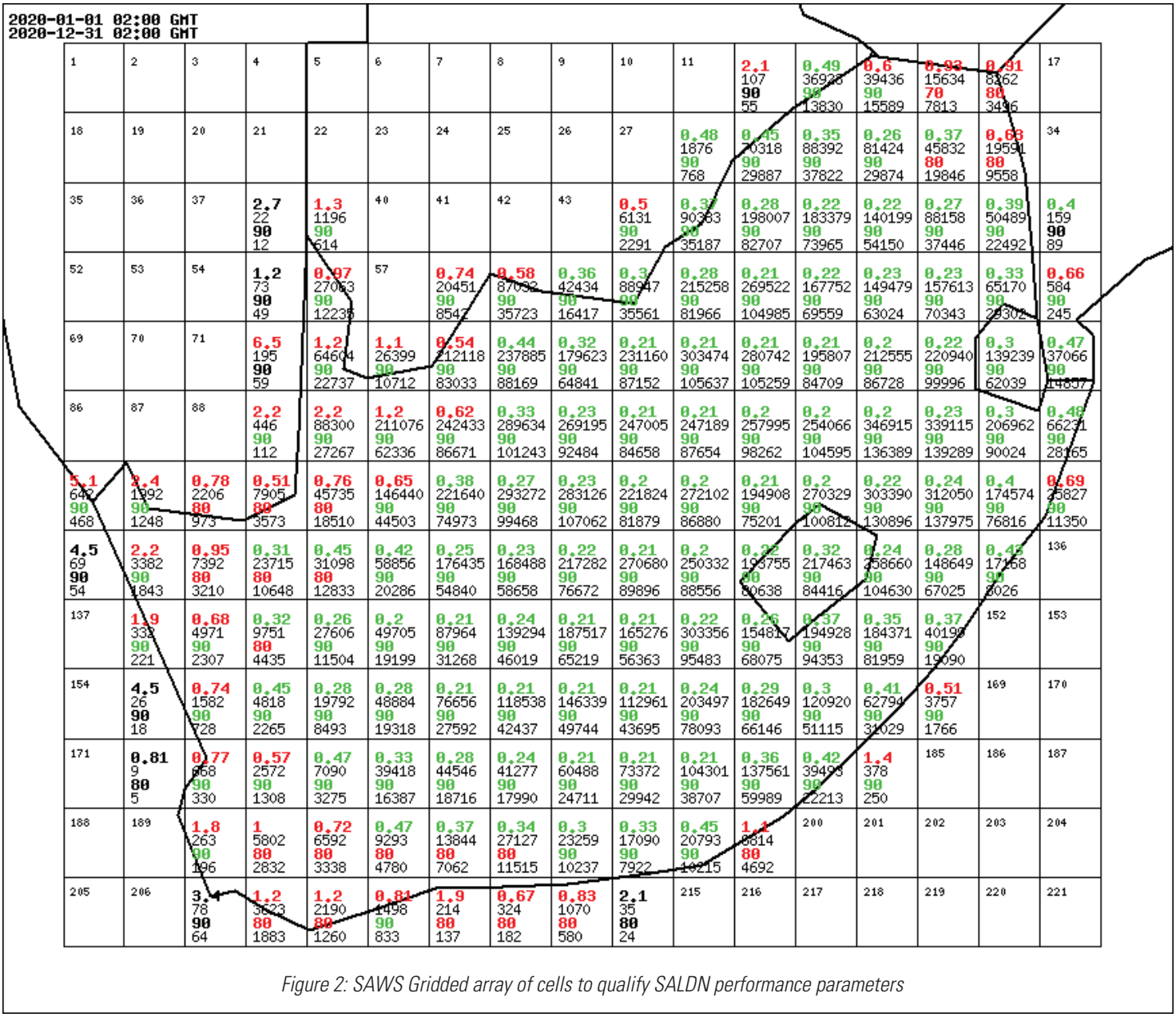

Figure 2: SAWS Gridded array of cells to qualify SALDN performance parameters

with all relevant parties to ensure that lightning risk is sustainably defined for South Africa with transparent proof of accuracy and reliability.

This includes engaging with the electrical engineering industry, independent validation, academic centres of excellence, lightning detection sensors manufacturers, and the international lightning scientific community. With the intent to advance lightning and atmospherics research and stability of available lightning risk knowledge.

LIGHTNING DAMAGE VERIFICATION

LIGHTNING DETECTION

The details given in the preceding sections, have a direct impact on the beneficial value contained in lightning data from an LLS.

The first task of an LLS is to detect lightning and hence the LLS in South Africa has been named the Southern African Lightning Detection Network (LDN) where detecting the lightning strokes that caused an incident, disruption, or damage, is a high priority. Note the name implies a subcontinental expansion as the network now is multi-national partnership with Eswatini (Swaziland) hosting one of the lightning sensors with the potential for further engagement across Southern Africa as the needs of our neighbouring countries may require.

TIMING AND MAGNITUDE

Depending on the nature of the incident, timing and lightning discharge intensity accuracy is also critical to successful lightning risk management. Eskom are a primary partner in this

regard, correlating power system faults to individual lightning events, prioritising localised sections of very large power line (wires business) networks and therefore able to manage assets according to business priorities and available resources. Eskom have been actively managing their assets in this manner for the past 15 years.

The high resolution GFD map as shown in figure 1 allows Eskom to compartmentalise localised elevated topographical areas and isolate risk to these higher GFD nodes. Further consolidated with confirmed system interruptions at the same locations. Thus, instead of sweeping remedial action to mitigate against significant storm related annual losses, the resources can be concentrated on these nodes.

It is therefore vital that the SALDN can provide these parameters as a sustainable part of the national risk mitigation solutions in addition to accurate location of the individual strokes and the long term lightning exposure values of GFD.

The systems used by SAWS quantify the performance of each sensor and the combined impact of sensors across regions, on a daily basis.

THUNDERSTORM WARNINGS

LEGISLATION – SAWS ACT

The SAWS is mandated, by the South African Weather Service Act 8 of 2001, to exclusively issue severe weather-related warnings over the geographical area of South Africa [section 4.(3) of the Act].

THE SALDN AND TWS SOLUTIONS

The SALDN provides SAWS the basis for an effective thunderstorm warning system (TWS) as covered in SANS 62793 "Protection against lightning - Thunderstorm warning systems", recognising that thunderstorms are not limited to lightning. Severe thunderstorms also contribute high winds, precipitation (rainfall), hail and other severe environmental conditions. To that end, SAWS have extended their lightning services to include 3rd party products that allow end-users to stipulate the target areas (TA) and surrounding areas (SA) to produce warnings ("alarms") on assets (objects) where they require immediate notice of imminent lightning threat.

All areas of South Africa fall within the coverage area (CA) of the SALDN and therefore SAWS are able to fulfil that legislative mandate to the South African community.

TWS AND ALARMS

The details of early warning notifications and factors that influence the effectiveness of a warning, are laid out in SANS 62793. Configurations are dependent on the surrounding area (SA), the monitoring area (MA), the target to be protected (TA), which will influence the timeous reports of lightning related events (LRE) with an appropriate Lead Time (LT) for the end-user to be able to respond safely and await an appropriate Time to Clear (TTC) after the storm has dissipated, before resuming.

LIGHTNING, FORECASTING AND NOWCASTING

The SALDN provides live reports of lightning "as it happens" and has been doing so for the past 15 years. SAWS secure lightning data to historical tables and broadcast the lightning data to end-users who have the necessary interfaces to view the discharges or alarms based on their requirements.

A large corporate end-user such as Eskom, can elect to have their own lightning diagnostic and tracking tools to apply GFD values and lightning stroke/flash data to their assets. In so doing, they can anticipate their areas of highest risk for asset management purposes on the one hand and anticipate storm and lightning threat for resource and contingency management purposes on the other.

SAWS understand the separation of forecasting from nowcasting. SAWS scientists have developed several solutions to improve lightning forecasting, discussed below, together with the ultimate benchmark of GFD.

Lightning nowcasting is a function of existing lightning activity as storm cells, and the speed with which those storm cells are changing.

The important parameters are:

a) Change and rate of change of size of storm cells over time,
b) Speed with which the storm cells are moving;
c) Direction a storm cell is moving.

Lightning nowcasting on its own, does not consider geographical changes to the topology, nor the presence of other dynamically changing meteorological factors.

To that end, end-users have the option to consider 3rd party lightning nowcasting tools only, or more integrated solutions enhancing the nowcasting experience with AI level early warning potential.

SALDN INSTALLED BASE

The SALDN was established to optimise detection of CG to specifically quantify the lightning risk exposure to assets on the ground in accordance with the SANS 62305 series of lightning protection standards.

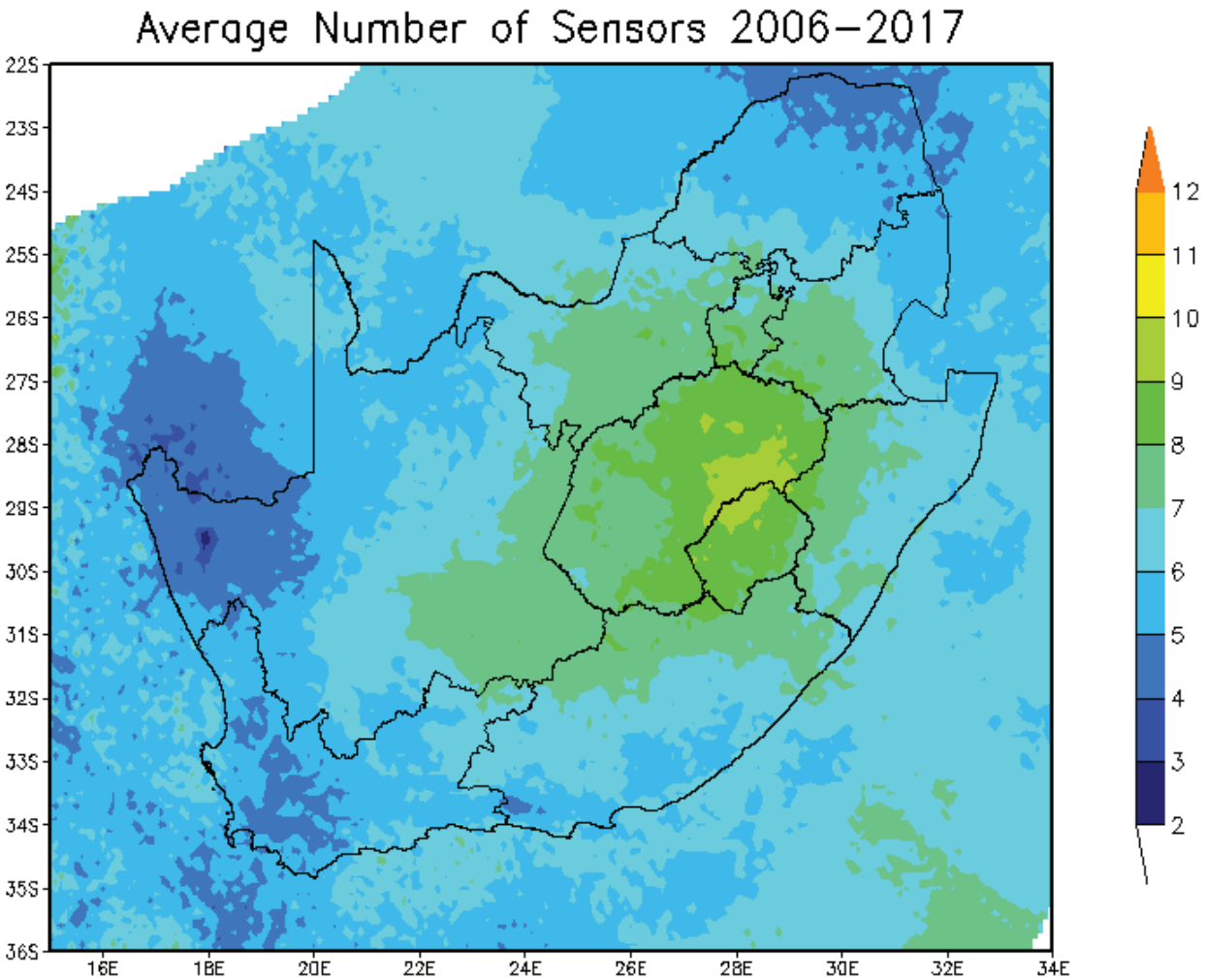

Figure 3: Example of sensor performance reporting - thematic map of average number of sensors participating in lightning solutions at each location.

Through an engagement process with Eskom, the power utility in South Africa, specific emphasis was placed on effective fault correlation where CG strokes DE of 100% with an average LA close to attraction radius of the power lines was desirable.

Financial constraints and available technologies required a compromise on the part of both Eskom and SAWS. Subsequent to an international survey of LLS technologies, SAWS elected to implement the Vaisala networks with an initial installation of 19 LS7000 sensors in 2006.

In the 2009/10 financial year, 3 LS7001 sensors were added and an LS7000 was replaced with an LS7001.

In 2011, another LS7001 was added, 4 LS7000's were relocated and the LS7000 warehoused in the previous year, redeployed at a new location.

In 2015, a further LS7001 sensor was commissioned bringing the total complement of lightning sensors to 25. In 2020, a further upgrade program was initiated, moving the SALDN to LS7002 sensor technology.

Contrary to speculation, the SALDN detects a very high percentage IC lightning.

The technology incorporates both Time-of-Arrival (ToA) and Magnetic Direction Finding (MDF) and achieves a higher degree of performance through optimal algorithm development with fewer sensors than would be otherwise required.

A "lightning solution" is the result of cumulative contributions of multiple sensors and the diagnostic process of the SALDN to produce the details of a lightning event. The number of sensors participating in any lightning solution is also tracked and analysed.

By example, the average number of sensors participating in lightning

solutions in 2017 across South Africa is illustrated in figure 3.

SAWS INTEGRATED SOLUTIONS AND RESEARCH

STORM SIMULATION AND NOWCAST

SAWS are applying lightning data from the SALDN in many applications. In addition, SAWS are researching and investigating more alternatives so as to effectively issue severe weather warnings cost effectively to South Africans.

This includes information from remote sensing tools such as radar, satellite and the SALDN, the blending of these observations, as well as the blending of observations with Numerical Weather Prediction (NWP) models.

New and improved blended nowcasting and very short-range forecasting methods in the next 0 to 12 hour forecasting timescale are being developed, including utilizing techniques such as artificial intelligence/machine learning to provide even more accurate warnings to the public.

From a lightning perspective, since all thunderstorms contain lightning, real-time data is used frequently to supplement other observation platforms such as weather radar and satellite improving both storm tracking and nowcasts.

