wattnow

SAIEE | THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | SEPTEMBER 2023

LIGHTNING

Serving Since 1909

Formed in 1909, The South African Institute of Electrical Engineers sports ± 6000 engineering professionals.

Why Join Us

Our members are professionally engaged in various engineering activities, including academic research, manufacturing, electronics, telecommunications, measurement and control, mining, and power infra-structural services. Members make meaningful contributions to the quality of life in communities and the steady advancement of technology. Their efforts are acknowledged in many countries worldwide.

Training Academy

We offer CPD training courses, a powerful learning tool to improve skills, ensuring that academic qualifications do not become outdated.

Skills Development

One of our core objectives is to harness and foster the growth of Education in the Engineering sector, which has been faced with a debilitating shortage of skills.

Corporate Forums

Corporates are invited to monthly forum meetings to discuss and brainstorm critical issues in South Africa and find solutions.

Our Purpose

To enhance the practice of electrical engineering in South Africa and the stature of our members through knowledge, networking, influence, education and communication.

SAIEE

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CONTENTS

FEATURES

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Dear **watt**now reader

As we enter the South African lightning season, which most of us either enjoy thoroughly or some, like animals, are extremely afraid of, I bring you this issue featuring Lightning.

You might have asked yourself, what happens when lightning strikes an aircraft? This issue features exciting papers that will answer this question.

Page 24 brings you "Lightning Strikes – Protection, Inspection and Repair," which discusses how Lightning strikes can affect airline operations and cause costly delays and service interruptions. Strikes to aeroplanes are relatively common but rarely result in a significant impact on the continued safe operation of the aircraft. Lightning protection is used on Boeing aeroplanes to avoid delays and interruptions and reduce the strike's significance. To increase the effectiveness of repairs to damage caused by lightning, maintenance personnel must be familiar with lightning protection measures, proper inspection, and repair procedures.

Our second feature article on page 34, "Aircraft Charging and its Influence on Triggered Lightning," brings you a paper on how commercial aircraft are typically struck by lightning around once per year. The vast majority of these events are triggered by the plane itself. The lightning discharge originates on the aircraft's surface in areas with sharp edges. Whether a discharge develops is in part due to the net electric charge of the plane, which can be acquired both naturally and artificially. Previous work has shown that it is theoretically possible to reduce the likelihood of a lightning strike by manipulating the aircraft's net charge.

The SAIEE Council has approved the 2024 Membership fees. Please familiarise yourself with the new fees that will take effect on 1 December 2023. Find it on page 70, and look at the benefits of being an SAIEE member on page 71.

The October issue features Energy Storage, and the deadline is 18 September. Please email me any articles on content on this matter.

Herewith the September issue; enjoy the read!

Minx

2023 Sasol TechnoX - pictures speaks louder than words!

The SAIEE Vaal Centre and head office membership team represented the SAIEE at the Sasol Techno X event in Sasolburg.

The Sasol Techno X has become the largest STEM career guidance exhibition in South Africa, bringing together more than 26,000 visitors from all area codes. As a proud host, Sasol is dedicated to contributing to developing smarter, entrepreneurial, innovative and productive minds.

Judging by these photos, it is evident that all the visitors, with our staff, had loads of fun. **wn**

The SAIEE team with CEO, Leanetse Matutoane and scholars.

From left: Carlisle Sampson (Immediate Past Chairman, Vaal Centre), Connie Makhalamele (SAIEE) & Joanne Griffin (SAIEE).

Wessel Sauer (Vaal Centre) with the SAIEE Membership ladies.

Mokgatla Lefawane (Vaal Centre) with Leanetse Matutoane, SAIEE CEO.

Eaton Energy Hub empowers key SA sectors

Eaton South Africa's newly launched turnkey power solutions unit offers dedicated design and support to shield against prevailing power challenges.

Intelligent power management company Eaton South Africa is set to deliver more holistic power solutions, specially designed and tailored to key sectors in the South African economy through its newly launched Energy Hub unit.

The unit, located at the firm's manufacturing facility in Wadeville, Germiston will allow mining operators, data centres and commercial building developers to access turnkey full-service solutions that fully address their power management needs in a seamless, integrated framework.

"What makes the Energy Hub so compelling is that we are able to manufacture most of the components within our local manufacturing premises, in the same location as where the Energy Hub is located," says Eaton South Africa Plant Manager and Managing Director, Godfrey Marema. "This means we can walk the entire journey with our clients to help them build safer, more efficient electrical architecture that gives them complete control of their operations, rather than having to engage with multiple suppliers that may not be fully aligned."

"The continuity of these sectors is especially critical during the current power challenges in Africa and abroad. The robustness and uniformity of their systems will ensure that their assets are protected through increasingly frequent outages, while the national grid receives a much-needed rehabilitation and installation of new capacity," he says.

The well-balanced selection of switchgear, circuit breakers, storage (industrial battery units) and uninterrupted power supply has been developed with the unique requirements of modern entities operating in the current environment.

Working closely with Eaton's manufacturing plant, the team of local skilled engineers at the Energy Hub is able to manufacture each component according to customers' unique requirements and conditions, including power quality, aesthetics, texture and indicated current and expected future load.

"With the unique ability to house our design, sales and manufacturing within the same facility, we have the added advantage of developing each product-set to customers' exact specifications and with much faster turnaround times," Marema continues. "We are not limited to offering individual items that may not integrate well with existing systems.

Rather, we can assist customers with rapid overall adjustments in a flexible consultative process that allows for in-depth engagement within a single environment, from start to finish." wn

INDUSTRY AFFAIRS

Two wins for IMPOWER at #SolarAssetsAfrica2023

South Africa's leading Engineering, Procurement and Construction company IMPOWER Pty Ltd walked away with two trophies at this year's Solar Assets Africa gathering in Johannesburg. The event (11 August 2023) recognised and celebrated outstanding achievements in renewable energy.

IMPOWER's General Manager, Arnu Fourie, won "Solar Project Lead of The Year" at the event. Arnu plays a significant role in IMPOWER's strategic leadership and currently oversees corporate finance, revenue management, investor relations, management of internal controls and generating various management reports.

The company's second win was a team award – "Best Team Performance of The Year, for Solar Project On-Site Service." This award recognises the team that demonstrated superior abilities by adding value to the Capitec solar project through their strategic and impactful project completion.

Gabriel Kroes (IMPOWER SOLAR Head of Engineering) accepting both awards from Chanda Nxumalo, Director of Harmattan Renewables and Chairperson of the SAPVIA board.

Founded in 2014, IMPOWER Pty Ltd. is a specialist engineering, procurement, and project management contractor within the solar and energy storage industry.

The company primarily serve the Commercial and Industrial property sector and provides tailored solar and energy storage solutions ranging between 100Kw and 1MW in size.

Smart Mobility Africa Summit | 1 - 3 October 2023 | Gallagher Estate, JHB

Smarter Mobility Africa summit takes place on 1-3 October 2023 at the Gallagher Convention Centre in Gauteng, South Africa, along with the Hosting Partners Gauteng Provincial Department of Roads and Transport, Transport Authority of Gauteng, and g-FleeT.

Celebrating its 5th anniversary, SMA summit is a key event for Africa Mobility Month and October Transport Month in South Africa, that inspires and connects visionary mobility solution providers, thought leaders, key buyers and decision makers from business and government to make mobility smarter and more integrated in Africa.

This year's theme is "Realising Vision 2030 Through Smarter Mobility" and focuses on the progress that has been made so far to achieve the UN Sustainable Development Goals and wider 2030 visions and goals across the continent.

SMA summit is driving forward the message that integrated smarter mobility is key for growing the economy and creating good jobs, increasing equality, protecting the environment, and improving public health.