As per the example in figure 4, the current storm cell tracks can be provided within the redline outlay, and the movement of the storm cells can be nowcasted for the next 30-minutes (blueline outlay) and 60-minutes (greenlined outlay) thus making lightning information very useful in areas not covered by radars or when a radar is not available.

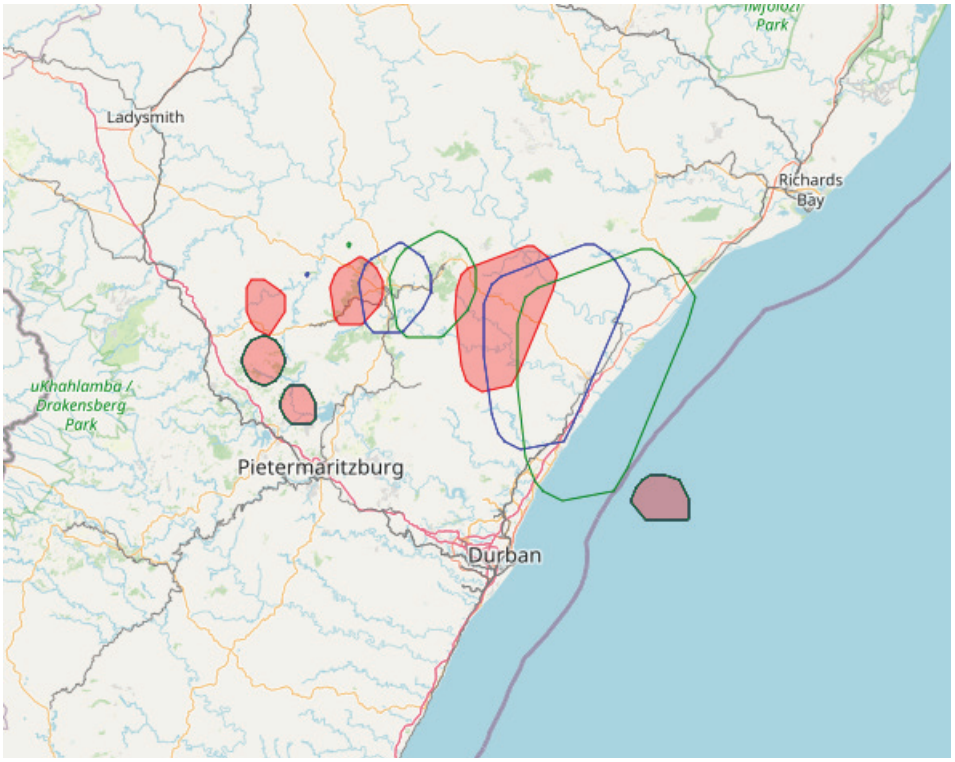

Figure 4: SAWS integrated storm nowcasts example

SAWS support client use of 3rd party tools and systems using SAWS SALDN lightning data to improve their own operational business management policies.

One such 3rd party tool is the "Lightning Tracking System" (LTS) offered by Vaisala as a stand-alone tool to create asset and business target areas (TA), defining and contracting to surrounding areas (SA), setting up monitoring areas (MA), identifying lightning related conditions (LRC) to then set up their own warning areas (alarms), verifying required lead times (LT) as well as determining the appropriate Time-to-Clear (TTC) for their respective operational standard procedures.

Eskom have had the tools actively operational in network control centres, resource despatch centres and customer contact centres across the country for the past 13 years.

SAWS SYSTEMS DEVELOPMENT VALIDATION

Apart from using lightning information directly in storm nowcasting products, it is also widely used within SAWS to validate newly developed or enhanced products that forms part of the operational suite of services.

Since lightning is present in all thunderstorms it serves as an excellent ground-truth of thunderstorm activity across the country and can therefore be used to validate the success of many of the storm prediction algorithms available.

LIGHTNING PREDICTION MODELS

Historical lightning observations were used to train a model by using machine learning techniques to provide a daily probability forecast of lightning from Numerical Weather Prediction (NWP) model parameters.

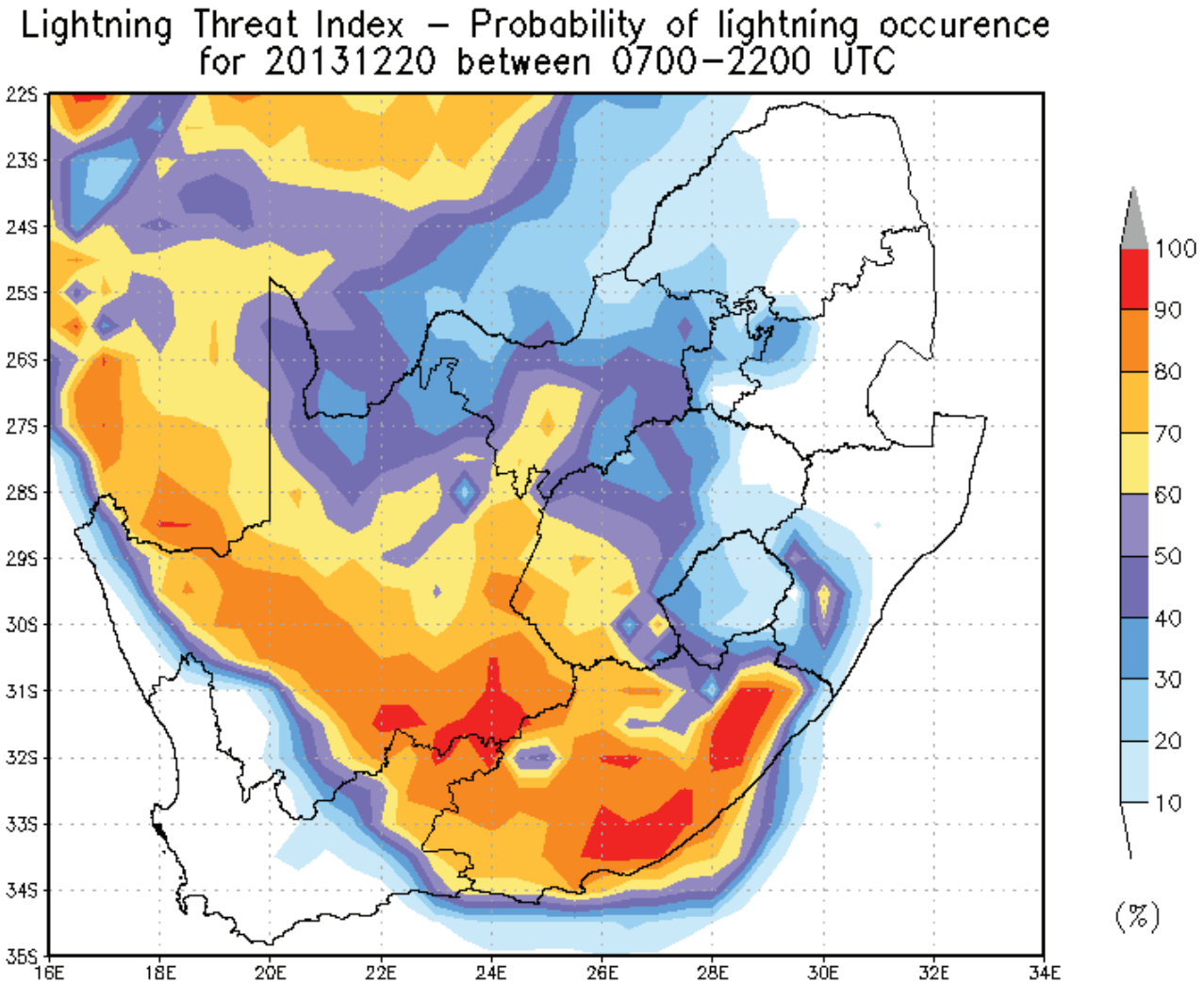

Figure 5: Lightning daily forecast model

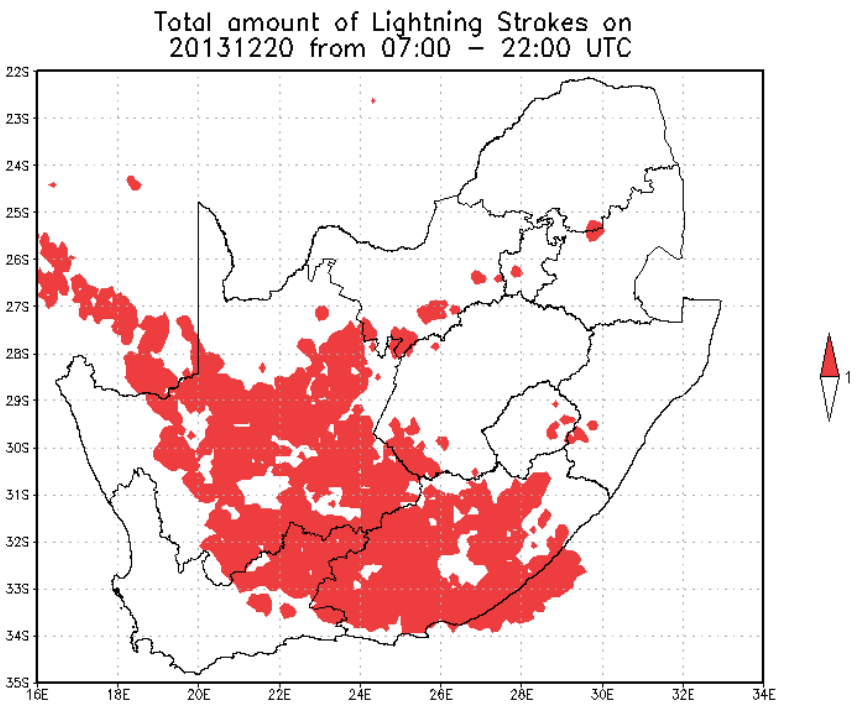

Figure 6: Lightning detected (compare to figure 5)

This model forecast is available early in the morning and provides a probability outlook of where lightning can be expected during the day.

A case study best demonstrates the principles. The model forecast for the 20 December 2013, is shown in figure 5.

Subsequent to the day, the lightning activity in figure 6 was detected on 20 December 2013.

There is an excellent correlation between the forecast and the actual development of storms thus afording South Africans at least 24 hour advanced warning of lightning risk. An extremely valuable tool for industries where not only lightning

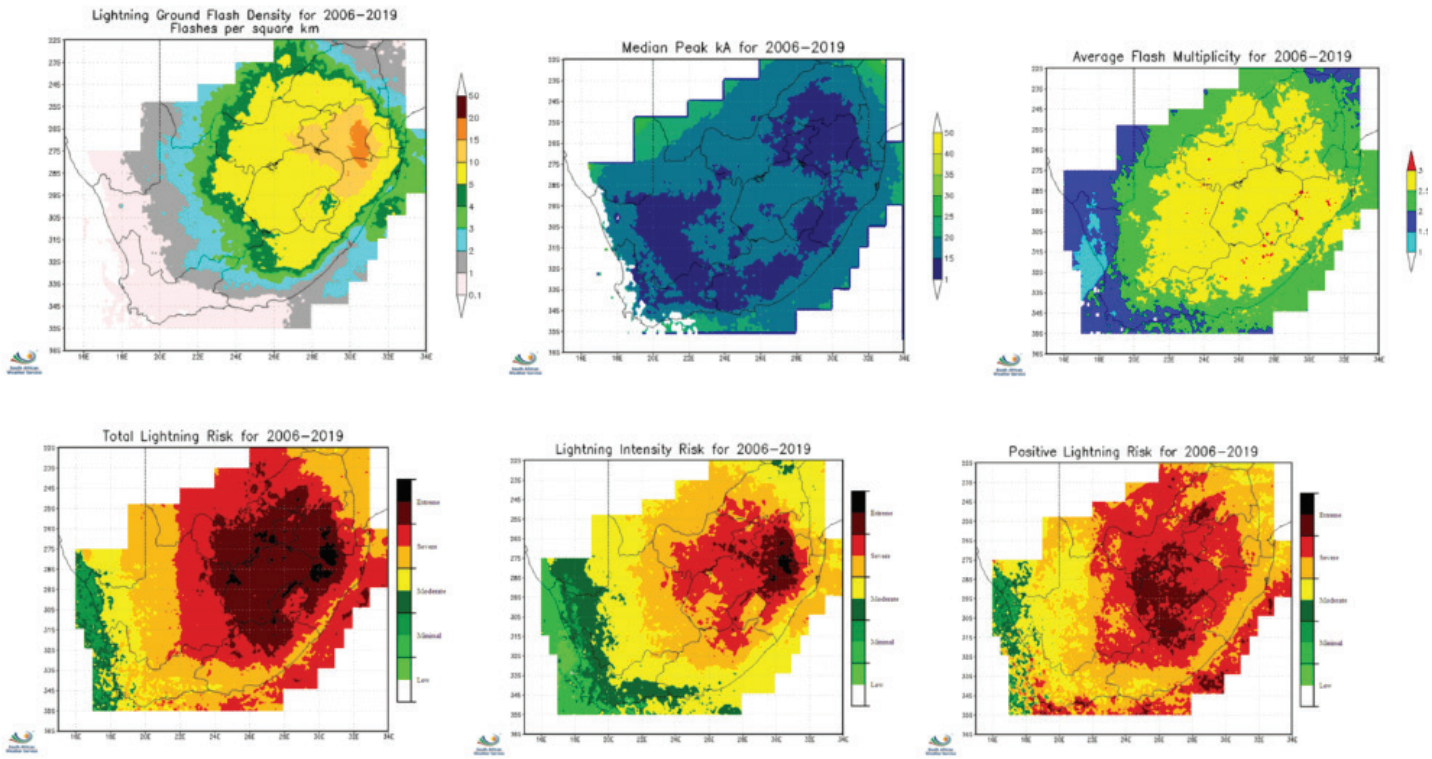

Figure 7: Ongoing experimental work seeking more useful tools to assist South Africans

but also storms can compromise the integrity of planned work.

The historical lightning data is also utilized from a climatological perspective, where various maps are produced and will be updated annually. Experimental work is continuously ongoing with some of the work illustrated in the maps below.

Historical lightning data is used widely by sectors interested in verifying lightning activity of an event such as the insurance sector and forensic pathologists.

SAWS provides a service where lightning verification reports can be issued to clients based on their specific area of interest. Much more collaborative work is required with stakeholders in our South African industries to meet your needs.

LIGHTNING AND THE SOUTH AFRICAN ELECTRICAL ENGINEER

It is with some concern that we recognise that the details as shared here are not yet common knowledge amongst Electrical Engineers.

SAWS are enthused about the new developments around ELPA and the launch of the SAIEE Lightning Chapter as well as new collaborative agreements being set up between SAWS and academic institutions such as Wits University.

An increasingly cooperative relationship amongst scientists and engineers in the lightning community not only across South Africa but across the world, bodes well in our endeavours to advance socio-economic development for all our citizens. wn

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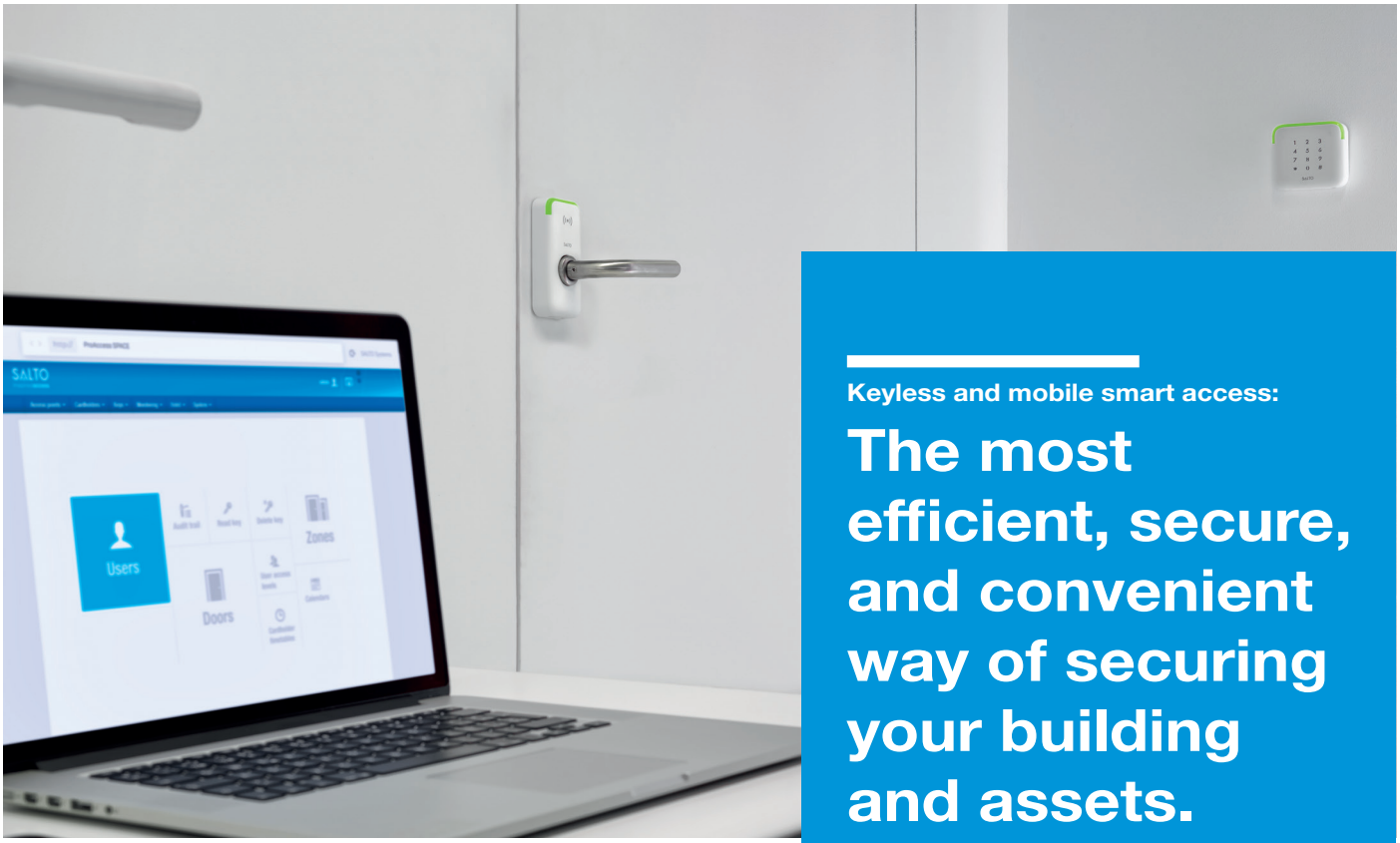

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Standards, Competency, Expertise and Safety

Lightning protection is the implementation of protection measures to reduce risk of damage or injury due to lightning.
Suitable "ideas" to ward off the lightning threat, the materials used to achieve effective lightning protection and the people who would implement the idea, all contribute to either create a safe and cost effective, secure environment or become a doubtful and debateable expense.

BY | RICHARD EVERT | NATIONAL DIRECTOR | ELPA

There are therefore 3 areas of consideration when considering the threat of lightning:

a) Design – effective solutions;
b) Capacity of materials; and
c) Competency of people

Lightning safety is vital to saving lives and reducing economic losses.

STANDARDS

The ISO (International Organisation for Standardization) and the International Electrotechnical Commission (IEC) have compiled guidelines on how to manage risk responsibly:

- ISO 31000:2018 Risk Management – Guidelines, and
- IEC 31010:2019 Risk Management - Risk assessment techniques.

Both have been adopted by the SABS (South African Bureau of Standards) as a SANS (South African National Standard): SANS 31000:2019 and SANS 31010:2020.

Lightning protection and ISO 31000 are not typically used in the same sentence. We should recognise that we also have a tendency to dramatize lightning as a subject with emotive distraction.

ISO 31000:2018 provides a neat and almost clinical view that is easily adopted when unpacking the national threat lightning poses to stakeholders.

Electrotechnical standards exist to convey confidence in risk management solutions, associated lightning protection design strategies, component reliability and human competence.

The South African Standards Act 8 of 2008 placed a mandate on the SABS to inculcate a mindset of consensus upon South African stakeholders. The Standards process is susceptible to abuse and exploitation if South African stakeholders do not participate in the process.

The process to implement an appropriate lightning protection solution is dictated in the same way

any other repeatable process is quantified for the benefit of South Africans, namely in a South African National Standard (SANS).

SANS 31000 VS SANS 62305-2

Most engineers will expect me to turn to the technical SANS 62305, SANS 10313, and SANS 62561 to address lightning protection design, materials, and competency.

But the first order of business is not a preconceived "cookie-cutter" solution but an understanding of who the stakeholder is and what risk that stakeholder needs to conceptualise.

When we consider stakeholders, consider the 4 criteria deemed to be deciding criteria in SANS 62305-2 (Protection against lightning Part 2: Risk management):

a) Loss of life/permanent injury;
b) Loss of services to the public;
c) Loss of cultural heritage, assets of personal sentimental values; and
d) Loss of economic value

Thresholds for the first 3 criteria are set by authorities accountable to all stakeholders where the subject matter experts deferred actual "tolerable risk" thresholds to "the authority having jurisdiction" in each country.

SANS 62305-2 does NOT define those thresholds on the basis of empirical risk analysis but on consensus of subject matter experts exposed to many variables.

While South African stakeholders continue to watch from the side-lines, these 3 parameters will remain oblique concepts that are abstract and therefore difficult to rationalise without clarification. We have not designated responsibility upon subject matter experts in so far as regulatory provision and actuarial analysis of risk, in order to empower "the authority having jurisdiction" in South Africa.

As an example, the threshold for loss of life is 10^{-5} or 0.00001/year…..
I am at my core, an "engineering

scientist" and I detest "dummies guides" that completely lose sight of the original problem and circumstances. The threshold value of 10^{-5} or 0.00001/year for human life only makes sense to mathematicians and rubber stampers.

The threshold for loss of life is 1 fatality or permanent injury in 100,000 years. If the calculations show that lightning may kill or permanently injure one or more people in the next 100,000 years, then lightning protection MUST be implemented on that property. Does this make logical sense? An actuarial scientist may shed some light on this. Statistics do not form part of the scope of this article so we will not labour the subject any further. More details will follow on the ELPA website and future SAIEE Lightning Chapter events.

Suffice to say that 1 death in 100,000 years provides no obvious bearing on immediate impact to the stakeholder nor on how we achieve such a "price on life".

SANS 31000 explains that "The purpose of risk management is the creation and protection of value. It improves performance, encourages innovation and supports the achievement of objectives."

In the context of property, safety, and security, creating and protecting value makes business sense.

STAKEHOLDERS

SANS 31000 defines stakeholder as a "person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity."

The last of the 4 criteria to consider when determining whether lightning poses a significant risk, is the economic losses that may occur.

PRIMARY STAKEHOLDER

Clearly the property owner is a stakeholder if not the primary stakeholder.

DEFERRED FINANCIAL LIABILITY

To quantify financial risk, the property owner would consider the value of the assets being the property itself and the contents of the structures.

At this point, the property owner would however, typically stop thinking abut the possible financial loss and instead, would defer to a licensed financial services provider who undertakes to provide a guarantee of compensation for specified loss, damage, illness, or death in return for payment of a specified premium.

SHORT TERM INSURANCE INDUSTRY

There can be no question that economically, the short term insurance industry carry the bulk of the financial risk of lightning damage to properties. The standards development processes of the IEC places great emphasis on "consensus". With the correct amount of consultation, all stakeholders can reach a settlement where the least amount of risk balances with the least amount of sacrifice.

SANS 31000 best illustrates the principles of risk management in Figure 1. Details of each of the principles can be viewed here.

While all stakeholders remain focused on "value creation and protection", a feasible solution will be found.

A common weakness in absorbing this level of information as a reader, is to disassociate from what is not being stated here. Either an argument will be launched about other stakeholders as a higher priority classification or regress and entirely forget about other stakeholders.

LEADERSHIP AND COMMITMENT

Overlapping the principles in figure 1, is a framework of factors that pull stakeholders and "organisation" together where leadership and sustained accountability is driven by unwavering commitment.

The negotiated lightning protection solution must be implemented in a manner such that the measures are effective in accordance with the design and with the expected success of the solution.

For the framework (depicted in figure 2) to give substance to the strategy, discipline to uphold the internationally recognised methodology is essential.

The concept of an "organisation" in the context of this article, applies to industry representative organisations who need to agree to work together with a view to ensuring their requirements and demands are continuously stated, considered, qualified and achieved.

The Governance departments of Employment and Labour (with the Chief Inspector of Health and Safety), Mineral Resources, (with the Chief Inspector of Mines), Cooperative Governance - CoGTA (including building inspectors/control officers), Basic Education, Higher Education, Environment (Forestry, Fisheries and Environment), Trade and Industry (and Competition), and the SABS form a critical part of the leadership of the "organisation".

The solutions to managing the threat of lightning is therefore not purely a singular technical solution dictated by scientists and engineers with expert knowledge in lightning science.

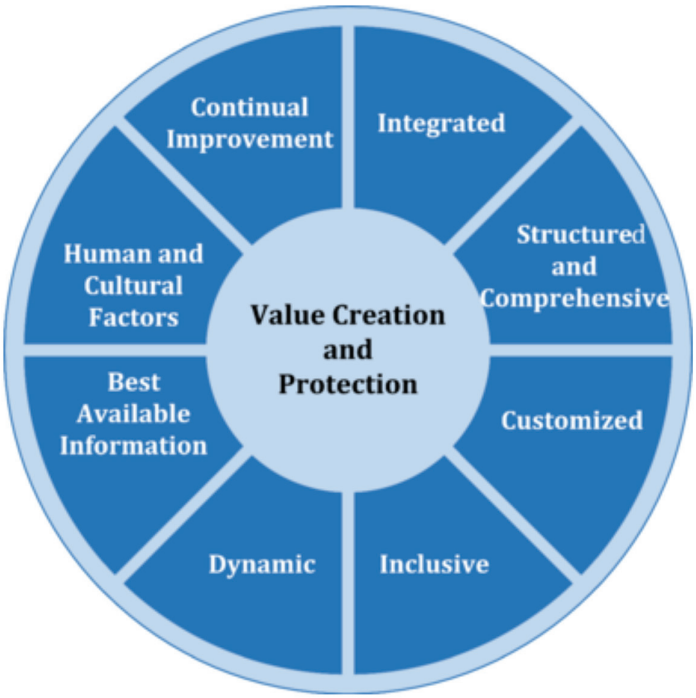

Figure 1: Risk Management Principles

Figure 2: Framework to sustain "Risk Treatment"

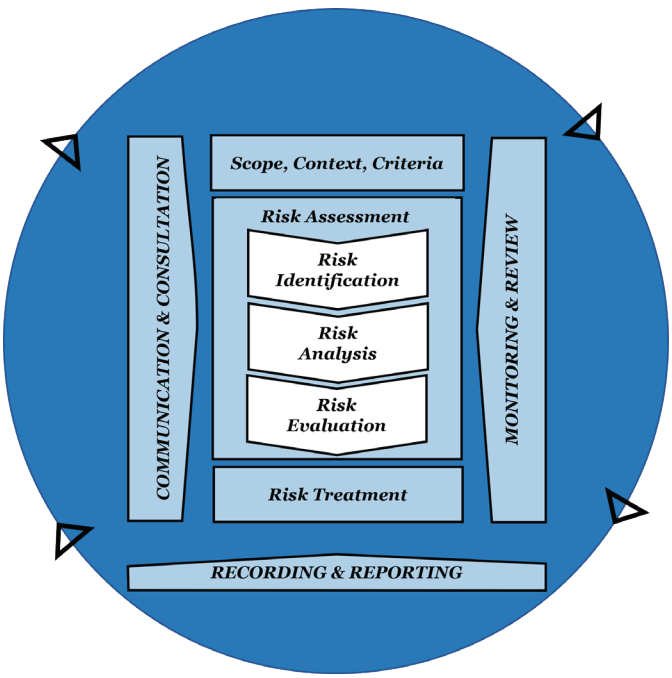

Figure 3: Process to sustainable solution

An integrated solution must exist where competency is real. ISO 31000 explains "Integrating risk management relies on an understanding of organizational structures and context."

Further details of possible organisational structures to achieve this in South Africa, will be unpacked on the ELPA website in the near future.

The final organisation that needs a mention here is the South African Qualifications Authority (SAQA). It is SAQA who are mandated to uphold the integrity of industry trade qualifications and part-qualifications.

COMPETENCY

The design and implementation illustrated in figure 2 address the national perspective of accepted solutions including allocation of responsibilities and resources.

Evaluation involves measurements of the strategies and the short term insurance industry are a key stakeholder in the best position to offer empirical data. It should be clear that this article is only touching the surface of this subject where competency is not limited to the installers and designers of lightning protection but also the stakeholder community as a whole.

Key processes before and after implementation, illustrated in figure 3, are essential to sustain a cost effective lightning protection plan for South Africa.

Before:

- Communication, and
- Consultation

After:

- Monitoring, and
- Review

Each aspect of the risk management process laid out in figure 3 requires competent resources.