The summit will encompass a wide range of themes to integrate mobility including #Micromobility, #PublicTransport, #ElectricVehicles & #BatteryTechnology,
#MobilityAsAService
#MaaS and #SmarterFleets

To join Africa's integrated smarter mobility event, click here.

SABS cautions suppliers and consumers to be wary of associations that appoint themselves as regulators, watchdogs or governing bodies

The South African Bureau of Standards (SABS) has noticed an increasing trend of some associations and industry bodies trying to derail the credibility of the SABS and creating confusion by publishing misleading information about their authority to regulate or govern certain industries.

The Chief Operating Officer (COO) of the SABS, Lungelo Ntobongwana, says: "The SABS is aware of associations in the plumbing, paint and steel industries that are intent on duping the industry that they are the sole industry bodies that have powers, and usually these claims are further backed by unfounded claims about the capabilities of the SABS. While competition is healthy for industrial development, competitors that rely on making false claims about the SABS and creating illegal market barriers cannot be allowed, and the SABS will continue to pursue legal action against such organisations."

"Some organisations create unfair technical barriers to trade by creating illegitimate requirements to profit from unknowing consumers and suppliers. Consumers must be wary of such associations when fee or subscription-based associations claim authority or offer competitive advantages.
Requirements for professional competencies, compulsory accreditation, product testing, certification and any other form of conformity assessment will be published via regulation or specification via the relevant arm of government or government agency, explains Ntobongwana.

The SABS does not hold regulatory powers, and such authority resides in various Government Departments and state-owned entities. The SABS is mandated to develop, maintain and promote national standards through the Standards Act, No. 8 of 2008. National standards are developed through technical committees comprising associations, industry bodies, academics, organisations and individuals on a voluntary basis. It is important to note that an association wherein members pay for membership has no more representation or rights in a technical committee than any other member.

The Standards Act also makes provision for conformity assessment services.
Conformity assessment services include testing, certification, verification and inspection services, which are offered through accredited services and are available through many service providers, including the SABS. "The SABS offers conformity assessment and certification services on a commercial basis and is subject to the conditions of accreditation, in that it is subject to auditing by the South African National Accreditation System (SANAS) to ensure that the SABS can deliver high-quality standards. It is important to note that while the SABS has the largest suite of testing laboratories in southern Africa, it cannot test and certify to all 7400 national standards.
Organisations can email info@sabs.co.za for more information about the SABS catalogue of services.

Addressing the gender gap in Science, Technology, Engineering and Mathematics

In a challenging economy and job market, equipping youth with the necessary skills and knowledge to be job ready is a crucial stepping stone following formal education. Practical skills development is especially important in the highly specialised fields of Science, Technology, Engineering and Mathematics (STEM), to facilitate the application of theoretical knowledge into practice. TechnoGirl is an innovative programme for young women who show an interest in STEM careers with the objective of narrowing the discrepancy in opportunities that still exist between men and women and impede social and economic transformation.

"South Africa is beginning to see a shift in gender diversity with more young women choosing STEM careers," says Staff Sithole, CEO of TechnoGirl Trust. "Our organisational objective is to facilitate transformation policies and processes with our corporate partners, that serve to better equip young women for entry into STEM careers."

To date, over 16 000 girls have participated in the TechnoGirl programme and, on average, 75% of the beneficiaries advance to register for STEM careers. In South Africa, only 13% of graduates in STEM fields are women. According to United Nations Educational, Scientific and Cultural Organisation (UNESCO), only 35% of STEM students in higher education globally are women. Young women also comprise only 25% of students in engineering or information and communication technology (ICT) careers.

TechnoGirl programme endeavours to break this historical trend by empowering young women through the programmes that they offer. The Job Shadowing programme offers girls in grades 9 to 11 a five-day job shadowing experience, three times per year at participating host organisations. Girls not placed in host organisations attend a virtual job shadowing programme, offered by the Trust, in their schools for grade 8 to 11 learners. There is also a programme specifically designed for Grade 12 learners to assist and guide them with on-time application for their post school studies and financial aid and to support them in preparation for their Grade 12 school year.