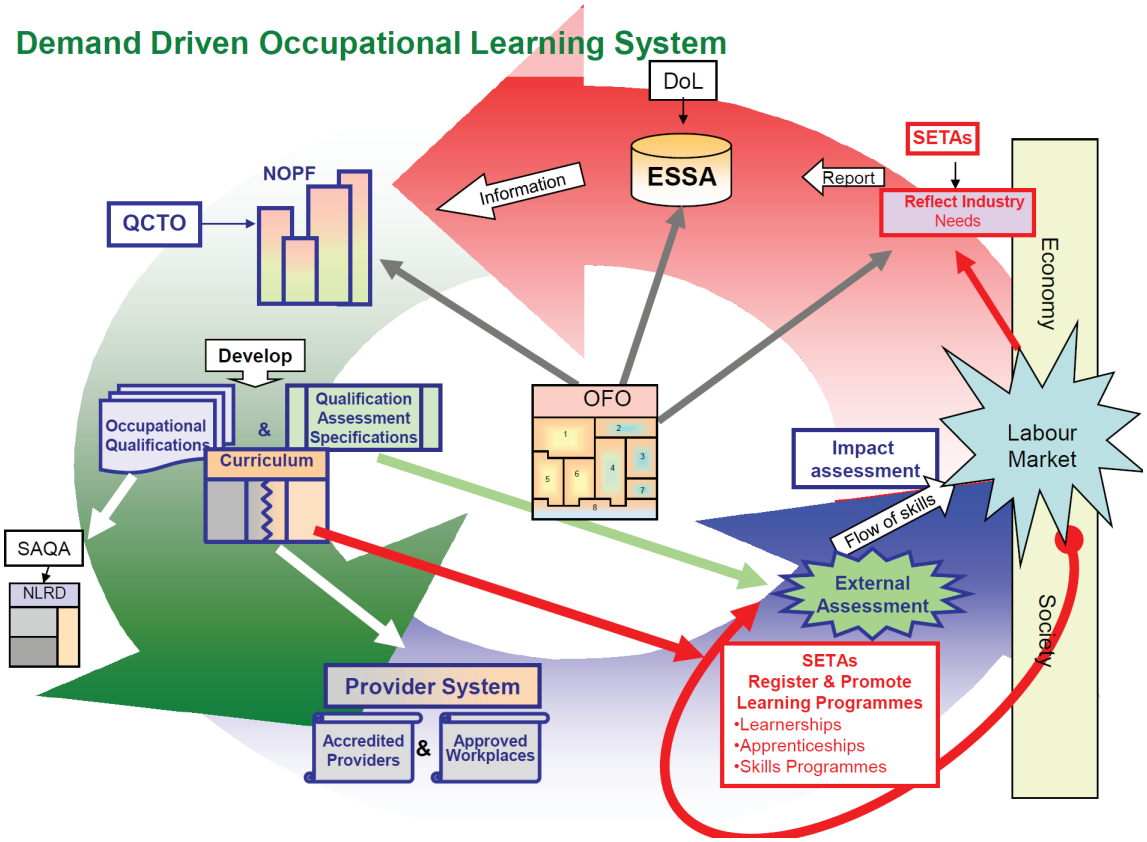

Figure 4: QCTO Curriculum Qualification Process

An intermediate level of recognised certification exists through ELPA, with the program to full formal SAQA recognised qualification underway.

In October 2015, a delegation of ELPA representatives met with Director of the Mechanical and Electrical Engineering Directorate of the Department of Employment and Labour, Mr Jacob Malatse, to discuss the future of the industry.

Mr Malatse, while supporting the intent of ELPA, made it clear that training and qualifications must be approved by and registered in cooperation, with SAQA.

IN A COLLABORATIVE

It is for that reason that ELPA are engaging with SAQA to finalise Professional Body status. And formally implement the registration of qualifications and training modules for the 3 tiers of lightning protection (designers, installers, and inspectors).

QUALITY ASSURANCE AND SAFETY

Lightning is first and foremost, a risk to people and property, assets, and animals.

By definition, lightning is neither the intentional production, transmission and distribution of electrical energy nor is it a threat solely to power utilities and similar endeavours. Therefore additional thought has gone into the considerations for electing one or other appropriate SETA within which to house this work.

COMPETENCY REGISTRATION

Technical resources working in the lightning protection industry receive no formal infrastructural curriculum and certification support from existing technical industry representative bodies.

Working with QCTO (Quality Council for Trades & Occupations), in support of several SETA (Sector Education Training Authorities), ELPA are following the QCTO prescribed curriculum development and registration process within the Occupational Qualifications Sub-Framework (OQSF).

All parties within the National Qualification Framework (NQF) are being consulted including Umalusi (Council for Quality Assurance in General and Further Education and Training) and the Council for Higher Education (CHE).

Some parts of the curriculum should commence at the level of basic education while others may be relevant at university level.

LIGHTNING SAFETY

All parts of our education infrastructure can participate not only in the development of the lightning protection industry, but also in lightning safety education of our children and communities throughout South Africa. wn

Africa Research Journal

Research Journal of the South African Institute of Electrical Engineers
Incorporating the SAIEE Transactions

As of January 2019, the *SAIEE Africa Research Journal* is indexed by IEEE / IET Electronic Library (IEL) (popularly known as Xplore)

Manuscripts can be submitted by visiting the IEEE Xplore website: www.saiee.org.za/arj

Further training material on compiling manuscripts is provided online.

We call upon researchers to consider the *SAIEE Africa Research Journal* as a medium for publishing their novel scholarly research, and in this way, contribute to the body of published knowledge.

We are grateful to the leadership and support of the IEEE Foundation and IEEE Africa Council; through the partial sponsorship and support of these groups, the journal continues to be available as open access.

SAIEE

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A glimpse into the future

Over the past 36 months we in South Africa have been afforded a view into how bad things can get.
If you do the maths, you will know that I am not referring to the national state of our politics and corruption and you will know that I am not referring to the Covid-19 pandemic.

BY | RICHARD EVERT | NATIONAL DIRECTOR | ELPA

Although all of the above can certainly be a distraction from activities in our industry.

- You are reading an electrical engineering magazine and
- The theme of the September 2021 edition is lightning.

You will have to forgive me when it becomes clear that the "we in South Africa" is somewhat addressing a segment of our South African industry that for all intents and purposes, is a relatively small percentage of our population.

Given the ravages of the pandemic and the crippling conditions of our economy, you could be forgiven if you chose to stop reading about what may seem to be a "storm in a teacup".

If you're still reading, then you deserve to know that we, in the lightning protection industry, have a plan.

A strategy that is turning our industry around.

The strategy starts with leadership, backbone, commitment, and passion and will be sustained with empathy and discipline.

RISK MANAGEMENT

Lightning poses a threat to people, animals, and property.

Lightning does not deliver on that threat in a scheduled manner and therefore you cannot predict exactly when it will threaten your life and your property.

LOW LIGHTNING EXPOSURE

Geographically you may reside in an area where you don't see or experience lightning more than one day every few years.

If this is you, the very thought that lightning may pose a threat to you, or your property may therefore appear to be a ludicrous suggestion and you would be considered a reasonable person for thinking so.

HIGH LIGHTNING EXPOSURE

In other areas, you may experience a lot of lightning. If this is you, you may be very familiar with the behaviour of storms and lightning in your hometown. So much so that you may even consider yourself somewhat of an expert when it comes to lightning.

If lightning is a frequent occurrence, you may also experience actual lightning strikes around your home or your office or while you go about your daily routine.

RESPONSE TO LIGHTNING THREAT

In these two seemingly extreme experiences, we have a conflict of perception:

- In the one, lightning seems to pose no threat (this person is most likely from Bellville in Cape Town),
- In the other, lightning starts in late spring, occurs nearly daily for months, dissipating somewhat in late summer (this person is in South Africa but not in Cape Town).

Who is right?

GLOBAL ELECTRIC CIRCUIT

The truth is that the planet has its own "global electric circuit".

Google (the act of doing a search on the internet…) the words "atmospheric electricity" and you should discover at least 822,000 references in under 460 milliseconds.

So much information but what does it mean?

I am going to indulge in scientists that I admire for their longstanding dedication to the science of lightning, Dr Martin A. Uman and Dr Vladimir A. Rakov.

They dedicated 5 pages of a 685-page book (Lightning - Physics and Effects) to this concept of a "global electric circuit".

As I started reading about this "global electric circuit" it very quickly became clear that the details are not far from what may be considered science fiction.

Very quickly the language "deteriorates" away from what would be called "normal English" into what may colloquially be described as "geek speak".

Topics covered range from conductivity of the atmosphere to cosmic rays, to natural radioactivity of the earth, ionisation rates, magnetic latitudes, solar activity, changes in air density, changes in electrical conductivity,

fair-weather electric fields, and to all manner of "spheres" – troposphere, ionosphere, stratosphere, mesosphere, and thermosphere ending up with electrosphere.

Under the guise of a little humour, the significance of this rambling is that, scientifically, around the globe, there is a capacitive electric circuit with a constant voltage of around 300kV between the earth's surface and the "electrosphere".

This is the important bit:
Fair-weather leakage current between the earth and the electrosphere would neutralize the charge on the earth within 10 minutes "if there were no charging mechanisms to replenish the neutralised charge".

The action of thunderstorms maintain that "global electric circuit" with an estimated 2,000 thunderstorms at any one time covering at least 10% of the earth's surface. Thunderstorms in this context are described as "global electric generators".

It should be understood that this global electric circuit is good for the planet and any thoughts of 'switching it off' would be counter-productive.

LIGHTNING 24/7

Translating all the geek-speak means the following: Lightning is a 100% phenomenon somewhere on the planet 7 days a week, 24 hours a day.
Therefore, the difference in perceptions described earlier has nothing to do with the global reality of lightning.

The differences are due to your fortunate or unfortunate providence to be at a location where lightning occurs when it occurs.

The scope of this article does not include explaining why lightning occurs in one area more than another. For that, stay tuned to the ELPA website that is evolving, with lightning related matters to be posted for industry. Several new portals are being launched for different industries with the revamp of the website.

GROUND FLASH DENSITY (GFD)

In another article in this edition of **watt**now, you can find the lightning GFD map of South Africa which quantifies the degree of sustained lightning activity across the country in flashes per square kilometre per year.

The higher the GFD value, the closer you move to sustained electric generators that drive the global electric circuit.

Sounds weird, surreal, science fiction and possibly even a bit over-melodramatic?

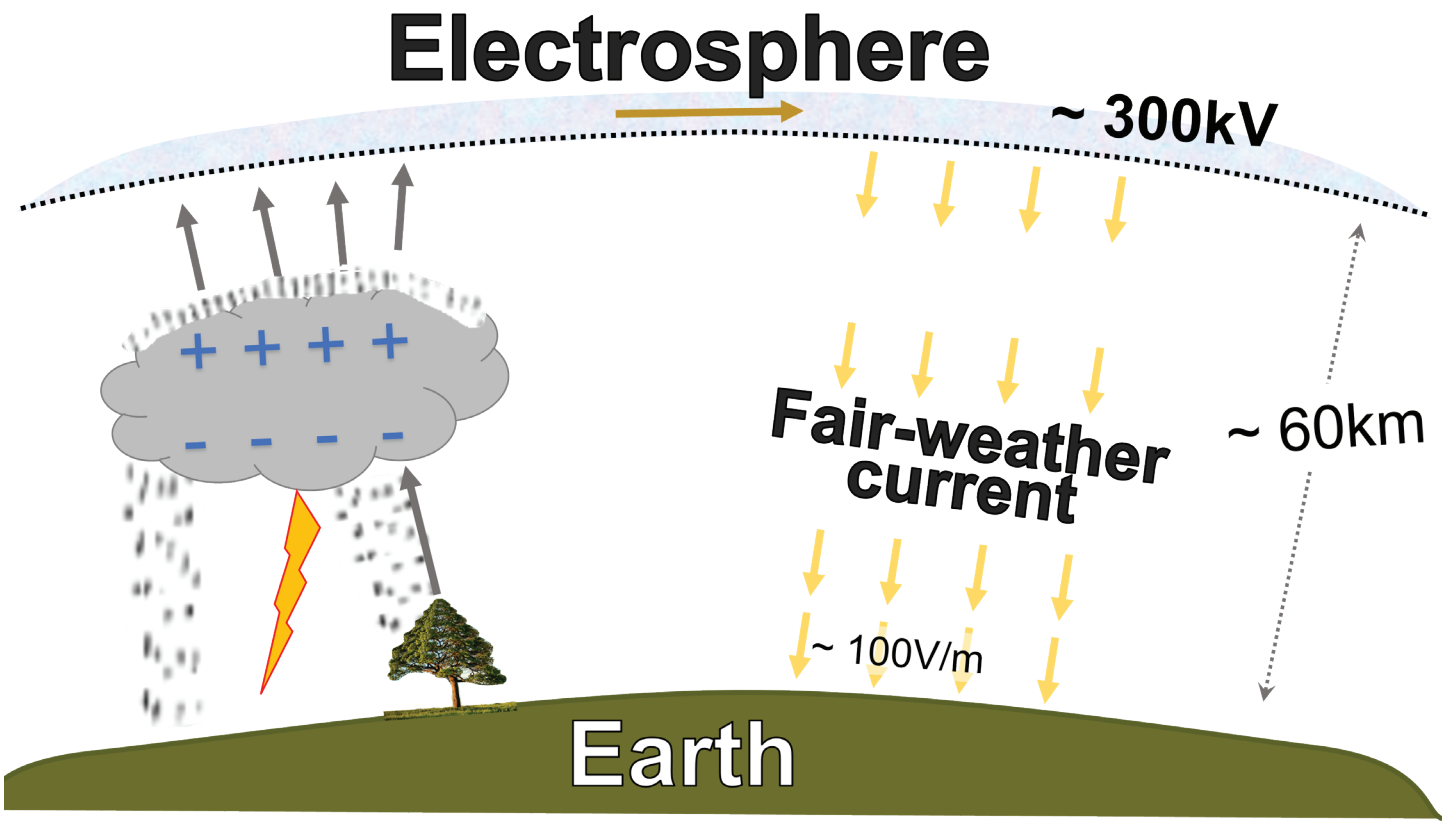


Fig 1: Illustration of global electric circuit (incl. precipitation, lightning, and corona)

Well then we could explain why the concept of lightning protection has not been handled in a manner that conveys confidence to the consumer and property owner.

It should be self-evident, that any measures taken to address the threat of lightning, should not be applied in the same manner across all properties all over South Africa.

ACCESS TO INFORMATION

In part 1, the concept of the stakeholder was discussed together with the importance of communication and consultation.

A key factor to confusion and conflict in the industry has been a lack of information and a lack of cohesion amongst subject matter experts.

ELPA are undertaking to provide critical information to the key stakeholders by way of an internet portal network for each industry in addition to opening a direct dialogue of engagement and consultation with each in pursuit of compliance with SANS 31000.

Included in this infrastructure will be a means by which the status of lightning protection at any particular location in South Africa can be determined for purposes as required by the stakeholders.

One such an example will be access to information required by short term insurance financial service providers regarding lightning protection systems (LPS):

- Lightning risk assessments;
- LPS commissioning reports;
- LPS test reports / routine inspections

Specific to the same providers and to be negotiated with the industry representative bodies such as the SAIA (South African Insurance Association):

- Compliance criteria for categories of structures, aligning those applied by the insurance industry;
- Factors such as risk exposure will be part of the considerations;
- Due consideration for actuarial data is also necessary and our consultation with actuary experts is vital.

Updates to the new portals will be posted regularly on the ELPA website.

CERTIFICATES OF COMPLETION

The term COC "Certificate of Compliance" applies primarily to the statutory electrical CoC in accordance with the regulated South African National Standard SANS 10142-1.

The predecessor to SANS 10313 (Protection against lightning — Physical damage to structures and life hazard), SABS 0313 from 1999, also used the term "Certificate of Compliance" to describe the document used to determine whether an LPS installation complied with the requirements of that standard.

In 2010, the SANS 10313 was revised to amend this detail by replacing the COC with two reports, namely the commissioning report with the title "Installation Safety Report" (ISR), and the routine inspections report with the title "Maintenance Certificate" (MC).

Both reports were an improvement on the LPS COC since both the LPS ISR and the LPS MC required more particular detail of installation. The commissioning report (ISR) dedicated a design section to the risk assessment. The reasons given for the change were associated with the ambiguous nature of some of the details stipulated in the standard.

It is evidence of poor industry collaboration and engagement that, 11 years later, many in the insurance and lightning protection industries still refer to the lightning protection systems COC. And go as far as stipulating this document as a minimum requirement for approval of an insurance policy. It is very distressing that we find ourselves in such a predicament where a non-existent document is deemed compulsory 11 years after it was discontinued.

ELPA have embarked on a program to install recognised competency across all levels of lightning protection service providers as discussed in part 1. This is not new and was part of the ELPA vision in June 2017 and is now being diligently driven in accordance with national governance.

As part of that program, an ELPA certificate of completion will be adopted that will be registered as a status certificate for any property in South Africa and will be available upon authorised enquiry.

The ELPA CoC will also reference known status of the Electrical CoC of the property for referral to the ECA and municipal building inspectors/officers for regional support to the property owner.

ELPA MEMBER COMPANY EXCLUSIVE GUIDANCE

All companies registered with ELPA obtain first-hand guidance on national policies, updates, changes to International Standards, Technical Reports, and developing Technical Specifications (where the content fails to meet the criteria to qualify as International Standards).

ELPA membership is not a one-way street. Each ELPA member company

acknowledges and commits to the ELPA Code of Conduct that can be read on the ELPA website (which as stated earlier, is itself due to undergo full revamp).

Our experiences as a collective will be leveraged as lightning protection service providers to contribute to collaborative engagement with (list not comprehensive):

- Industry representative bodies and organisations such as the SAIEE, ECA, ECB, SAIA, CESA, to name but a few,
- The Governance departments of Employment and Labour (with the Chief Inspector of Health and Safety), Mineral Resources, (with the Chief Inspector of Mines), Cooperative Governance - CoGTA (including building inspectors/control officers), Basic Education, Higher Education, Environment (Forestry, Fisheries and Environment), and Trade and Industry (and Competition),
- competency skills development standards body SAQA and QCTO,
- electrotechnical standards body SABS and therefore the IEC,
- the property owners and representatives, body corporates, etc.

These experiences place ELPA as a national representative body at the forefront to understand where our standards do not meet the requirements of our country and permit us to contribute to the international body of knowledge being used to improve lightning protection worldwide.

ELPA MEMBER COMPANY EMPLOYEE SKILLS DEVELOPMENT

ELPA member companies are companies deemed to be competent in the field of lightning protection and therefore it stands to reason that an online portal exclusive to ELPA member company employees will afford each employee membership status and a career development path program. Details will include skills development progress and performance tracking associated with the project work completed each year for their companies. Thus, an equivalent CPD level of assessments will take place annually.

Should an employee find themselves in a situation where change happens and move to another ELPA member company, their career skills development records will move with them. No records will be discarded, and the individual will retain copies of records for life.

The SAQA processes will be afforded to all individual members and registration on the NLRD of approved ELPA Qualifications will form the basis of that career development path. Note that once the registrations of curriculum are completed, these qualifications will not be known as ELPA Qualifications but rather national qualifications in lightning protection registered by SAQA on the National Qualification Framework.

This process will enable ELPA to support and structure an internship program in support of all ELPA member companies and optimising costs in support of the channelled skills development framework and SDL expenditure back towards the LP industry.

LIGHTNING PROTECTION SKILLS COMPETENCIES

It has been a great concern to the ELPA Board of Directors that circumstances have necessitated a freeze on the examinations process for ELPA level 1 Installers. Without formal training regimens and a curriculum endorsed by SAQA, the industry was not being stabilised and strengthened.

Together with the registration as Professional Body, ELPA is actively preparing documentation for the Advanced LPS Installer and General LPS Designer levels to be reviewed by QCTO appointed project team.

Upon approval, these will be registered with SAQA affording these levels as registered in accordance with our national competency registration legislation for consideration in the arena of the Authorised Inspection Authority (AIA) with approval from the Chief Inspector Health and Safety.

In the Designer certifications, particular attention is being given to a fundamental risk management module geared to a scientifically repeatable risk assessment process that will produce repeatable results irrespective of who does the risk assessment.

Surety of a consistent risk assessment is a critical element to our industry. It is also here that actuaries may be called upon to add value.

STANDARDS - LIGHTNING PROTECTION

In part 1 I covered many of the fundamentals principles that must direct our application of standards.

It is unfortunate that not enough detail of developments in the revision of SANS 62305 by the IEC Technical Committee TC81 (on Lightning Protection), have been shared across South African industries who needed this information. In some instances, redundant work has been undertaken by our local working groups potentially duplicating efforts of our international colleagues and depriving them of

valuable feedback we should have submitted to the Technical Committee and Maintenance Teams of IEC 62305. Several related SANS have seen potentially unsolicited changes due to a lack of consultation amongst stakeholders.

All 4 parts of the IEC 62305 are being revised by the IEC and the MT (Maintenance Teams) are now in the final stages of review.

To fast track the significance of those changes, details will be published on the ELPA website as fast as we can facilitate verification of all approved changes that can and should have been circulated.

Where changes will impact those installers already certified by ELPA (Level 1), those details will be made available to them via the ELPA portals mentioned above – individuals will be notified and issued with login details to secure libraries created for the new Knowledge base.

Members are reminded that certification can only be released upon commitment of the employer to the ELPA Code of Ethics such that the employee does not get caught in a conflict of interest over any non-compliant or unethical business practices.

Several parts of the SANS 62561 LPS components compliance standards are also being revised by IEC TC81 and the proposed improvements will be circulated on the same basis.

ELPA member companies will be directly privy to all future proposed changes as members of this industry and our responsibility to consult with and represent your interests.

And finally, this leads to the future of SANS 10313.
Since this standard is directly linked to SANS / IEC 62305-3, the document must be revised in accordance with the new changes in that standard.

However, a number of critical aspects of our industry has consistently been overlooked in favour of commercially motivated interests which has been a major cause for concern.

(a) The LPS commissioning and maintenance reports in SANS 10313 fail to address core aspects of the tracking process and will need to be revised with a view to providing a positive link with risk management, client consultation, and sustainable integrity tracking in a manner that is transparent and systematic.

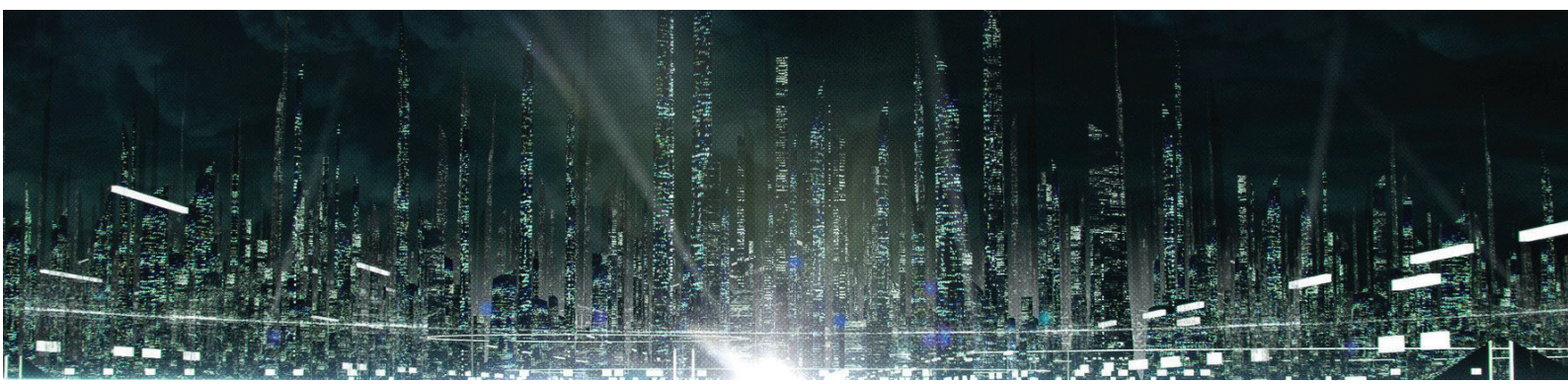
It is for this reason that the supplementary ELPA Certificate of Completion was formulated to provide industry and property owners with surety of state of installations and a means to implement defect corrective plans;

(b) The SAWS and the SABS need to consider proposals that will assist both parties to fulfil their legislative mandates in a collaborative manner that will see the National Lightning Ground Flash Density map gazetted in a manner that will release published figures audited by an independent party.

Such a process needs to be formalised and is not unlike a similar document applied in the UK.

Therefore, a proposal will be prepared through the SABS standardisation processes for consultation with all affected industries, to expand SANS 10313 to also provide valuable South African information pertinent to IEC / SANS 62305-2.

Similar consideration is being given to SANS 62305-4 where we perceive the processes for design and selection of suitable surge protection measures to be inadequate. However, any such considerations will only be initiated once all related IEC and SANS documentation pertaining to surge protection have been reviewed and consensus reached within existing SABS standardisation technical committees and maintenance working groups. wn



Feigenbaum Chaos

Mitchell Jay Feigenbaum (1944-2019) made a significant contribution to chaos theory in 1975 by studying the growth of a hypothetical population of rabbits. Fibonacci (c1170-1240+) came to his famous mathematical series of numbers by studying rabbits' breeding patterns.

COMPILED BY | DUDLEY BASSON

A fascinating aspect of the Feigenbaum function is that when graphically plotted as a logistic map, it can result in chaos by repetitive bifurcations, which decrease in size by a fixed ratio, which has become known as the Feigenbaum constant: δ = 4,669 201 609...

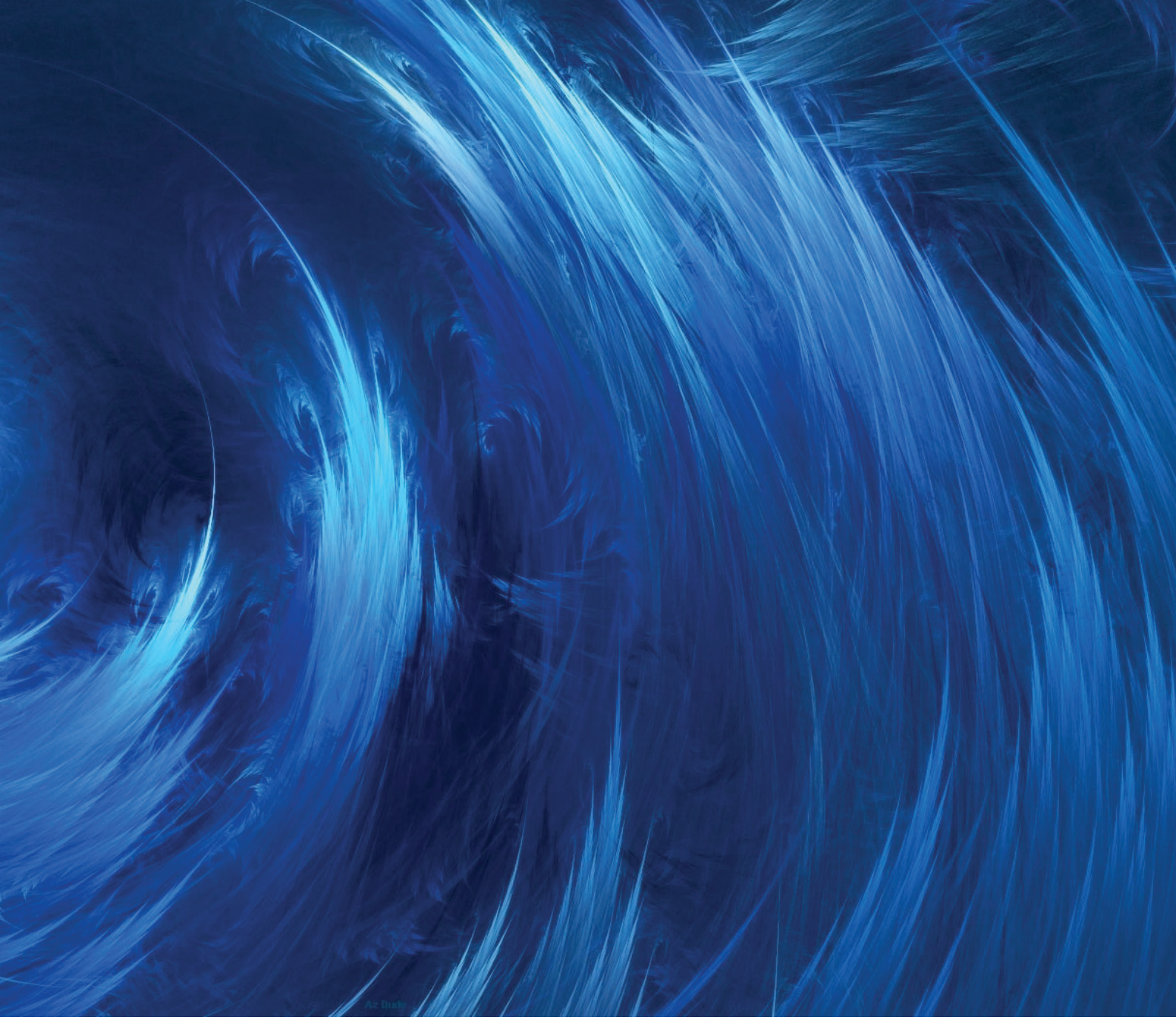
Remarkably, the Feigenbaum constant "δ" and the Fibonacci series have close links to the Mandelbrot set. The link of the Fibonacci series to the Mandelbrot set can be seen here.