The post school mentorship programme is offered to girls studying, to support them at their post-schooling institutions and to increase access to subsequent job opportunities. TechnoGirl Digital Skills programme has been designed to develop the skills of unemployed youth specifically for the Fourth Industrial Revolution (4IR).

"It is essential that we invest in reducing the gender disparity in STEM fields by providing young women from under-resourced and marginalised communities with the means to pursue these careers," says Sithole. "If we can do this we can not only have transformed and more diverse workplaces but we can also break the cycle of poverty in marginalised communities." wn

Considering a career at Schneider Electric Services - here's why you should

By Sarika Andhee, Marketing Leader, Services at Schneider Electric

Traditionally perceived as a "spare parts and breakdowns" business, services has evolved into so much more. Focus has moved to insightful consulting audits, tailor-made maintenance contracts, enhanced modernisation activities and digitalisation of multiple industries and segments. Customers can leverage off our predictive tools to manage their current infrastructure and plan for the future.

Pursuing a career in Services is truly rewarding, particularly to those individuals that are interested in technical, dynamic environments that require problem-solving acumen and a passion for data analytics.

Service teams encounter a wide array of challenges whilst working on various customer sites. This offers an excellent opportunity to enhance problem-solving skills and critical thinking as they are required to diagnose and find solutions quickly and often under tremendous pressure.

For example, pursuing a career at Schneider Electric Services offer exciting prospect as you are continuously developing new skills and being trained in the latest technological advancements. Having this knowledge helps us become the trusted advisors for our customers in solving their everyday challenges.

The demand for technically skilled individuals makes Services an attractive team to work for. As long as industries rely on equipment, there will always be demand for onsite support and maintenance. Services skills are also transferable across industries, providing flexibility in career options and the potential to work in different sectors.

Another benefit of pursuing a career in services is travel opportunity, which can be particularly attractive to younger employees. This provides great exposure to broaden one's horizons, whilst working closely with a vast array of customers.

Working in services is a great foundation for evolving and advancing one's career path, starting from engineering to operations roles and progressing to senior management positions.

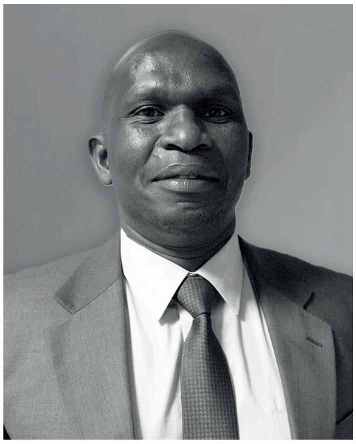
It offers individuals the opportunity to understand the full value chain, starting with application of equipment on a customer site and cascading through other departments within the organisation. With each role, employees gain a better understanding of urgency and how to handle customer issues, even under pressure.

Ultimately, pursuing a career in services promises to offer technical challenges, continuous learning, travel opportunities, and the satisfaction of supporting critical industries.

It is an exciting and fulfilling career choice for individuals who have a passion for problem-solving, technical proficiency and enjoy working with customers. wn