The constant "δ" can be found in many unrelated chaotic events, such as dripping water taps, noise in electric circuits, weather patterns, conscious information processing, particle physics and, together with the Navier Stokes equations, in the study of the laminar and turbulent flow of fluids.

Feigenbaum constants have also been seen to appear in financial matters, forecasting stock behaviour. A time-series comparison between S&P500 data in 1997 and 1998 has been conducted. Phase trajectories and the corresponding density histograms were built. It turned out that the ratio of distances between neighbouring regions of maximum density of the phase trajectories is determined by the Feigenbaum constant
α = 2,502 907 875...

This characterises splittings of phase trajectory in a series of period-doubling bifurcations in the way from order to chaos for many non-linear dynamical systems. Thus, α can be used in forecasting stock indices behaviour.

Interestingly, the ratio between adjacent numbers in the Fibonacci



infinite series converges on another widely occurring natural number, the golden ratio: Φ = 1,618 033 988.

Close approximations of δ and α can be calculated using the golden ratio (golden mean) Φ.

There is also a simple numerical relation between the Feigenbaum constant "δ" and the Sommerfeld "α" fine structure constant of particle physics $\sqrt{(1/2\pi\alpha)}$. This very close approximation must remain a coincidence until some deep-seated link can be found.

The Fibonacci series, golden ratio, and the Mandelbrot set are described in the November 2019 issue of **watt**now.

Supercomputer colourised zooms down the infinite complexity of the Mandelbrot fractal set are included.

Fibonacci's series does not include any limiting factor, so that the series continues indefinitely. The Feigenbaum function does have a limiting component, which for rabbits would include breeding fertility, food availability, predation etc.

Before reading further, it is essential to view this video describing the Feigenbaum function and bifurcation diagram. (18:35 mins.)

The second Feigenbaum constant α= 2,502 907 875 is the ratio between the width of a tine and the width of one of its two subtines (Branches of a bifurcation diagram).

The Feigenbaum constants do not appear precisely at the first bifurcation but will eventually converge on these values.

For a paper "Introduction to Chaos in Deterministic Systems" by Carlos Gershenson, see.

A vast body of research has been done into the self-similar fractal noise in telegraph lines illustrated by the Feigenbaum constant and the Mandelbrot set.

Here is another 'must see' video – Non-linear Feigenbaum dynamics (5:57 mins):

Also, this one on the Butterfly Effect (12:48 mins.).
This shows how a trivial change to starting conditions of a chaotic system can produce vastly differing results.

The function $Z_n^2 + C$ is not the only function used to generate the Mandelbrot set. Using Z_n^2 gives the familiar cardioid as the central figure. This is an epicycloid with the base and rolling circles of equal size. Using higher powers of Z_n will result in fractional sizes of the rolling circles giving the sequence of cardioid, nephroid, trefoil, quatrefoil etc. The resulting Mandelbrot sets will have different patterns in the resulting fractals, and the spirals will become multiple spirals.

The reproductive Feigenbaum ratio 'r' is all-important. This determines whether the population will decrease to extinction, move to stability, or increase to destructive overpopulation.

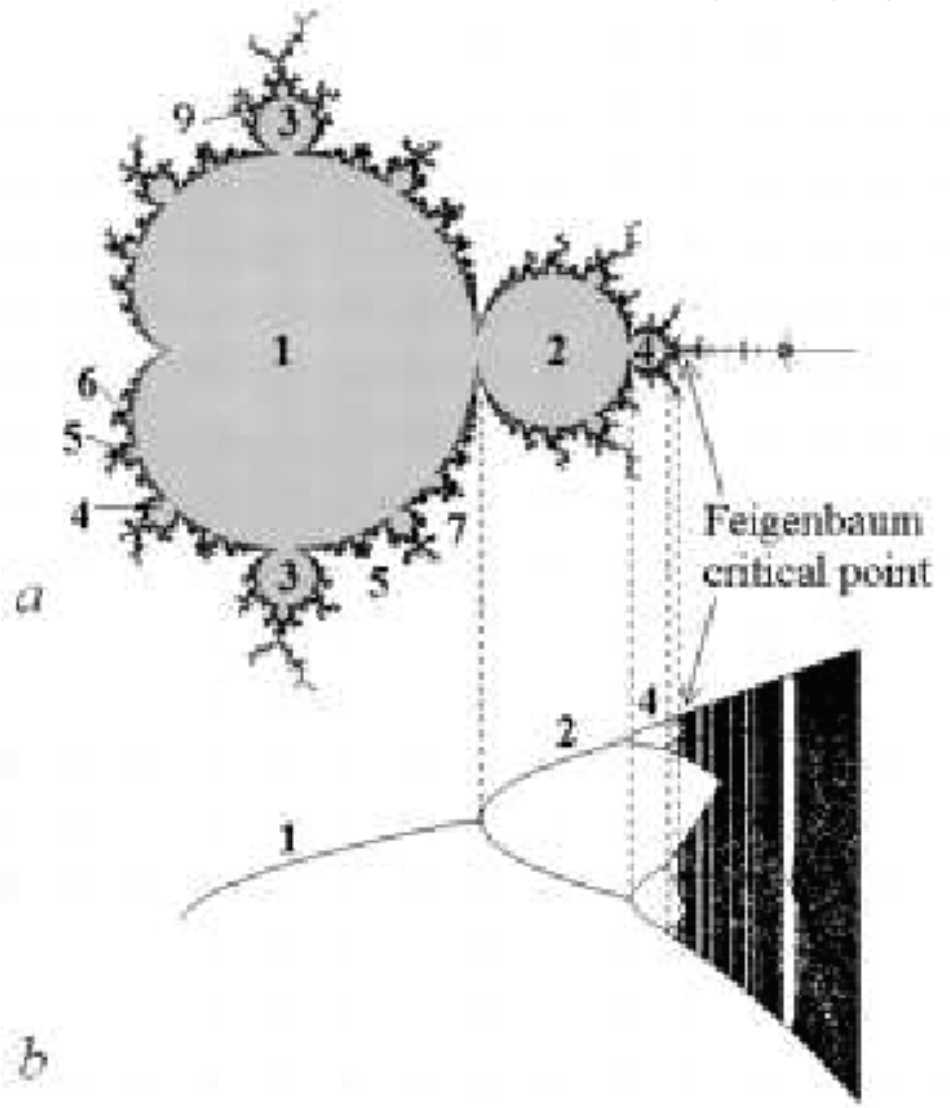
The function $r X_n (1-X_n)$ plotted from 0 to 1 gives a parabolic hump orbit. Any other function can be used provided that it produces a hump. Values of 'r' between 0 and 3 represent the steady-state regime.

Values of less than 1 will lead to extinction. Values from 3 to 3,5699 map interesting orbiting dynamic characteristics where the population system being modelled may cycle between orbits of frequency multiples of 2, 4, 8, 16, 32, 64 … When a range of 3,5699 to 4 is used, the logistics mapping of a system exists in the 'region of chaos'.

The overpopulation phenomenon can be seen in the small Norwegian rodents known as lemmings, which overpopulate and migrate on a four-year cycle. This has given rise to a mythical notion that these creatures self-destruct. Currently, Australian farms are experiencing chaotic overpopulations of mice which have made some farmhouses uninhabitable.

For a fascinating (must see) video of the combined Mandelbrot set, cobweb plot, and bifurcation diagram progressing in unison, see (3:29 mins.)

Watch this video for a fascinating chaotic logistic map zoom-in (2:30 mins.). This gives the appearance of a fractal zoom-in, which indeed it is.



The Feigenbaum bifurcation diagram maps directly to the Mandelbrot set

Mandelbrot set:	$Z_{n+1} \rightarrow Z_n^2 + C$	(Complex numbers)
Feigenbaum function:	$X_{n+1} \rightarrow r X_n (1-X_n)$	Many other iterations can be used.
	$X_{n+1} \rightarrow r \sin(\pi \sqrt{X_n})$	to give the same constants.

Interestingly, the Feigenbaum logistic map can reach a critical point where it cascades into chaos between the upper and lower tines of the bifurcation diagram, raising the entropy.

Natural processes cannot lower entropy. In the cosmos, the entropy of gas can be lowered by gravitation.

For a 2013 mathematical paper by R. Smith on period-doubling, information entropy, and Feigenbaum constants, click here.

The Feigenbaum logistic diagram can be converted to audible sound frequencies, but this will hardly be anyone's idea of music. Have a listen (1:10 mins.).

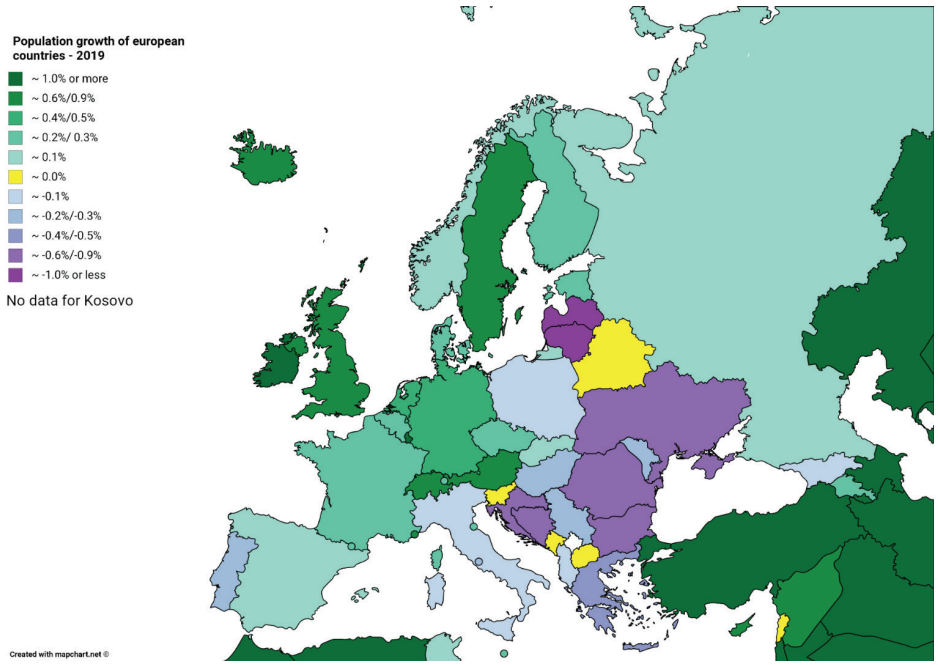
For a brief description of the Feigenbaum cobweb diagram, click here.

For a fascinating video of bifurcations and the cobweb plot in the Mandelbrot set, watch.

For an interesting article titled 'Analysis of chaotic systems, and implementation of the logistic equation', click here.

As expected, the Feigenbaum mathematical modelling can be applied to the spread and control of the Covid-19 virus in various global countries. There are examples of countries where stringent controls have the infection rate decline, and others where the virus is cascading out of control. For a mathematical modelling paper (22 pages) describing this tragic pandemic, click here.

Feigenbaum bifurcation and chaos are also applicable to non-linear dynamical studies in chemical and biochemical engineering.



Population annual growth rate of European countries

A real-life example of the Feigenbaum population demographics can be seen in present-day Europe. The shrinking populations have resulted in several countries using imported foreign labour, particularly Germany, importing "gastarbeiter" from Turkey.

The situation has taken a dramatic turn since 2015 with the start of a considerable influx of largely undocumented migrants from Third World countries into Europe. With the negative growth of some ageing European populations and the rapid growth of the migrant populations, which remain as parallel societies in their host countries, the scene seems to be set for the eventual disappearance of the individual European countries and a total population replacement. This situation appears to be exacerbated by widespread scant regard for preserving national identity or cultural heritage.

In the 20th century, some eastern countries introduced harsh government measures to reduce the population growth but with varying degrees of success and some regrettable outcomes. For a human population to stabilise (r = 1), a minimum Total Fertility Rate (TFR) of at least 2,1 is required – TFR is the average number of children per woman over her lifetime. Globally the average TFR is 2,5. As of 2020, the total fertility rate varied from 0,84 in South Korea to 7,0 in Niger. Almost half of all people live in a country where the TFR is below the replacement rate. For an extensive report on global populations, click here.

Countries experiencing chaotic overpopulation will find themselves on track to societal collapse by famine, war, pestilence or other calamities.

The Feigenbaum bifurcations and chaos are also applicable to urban populations and urban-rural population interaction and growth. A 2021 study by a director of accounting firm KPMG, Gaya Herrington, of a model of world society by MIT researchers in 1972, called World3, and published in a book titled "Limits to Growth" predicting the collapse of society in the 21st century, shows the model being alarmingly on track.

The KPMG study, published in Yale "Journal of Industrial Ecology", concludes that the 1972 model was strikingly aligned with current data. Without change, it says, global civilisation is heading toward a free-falling economic decline in the coming decade, leading to societal collapse by around 2040.

The new analysis examined population, fertility rates, mortality rates, industrial output, food production, services, non-renewable resources, persistent pollution, human welfare, and ecological footprint.

In her study, Herrington says: "continuing business as usual, that is, pursuing continuous growth, is not possible.

Even when paired with unprecedented technological development and adaption, business as usual as modelled by limits to growth would inevitably lead to declines in industrial capital, agricultural output, and welfare levels within this century."

However, not all hope is lost, the study says. We have a tiny window in which to make the necessary changes to avoid the worst-case scenario.

The paper reads: "A deliberate trajectory change brought about by society turning toward another goal than growth is still possible. The limit to growth implies that this window of opportunity is closing fast."

In his 2014 science fiction novel 'The Peripheral,' William Gibson, the godfather of the cyberpunk genre, predicted a future in which society slowly and knowingly ground its way towards a societal collapse brought on by climate change, pandemics, and other factors.

The novel emphasises that its premise was not brought on by one cataclysmic event but rather by a combination of factors slowly taking effect over decades.

A KPMG director signalling the end of times, barring profound changes to the socio-economic status quo, might seem like fiction, but such predictions have been hiding in plain sight for decades.

Possibly the greatest threat to our planet at present is the increase of greenhouse gases in the atmosphere causing global warming, rising sea levels and changing weather patterns.

In turn, these will lead to widespread extinction of species due to changing habitat and massive relocation of human populations due to loss of coastal land and cities. This will result in demographic chaos on an unprecedented scale. The planet has seen several mass extinctions, but this will be the first since the appearance of human life.

For a paper on: "Measuring Feigenbaum's constant in a bifurcating electric circuit" (4 pages) click here.

For a paper on: "A Non-linear Electrical Circuit Exhibiting Period Doubling Bifurcation and Chaotic Behaviour" (4 pages), click here.

For an 83-page thesis on non-linear bifurcating systems, "Numerical and experimental analysis of multiple Chua circuits" by R. van der Steen click here.

For a particle physics paper titled "Are Particles Self-Organized Systems?" which describes three families of fermions organised as bifurcation diagrams, click here.

In 1940, mathematician Dame Mary Cartwright made a vital discovery connected to problems in military radio receivers. She found that the problem was caused by an excessive gain on the amplifiers in which frequencies would go onto bifurcation and then chaos.

Click here for a mathematical look at the Feigenbaum constants.

Sophie Germain's classic differential equation describing the vibration of a Chladni surface has been taken further to include Feigenbaum frequency doubling bifurcations and chaos and extended to thin shells and surfaces with various loads, constraints and non-linear drivers.

Let us take a brief look at an abstract of a 2007 electric circuit paper by Bucharest academics Cristescu Constantin, Mereu Bogdan & Agop Maricel, titled: "Feigenbaum scenario in the dynamics of a metal-oxide semiconductor heterostructure under harmonic perturbation, golden mean criticality, chaos, solitons and fractals".

Experimental investigations and theoretical analysis on the dynamics of a metal–oxide semiconductor heterostructure used as non-linear capacity in a series RLC electric circuit are presented. A harmonic voltage perturbation can induce various non-linear behaviours, particularly evolution to chaos by period-doubling and torus destabilisation. This work focuses on the change in dynamics induced by sinusoidal driving with constant frequency and variable amplitude. Theoretical treatment based on the microscopic mechanisms involved led us to a dynamic system with a piecewise behaviour. Consequently, a model consisting of a non-linear oscillator described by a piecewise

Mitchell Jay Feigenbaum (1944-2019)

second-order ordinary differential equation is proposed. The asymmetry requires this kind of treatment in the behaviour of the metal–oxide semiconductor for the polarisation of the perturbing voltage. The dynamics of the theoretical model is in good agreement with the experimental results. A connection with El Naschie's E-infinity space-time is established based on the interpretation of our experimental results as evidence of the importance of the golden mean criticality in the microscopic world.

The Feigenbaum bifurcation diagram can be used as a model of the limits of conscious information processing. A brief extract from a paper by psychoanalyst/hypnoanalyst Dr Ernest Lawrence Rossi (1933-2020): The Feigenbaum scenario of the mathematical period-doubling sequence from order to deterministic chaos has led to new insights into the non-linear dynamics of many physical and biological systems. Multiple realms from purely mechanical systems, fluid dynamics and weather to the patterns of biological growth and the dynamics of the heart, hormone and brain rhythms have been found to exhibit aspects of the Feigenbaum period-doubling sequence.

We explore the possibility that the Feigenbaum scenario can be extended to experiences of sensation, perception and human cognition. We also review the empirical data that supports the view that the Feigenbaum scenario of the period-doubling sequence may portray an essential limit in conscious information processing.

We conclude that a significant function of consciousness may be to transform the non-linear, irrational and difficult to predict dynamics of unconscious nature into the more linear, rational and predictable psychodynamics that make the human experience and social life possible.

Albert Einstein wrote a letter outlining his philosophy of science a few years before his death in 1955 to his friend Maurice Solovine. The essence of Einstein's view was illustrated in a simple freehand drawing he made of how one must first take a "creative leap" to formulate a new "axiom." One subsequently deduces a series of consequences from this axiom that may be tested for empirical verification in the "real world." Quaint as this classical view of science may seem in our post-

modern age of de-constructivism, it indeed served Einstein well in developing his revolutionary concepts on all levels, from the cosmological to the quantum. This paper will follow Einstein's approach to take a creative leap regarding the significance of Feigenbaum's scenario as portraying a limit in conscious human information processing. We will review how existing empirical data support this hypothesis and further research to confirm it. We will conclude with several open questions about the relevance of the Feigenbaum period-doubling sequence for a deeper understanding of the paradoxes and uncertainties of human experience awaiting exploration in the fields of logic, computer science and quantum physics psychobiology, depth psychology and the social sciences.

That is the creative leap that we would like to explore with the Feigenbaum period-doubling sequence of the logistic equation that was initially proposed as a model of population dynamics, where feedback prevents populations of bacteria, plants and animals from growing infinitely because of environmental limitations of food supplies and space as well as the presence of predators. Since psychobiological processes utilise iterative information feedback on many levels as portrayed by the Feigenbaum period-doubling sequence, we naturally wonder whether this bifurcation model can illustrate anything interesting and empirically verifiable about human choice points and information processing on the conscious and unconscious levels. Can the logistic equation and other equations leading to the parabolic or hump structure be used to illustrate any facets of the population dynamics of ideas, awareness or consciousness? Does the limitation in the human-conscious perception of the Feigenbaum period-doubling sequence to the range of 7 to 15 units or pathways have any empirical foundation in human experience?

Several classical studies in experimental psychology confirm that seven units or chunks (plus or minus two) is, in fact, a widespread limit in human sensation, perception, memory and performance (Miller, 1956).

Traditionally humans are regarded as having five basic senses. If one includes the more subtle varieties of kinesthetic and proprioceptive sensations, the human number of conscious senses quickly jumps to seven but probably not much beyond that. Sperling (1960) found that people could remember about seven letters over a 1-second interval. He called this the iconic trace. Neisser (1967) found that the auditory trance, which he called echoic memory, had similar characteristics. Musical tone recognition ranges from the familiar octave scale to the more cerebral 12 tone scale. Is the number seven as a typical bandwidth in humans such sensory-perceptual-memory studies and the seven chunks or paths we can see easily in the Feigenbaum period-doubling sequence simply a coincidence? Or is it another example of the seemingly unreasonable effectiveness of mathematics in modelling human experience in the most unexpected ways? The upper limit of about 15 units in conscious human perception illustrated in the Feigenbaum period-doubling sequence is supported by Kihlstrom (1980). Kihlstrom found that 15 items set the upper limit for post-hypnotic memory in low and highly susceptible hypnotic subjects who achieved that performance limit by different routes.

An intriguing indication that seven is an essential limit in complex human conscious functioning was discussed by Hofstadter (1995), who reports that he played and practised extensively with anagrams since early youth. How many arbitrarily arranged letters can one juggle in one's mind simultaneously until they suddenly rearrange into a meaningful word? He says, "Six letters, yes, but ten, definitely not." The same range is evident in juggling physical objects as well. The world record for juggling is nine balls. Ronald Graham, a chief scientist at AT&T laboratories, is a gifted juggler who reports that he can juggle six balls consistently and sometimes seven "playing around."

Further evidence of the significance of seven in complex human conscious information processing is extensive use of subjective rating scales involving human judgments about everything from sense perception to emotional experience.

Research documents that most rating scales used in psychological assessment and personality testing, for example, can be optimised by requesting discrimination on a scale of about seven points. Subjects are asked to judge how happy or satisfied they are with a particular situation or life experience on a five to seven-point scale that runs something like "1. Extremely Satisfied, 2. Satisfied, 3. Neutral, 4. Unsatisfactory, 5. Extremely Unsatisfactory."
Recently developed cognitive-behavioural approaches for assessing a patient's response to psychotherapy use a seven-point "Validity of Cognition" scale. This is to check how much conviction patients have that they have been helped, as well as a ten-point "Subjective Units of Discomfort Scale" to check on how much their pain or psychological discomfort has changed during therapy. Research is now needed to confirm the relevance of the Feigenbaum point and period-doubling

sequence in this optimal perceptual, performance and subjective judgment limit of 7 to 15 chunks of conscious experience on the path from order to chaos in human awareness. Freeman's (1995) research on the non-linear dynamics of the sensory-perceptual dynamics of smell, for example, would be a critical test case.

At present, we can only speculate about several open questions about the explanatory power of the Feigenbaum point and period-doubling sequence in human experience. We can only wonder whether the significance of the number seven in gambling and many ancient mantic and mystical belief systems could have the same source in the limitations in our conscious sensory-perceptual-cognitive limits of awareness illustrated in the bifurcation diagrams of the Feigenbaum period-doubling sequence. Seven items are about as much as we usually can hold in consciousness, so we feel we know them and are comfortable with them. When consciousness has to juggle more than seven items, dimensions or levels, we experience the stress of the heightened arousal of our neuroendocrine system and ultimately failure as documented by the extensive data supporting the Yerkes-Dodson law. On a cognitive level, human cognition seems to become chaotic, dark, fearful, unconscious and perhaps unreal when we must hold in memory and manipulate more than 7 to 15 factors at one time.

The universality in the appearance of the Feigenbaum period-doubling sequence in many complex systems has led to many highly speculative views about the possible significance of the Feigenbaum point for psychology, sociology, and the humanities in general. Merry (1995, p. 37) suggests, for example, that the Feigenbaum point (about 3.7) is where systems cascade into chaos "where infinite choices create a situation in which freedom has no more meaning." We could generalise this to say that emotions, imagery, behaviour and cognition and psychosomatic symptoms that have lost their meaning have somehow fallen into the chaotic regime within experiential space where our sense of reality teeters off the edge of comprehension or rationality. This suggests that beyond the Feigenbaum point, inner subjective experience may fall into a sense of unreality.

Put another way, the Feigenbaum point may signal the division between the primary process (irrational) versus the secondary processes (rational, ego processes) as defined in psychoanalysis. In this sense, the Feigenbaum point could represent a limit of our sense of voluntary ego control over our mental experience and behaviour. The physicist uses the route to chaos to describe turbulence in nature (fast-moving water flowing over rocks, air turbulence behind an aircraft, etc.). Likewise, the psychologist could describe the experience of confusion, disorientation and unreality as the turbulence of the mind moving past the Feigenbaum point into deterministic chaos.

I now propose that the Feigenbaum point marks the transition between the explicit realm of conscious choice and behaviour and the implicate realm of deterministic chaos on the unconscious level. The Feigenbaum point is the limit of "subitising" – the ability to tell at a glance whether there are 1, 2 or 3 objects in conscious (explicit) perception. These 1, 2 or 3 objects in conscious perception correspond to the first, second and third bifurcation of the Feigenbaum Scenario as illustrated previously.

The deep correspondence between the non-linear dynamics of the Feigenbaum period-doubling sequence and the empirical data of psychobiology, chronobiology, experimental psychology, and psychoanalysis psychodynamics suggest they all derive from a common archetypal foundation of foundation iterative feedback processes.

The Feigenbaum point may represent an essential limit in conscious information processing that brings together previously scattered data that has been summarised in the unification hypothesis of chronobiology. A primary function of consciousness may be to temporarily transform bits and pieces of the non-linear, irrational, and difficult to predict dynamics of unconscious nature into the more linear, rational and predictable psychodynamics that make the human experience and social life possible. Click here for the full paper.

Dr Rossi's reference to a juggler who can manage up to nine balls can exceed an orchestral conductor. Another example of extreme multitasking is performed by organists who may have to play on up to five manuals (keyboards) and pedals and make selections from a vast number of stops.

Click here for a highly technical paper titled "Is there chaos in the brain? II. Experimental evidence and related models", which describes bifurcations and deterministic chaos in neural networks in the brain (Keywords: neuronal dynamics, neurochaos, networks, chaotic itinerancy, winnerless competition, representation, neuronal code).

The Human Brain Project is a Swiss national initiative that aims to create a digital reconstruction of a brain by reverse-engineering brain circuitry. It

is hoped that it will eventually shed light on the nature of consciousness. This was founded in 2005 by the Brain and Mind Institute of the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland.

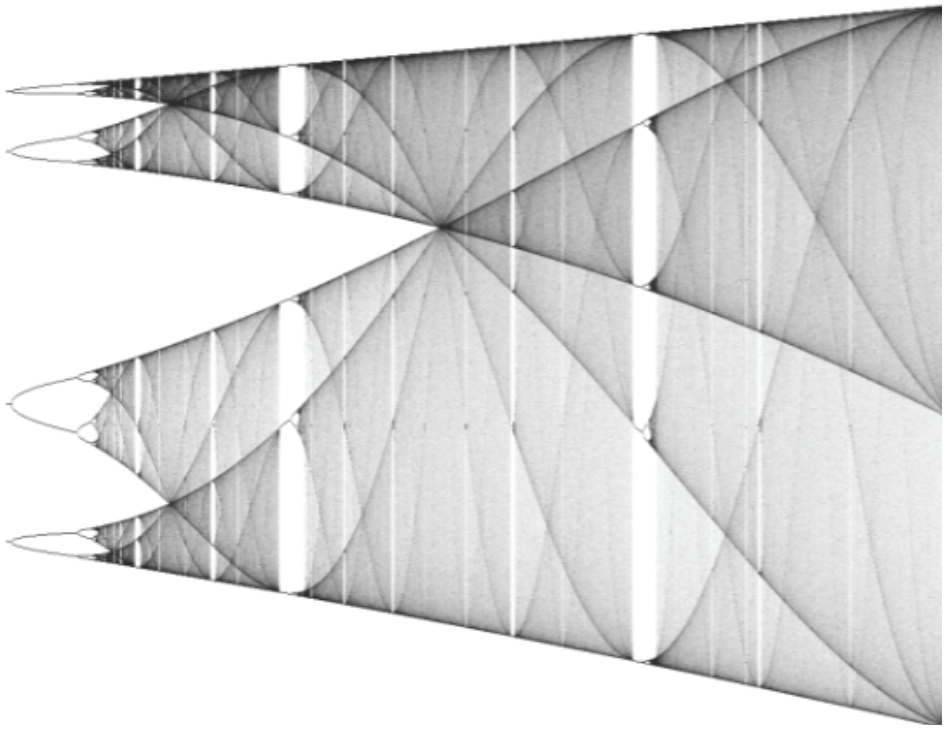
Modelling found that a brain functions in up to eleven dimensions, with a bizarre possibility that consciousness could be established in a quantum computer. A fascinating link is available (7:25 mins.) here.

When the researchers presented virtual brain tissue with a stimulus, cliques of progressively higher dimensions assembled momentarily to enclose high-dimensional holes that the researchers refer to as cavities.

Ran Levi of Aberdeen University commented: "The appearance of high-dimensional cavities when the brain is processing information means that the neurons in the network react to stimuli in an extremely organised manner.

It is as if the brain reacts to a stimulus by building then razing a tower of multi-dimensional blocks, starting with rods (1D), then planks (2D), then cubes (3D), and then more complex geometries with 4D, 5D, etc. The progression of activity through the brain resembles a multi-dimensional sandcastle that materialises out of the sand and then disintegrates."

Neuroscientist Henry Markram, director of Blue Brain Project and professor at the EPFL in Lausanne, remarked: "We found a world that we had never imagined; there are tens of millions of these objects even in a small speck of the brain, up through seven dimensions. In some networks, we even found structures with up to eleven dimensions."