INDUSTRYAFFAIRS

Zutari Kenya officially launched in Nairobi to focus on East African market



Dr Meschak Ochieng, Technical Director Transport and Future Mobility, Zutari

Dr Paul Lombard, Regional Director of East Africa, Zutari

Teddy Daka, CEO, Zutari

Webb Meko, Chief Clients Officer, Zutari

Leading consulting engineering and infrastructure advisory firm Zutari has officially been registered as a fully licensed company in Nairobi, Kenya. "East Africa has long been identified as a growth area for Zutari, with Kenya at the centre of our expansion initiatives into the region," says Zutari CEO Teddy Daka. In recent years, Kenya has placed more emphasis on the extent to which companies are locally owned. The engineering profession in Kenya is regulated by the Kenyan Engineers Act (2011), which contains stringent requirements for engineering companies and consulting firms who would like to conduct business in Kenya. To ensure compliance to the Act, these organisations must be registered with the Engineers Board of Kenya (EBK). Zutari Kenya Ltd has since reached this important milestone and is now registered with the EBK in civil and electrical engineering disciplines. "We are proud of the impact our Nairobi office has unlocked through its many infrastructure feats over multiple decades of operating in Kenya. These still stand proudly across all of Kenya, a testament to the enduring power of infrastructure to create the kind of change the world needs today," comments Dr. Paul Lombard, Regional Director of East Africa, Zutari.

As an infrastructure engineering and advisory practice in Kenya, flagship projects to date have included design and management services to support Scania to build the first of 15 global service centres in Nairobi, comprising an extensive warehouse complex, service pits, and offices.

Zutari also provided its services for the East African Community (EAC) Transport Master Plan and was tasked to develop a unified transport and regional road sector development programme for the EAC. The region is served by an extensive road, rail, lake, and pipeline transportation network, as well as two major seaports and several international airports.

Creating a strategy and multi-year development plan to guide regional transport policies and investment involved considerable technical expertise and co-engineered impact by unifying the goals and aspirations of seven member states.

In 2017, Zutari was appointed as an implementation support consultant for a sub-component of the Kenya Water Security and Climate Resilience Project, Phase 1 (KWSCRP-1), funded by the World Bank. The project is aimed at financing critical investments in the water sector in Kenya, promoting sustained investment, and building an enabling legal and institutional foundation.

Zutari completed its first project in Kenya in 1995, resulting in 28+ years of engineered impact across Kenya and East Africa. It has 20+ Kenyan engineering consultants and trusted advisors working from the Nairobi office on projects across Kenya and East Africa. To date, it has been involved with 100+ infrastructure projects in Kenya, spanning full infrastructure lifecycle solutions across the water, transport, energy, resources, and built-environment infrastructure markets.

Speakers at the official opening of the Nairobi office included Webb Meko, Chief Clients Officer, Zutari, and Dr. Meschak Ochieng, Technical Director: Transport and Future Mobility, Zutari. wn

#EmpoweringHERVoice Oral Competition and Career Expo

From left: Apiwe Hotele (Organiser), Puleng Vilakazi (1st prize winner) and Innocentia Mahlangu (SAICE).

From left: Apiwe Hotele (Organiser), Bande Msibi (2nd place winner) and Innocentia Mahlangu (SAICE).

From left: Phandimfundo SSS Teacher, Apiwe Hotele (Organiser) and 3rd place winner, Mbali Pretty Kabini.

Students from Pinegrove Primary and Phandimfundo Secondary Schools with the judges.

Minx Avrabos - judge (SAIEE) and Apiwe Hotele (Organiser).

On Friday, the 25th of August 2023, #BreakingTheStereotype successfully launched the inaugural #EmpoweringHERVoice Oral Competition and Career Expo. #BreakingTheStereotype is an NPC to motivate girls to take on Science, Technology, Engineering and Mathematics (STEM) subjects, encourage students to study science and engineering at institutions of learning and support science and engineering professionals. #EmpoweringHerVoice is an annual competition for girls and boys between the ages of 13 - 15 with the following aim:

Encourage young girls to take on Mathematics and Physical Science in high school.

Empower young girls to understand the importance and power of their voices.

Boost the confidence of young girls.

Improve presentation, communication and articulation skills.

Girls and boys (aged 13 - 15) were asked to write essays responding to the following questions:

- Why do we have few girls in STEM?
- How can we get more girls in STEM?
- What activities can schools do to increase the participation of girls in STEM
- What role can society play in ensuring that young girls take on STEM subjects?