Chaotic region of Feigenbaum bifurcations

The logistic map or bifurcation diagram is a prominent example of the mappings that Feigenbaum studied in his noted 1978 article: "Quantitative Universality for a Class of Non-linear Transformations."

Feigenbaum's other contributions include important new fractal methods in cartography, starting when he was employed to develop techniques to allow computers to assist in drawing maps.

The introduction to the Hammond Atlas 1992 states: "Using fractal geometry to describe natural forms such as coastlines, mathematical physicist Mitchell Feigenbaum developed software capable of reconfiguring coastlines, borders, and mountain ranges to fit a multitude of map scales and projections. Dr Feigenbaum also created a new computerised type placement program which places thousands of map labels in minutes, a task that previously required days of tedious labour."

In another practical application of his work, he founded Numerix with Michael Goodkin in 1996. The company's initial product was a software algorithm that dramatically reduced the time required for Monte Carlo pricing of exotic financial derivatives and structured products. Numerix remains one of the leading software providers to financial market participants. The press release made on the occasion of Feigenbaum receiving the Wolf Prize summed up his works with: "The impact of Feigenbaum's discoveries has been phenomenal. It has spanned new fields of theoretical and experimental mathematics. It is hard to think of any other development in recent theoretical science that has had so broad an impact over so wide a range of fields, spanning both the very pure and the very applied."

For an excellent historical account of Feigenbaum and his work, click here.

Click here for an excellent overview of chaos theory with extensive references. wn

SAIEE Coffee table book

Second Edition

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

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

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

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

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

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

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Energy Conservation

The Cornerstone of Low Carbon Objectives

2021 appears to be the year of net-zero and carbon-neutral position statements. Do you realise that achieving your low carbon objectives will cost you even more if your strategic plans are not built on a cornerstone of energy conservation?

BY | ANDREW COOPER | PR.ENG, B.COMM, CEM, CMVP

Why? Because energy conservation eliminates energy waste. Energy waste is a cunning adversary which slowly but surely, eats away at your profits.

A little over a month ago, I put an item I planned to return to the store in an "obvious place" where I could not miss it. Guess what?

After a couple of weeks, it became part of the furniture. It was hiding in plain sight, and I forgot about it. Energy waste is like that.

From the small and seemingly insignificant lights left on and compressed air leaks, for example, to the large and ignored, like conveyors left running or vehicles idling, energy waste hides in plain sight. Each instance costs you money, and these instances add up. This waste can account for up to 10% of your annual energy expense.

For a mining company, where energy is typically the second biggest expense after employee salaries and benefits, waste elimination positively impacts profitability.

As you transition to a low carbon future, there are additional financial benefits. If you are not wasting energy, you reduce the cost of achieving your low carbon objectives. Why? Because you will only install the renewable energy or purchase the carbon offsets you need. Why squander your money on wasted energy?

Implementing an energy management system needs to be the first step in your strategic plans for a low carbon future. ISO 50001 and the Mining Association of Canada's Toward Sustainable Mining (TSM) Climate Change Protocol are internationally recognised systems.

There are many other systems out there.

Please do your research, pick one that works for you and implement it.

Energy Matters! Remember the importance of energy conservation. Without this cornerstone, the transition costs to achieve the low carbon proclamations in your public position statements are going to be greater than they need to be. wn

UPSKILL TODAY!

Since its inception in 2009, The SAIEE CPD Training Academy has focussed on offering CPD validated courses for ECSA Registered Electrical Engineering Professionals to maintain their professional registration and for those SAIEE members wishing to attend quality courses to gain knowledge and maintain competence in the industry.

With increased progress and growth year on year, the decision was made to include technically related courses to add towards professional development. The SAIEE Training Academy provides training at an affordable cost and will offer any of the available courses for in-house and online training.

To enquire further or if you would like to be added to the SAIEE Training Academy's mailing list please contact:

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Seven Ways Flexspace Can Enhance Your Working Week

Not ready for a daily commute again? A flexible neighbourhood with workspaces for professionals who want to split their time between home, the office and a co-working hub is becoming a much-needed solution to the workplace quandary.

After more than a year and a half of working remotely, many of us are set to revisit the office. But are we really looking forward to re-joining the rat race?

Working from home (WFH) has benefits that people have come to value during the Covid-19 crisis, including no obligation to commute, a more relaxed dress code and more quality time with friends and family.

However, it also has challenges, not least the tendency for work and home life boundaries to blur. In early 2021, research into the realities of working from home found that people were spending longer at their desks than they did before the pandemic. In South Africa, the average length of time employees logged on to their computers increased by around two hours a day.

It's no surprise, then, that businesses are adopting a hybrid approach. This model of working – which allows staff to spend some time at home, some at the company HQ and some at a third location, such as a local, flexible workspace – offers all the benefits of remote working while helping employees stay connected to company culture.

Here, we outline seven ways to include visits to a flexible or co-working space that can enhance your working week, boosting productivity, focus, and creativity.

1. ENJOY A PROFESSIONAL ENVIRONMENT

Some people boast natural get-up-and-go, while others need to be nudged into the work zone. What's more, it's well known that our environment impacts performance and productivity, with cluttered kitchens or cramped bedrooms not conducive to either.

Light, well ventilated and equipped with ergonomic desks and chairs, modern co-working spaces are all designed with productivity and professionalism in mind. Comfortable and calm, a local, flexible workspace is set up with work in mind and can immediately put you in the right headspace for a good day's graft.

2. JOIN A CREATIVE COMMUNITY

In the new world of work, visits to the company HQ are likely to be for collaboration but, if your creative juices are refusing to flow between meetings, spending time at a flex space could help.

Co-working alongside other professionals in a buzzy atmosphere will spark your imagination and may even help you find like-minded new friends you can bounce ideas around with.

3. FIGHT FEELINGS OF ISOLATION

People are naturally social beings, and being isolated at home for lengthy periods can have a negative effect on the mindset.

Whether it's a quiet nod at the coffee machine or a breezy chat over the water cooler, interacting with others at a local flex space can offer the social

buzz we all need to be happier and healthier.

4. STAY CALM WITH TECH YOU CAN RELY ON

A key refrain we've all heard repeated during the pandemic is that people can now work 'wherever there's WiFi'. However, as anyone who's ever experienced Zoom freeze will attest, not all WiFi networks are created equally.

Like corporate offices, flexible workspaces benefit from an IT set-up that's better than anything most of us have at home. "Our locations are all equipped with secure, high-speed WiFi networks and offer access to printers and scanners, which can remove additional stress from your working day", says Joanne Bushell, MD of IWG Plc. South Africa

5. PRESS THE 'OFF' BUTTON (PROPERLY)

Whether checking emails over breakfast or labouring late into the night to finish a project, when you work from home, time becomes more elastic than when you work in an office. On average, remote employees work six hours more per week than if based in an office.

"Working from a co-working space sets firm boundaries between work and home, allowing you to switch off properly at the end of the day", Bushell adds.

6. DITCH DOMESTIC DISTRACTIONS

Procrastination is all too easy when you work where you live. Whether it's the ever-growing pile of laundry taunting you, your neighbours using you as a pseudo post office or frequent disturbances from family members that break your concentration, it can be tough to focus properly on professional tasks.

Using a physical office space away from home will remove these domestic distractions, providing vital peace and calm so you can focus solely on the workday ahead.

7. ENJOY EXCITING NETWORKING OPPORTUNITIES

Whatever your profession, face-to-face networking has become an essential part of working life. However, it's hard to network from your kitchen table.

Flex space locations offer regular networking events, including talks from local business leaders and networking lunches. In addition, simply co-working alongside others can help grow your network of contacts, opening up opportunities and boosting your profile.

Be flexible - whatever you are working on, embracing a hybrid professional lifestyle will give you the best of all worlds – freedom, motivation, community and convenience. It's the future. wn

DEFINITIONS

DEFINITIONS - LIGHTNING LOCATION SYSTEMS, LIGHTNING PROTECTION, THUNDERSTORM WARNING SYSTEMS	
Alarm (Warning)	Information indicating that a defined area is likely to be affected by thunderstorms and the accompanying Lightning Related Events (LRE)
Cloud-Ground Lightning (CG)	Lightning discharge that propagates from cloud to ground or vice versa and leads to a net transfer of charge between cloud and ground
Coverage Area (CA)	Area where given warning equipment has a sufficient Detection Efficiency (DE) and/or 256 accuracy to give a warning
Detection Efficiency (DE)	Percentage of strokes or flashes detected as a percentage of the total number of strokes or flashes occurring in reality
Effective Alarms (EA)	Alarm where a Lightning Related Event (LRE) occurs in the Surrounding Aarea (SA) during the Total Alarm Duration (TAD)
Electric Discharge	All references to a "discharge" made here, refer to an "electric discharge": discontinuous movement of charge carriers through part of an otherwise insulating medium, initiated by electronic avalanche and supplemented by secondary processes
Global Electric Circuit	Continuously charged spherical capacitive electric circuit between the conductive layers of the electrosphere and the earth's surface, with thunderstorms as the electric generator
Ground Flash Density (GFD or NG)	The mean number of cloud-to-ground flashes per unit area per unit time and stated as "flashes per km^2 per year"
Intra-Cloud / Inter-Cloud Lightning (IC)	Lightning discharge occurring within or among thunderclouds or between thunderclouds and air and which does not have a ground termination
Lead Time (LT)	Time between the start of an alarm and the effective occurrence of the first Lightning Related Event (LRE) in the Surrounding Area (SA)
Lightning CG Flash	Lightning discharge of one or more CG strokes. A CG Flash comprises a "first" stroke and multiple "subsequent strokes", and other elements (continuing currents, M-components)
Lightning Detection Network (LDN)	An LDN, not included as a definition by IEC, has the same meaning as an LLS.
Lightning Discharge	A transient, high-current (typically tens of kiloamperes) electric discharge, of atmospheric origin, in air whose length is measured in kilometers
Lightning Location System (LLS)	A network of lightning sensors that work together to detect and geolocate lightning events within the area of the system's coverage
Lightning Related Conditions (LRC)	Static electric field that has reached a level high enough so that lightning is expected to occur at any time in the Surrounding Area (SA)
Lightning Related Event (LRE)	One or more Cloud to Ground (CG) lightning occurring inside the Surrounding Area (SA)
Lightning sensor	A device that measures electromagnetic signals produced by lightning discharges
Lightning Stroke	Single electrical discharge in a lightning flash to earth
Location Accuracy (LA)	Distance between real stroke location and the stroke location given by a lightning location system
Low Frequency (LF)	Frequency range from 30 to 300kHz
Magnetic Direction Finding (MDF)	Method to locate the detected lightning - apply angle of incidence of lightning radiated magnetic field at multiple sensors
Median LA	Median value of the Location Accuracy
Monitoring Area (MA)	Geographic area where the lightning or upcoming lightning (lightning is expected to occur at any time) activity is monitored in order to provide a valid warning for the Surrounding Area (SA)
Preventive actions	Actions of a temporary nature, that should be completed before the end of the Lead Time (LT), taken on the basis of the preventive information and included in the emergency plans

ABBREVIATIONS

Surrounding Area (SA)	Geographic area in which a Lightning Related Event (LRE) causes a potential danger and which surrounds and includes the Target Area (TA) to be protected
Target Area (TA)	Object or area for which a thunderstorm warning is needed
Thunderstorm detector	Equipment capable of evaluating one or more parameters associated with the electrical characteristics of the thunderstorm
Thunderstorm Warning System (TWS)	System composed of thunderstorm detector(s) able to monitor the lightning or upcoming lightning activity in the Monitoring Area (MA) and tools for processing the acquired data to provide a valid alarm (warning) related to the Lightning Related Events (LRE) or Conditions (LRC) for a defined Surrounding Area (SA)
Time-of-Arrival (TOA)	Method to locate the detected lightning - apply time difference delay from source of radiation to multiple sensors
Time-To-Clear (TTC)	Time between the occurrence of the last Lightning Related Event (LRE) in the Monitoring Area (MA) and the time when the alarm is released
Total Alarm Time (TAD)	Time between the start and the end of an alarm
Very High Frequency (VHF)	Frequency range from 30 to 300MHz
Very Low Frequency (VLF)	Frequency range from 3 to 30kHz

ABBREVIATIONS

SAWS	South African Weather Service
SALDN	Southern African Lightning Detection Network
GFD	Ground Flash Density
CSIR	Council for Scientific and Industrial Research
LLS	Lightning Location System
IEC	International Electrotechnical Commission
SANS	South African National Standards
CA	Coverage Area
LA	Location Accuracy
DE	Detection Efficiency
CG	Cloud-to Ground lightning
IC	Intra-cloud and Inter-cloud lightning
LDN	Lightning Detection Network
TWS	Thunderstorm Warning System
TA	Target (Object or area)
SA	Surrounding Area
MA	Monitoring Area
LRE	Lightning Related Event
LRC	Lightning Related Conditions
TTC	Time to Clear
LT	Lead Time
TOA	Time-of-Arrival
MDF	Magnetic Direction Finding
VHF	Very High Frequency (30 to 300MHz)
LF	Low Frequency (30 to 300kHz)
VLF	Very Low Frequency (3 to 30kHz)

ADDITIONAL ABBREVIATIONS	
NOPF	National Occupational Pathways Framework
OFO	Organising Framework for Occupations
NLRD	National Learners Records Database
ESSA	Employment Services South Africa

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02/09/2021	Maintaining And Remediating The Cloud
06/09/2021	Fundamentals of Lighting Design
07/09/2021	Advanced Excel Practical - Data Management Applications for Engineers
08/09/2021	Energy Storage Chapter webinar - debate
09/09/2021	Energy Storage Chapter webinar- day 2
14/09/2021	Design of Economical Earthing Systems for Utility Electrical Installations
14/09/2021	SALTO Workshop - Day 1
15/09/2021	SALTO Workshop - Day 2
16/09/2021	LV/MV/HV Switchgear Operation, Safety, Maintenance and Management
16/09/2021	Waste to Energy - Corporate Partner Physical Event - by invitation only
20/09/2021	Fundamentals of Financial Evaluation of Projects
20/09/2021	Fundamentals of Medium Voltage Protection
20/09/2021	Run your project as a business
21/09/2021	SALTO Webinar
21/09/2021	Fundamentals of Developing Renewable Energy Plants
22/09/2021	Design Thinking and Innovation for Engineering Professionals
22/09/2021	KZN Centre Webinar
28/09/2021	Rotating Machines Webinar
28/09/2021	Finance Essentials for Engineers
29/09/2021	Women in Engineering Webinar
29/09/2021	Power Systems Protection
30/09/2021	70th Bernard Price Memorial Lecture 2021

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