Two schools from Gauteng participated, namely Pinegrove Primary School from Springs and Phandimfundo Senior Secondary School from Twatwa in Benoni.

The essays were adjudicated by a panel of 5 judges, namely Innocentia Mahlangu, Audrey Dikgale-Mahlakoana, Simphiwe Madlanga, Xiluva Maswanganye and Minx Avrabos. The top 15 were invited to do oral presentations on the 25th of August, 2023, at Pinegrove Primary School in Springs, Gauteng. Cash prizes donated by the South African Institute of Civil Engineers (SAICE) were awarded to the top three students, and catering for the event was provided by the South African Institute of Electrical Engineers (SAIEE). Our second runner-up, Mbali Pretty Kabini from Phandimfundo SSS, won R1,000. Our first runner-up, Bande Msibi from Pinegrove Primary School, won R1,500. Finally, the winner, Puleng Vilakazi from Pinegrove Primary School, won R2,500.

The #BreakingTheStereotype team is grateful to Pinegrove Primary School for agreeing to host the event and assisting with the event's planning—Phandimfundo SSS for transporting the students, the SAIEE, and SAICE for their sponsorships. The team is planning to go bigger and better next year. wn

SAIEE partners with Hydrogen, Safety & Hazardous Areas Conference

4 - 5 DECEMBER 2023 | CEDARWOODS | SANDTON | JHB

Dear SAIEE Members

IDC Technologies is excited to bring this conference to South Africa. Having previously been held in Brisbane in Perth, this technical two-day event delivers an in-depth learning opportunity for stakeholders in South Africa and Africa's hydrogen and hazardous areas industry.

This technical conference is designed to deliver practical insights, real-world case studies, presentations, panel discussions, and the chance to participate in a hazardous safety masterclass.

We want to equip attendees with a comprehensive understanding of hydrogen safety and its related hazards. The conference is timely as it contributes to advancing South Africa's renewable energy initiative. Your participation holds immense significance, as it will serve as a driving force addressing the importance of safety as we propel renewable energies forward. It is also an excellent opportunity to connect with industry, forge new partnerships, and build knowledge.

EVENT DETAILS:

Hydrogen Safety & Hazardous Areas Conference
4 & 5 December
Cedarwoods
Sandton
South Africa

WHAT TO EXPECT:

INSIGHTS: Gain valuable insights from experts in hydrogen and hazardous areas who bring experience to the forefront.

MICROGRIDS AND HYDROGEN TECHNOLOGY: Learn the integration of hydrogen technology, uncovering innovative ways to enhance new energy systems.

HYDROGEN EXPLORATION: From design to production, transportation, and storage, here is a presentation on the whole hydrogen cycle.

PRESENTATIONS: A variation in presentations, panel discussions, masterclasses, and case studies.

SAFETY IN HAZARDOUS AREAS: Learn how to secure your operation in a challenging environment to mitigate risks, IEC and 60079 Standards, augmenting your understanding.

ENERGISING SOUTH AFRICA: Understanding the renewable energy landscape in South Africa.

LEGAL EXPERTISE: Get insight into being legally aware. What are the dos and don'ts of ensuring your energy project meets current standards?

THE CONFERENCE PACKAGE INCLUDES:

- Two-day conference pass.
- Hear from 12 speakers.
- Receive a conference manual inclusive of technical papers and presentations.
- Attend a networking event, including drinks and canapes, on Monday, 4 December.
- Full catering, including morning tea, lunch and afternoon tea.
- Receive conference papers and updated presentations electronically after the conference.
- All attendees will receive a 10% discount on the Engineering Institute of Technologies' upcoming live and online Hydrogen Energy 3-month short course.
- All attendees will receive a certificate of attendance.

For more information and to view the program, click here.

The South African Institute of Electrical Engineers (SAIEE) is a supporting sponsor of the conference. SAIEE members are eligible to receive a sponsor discount.

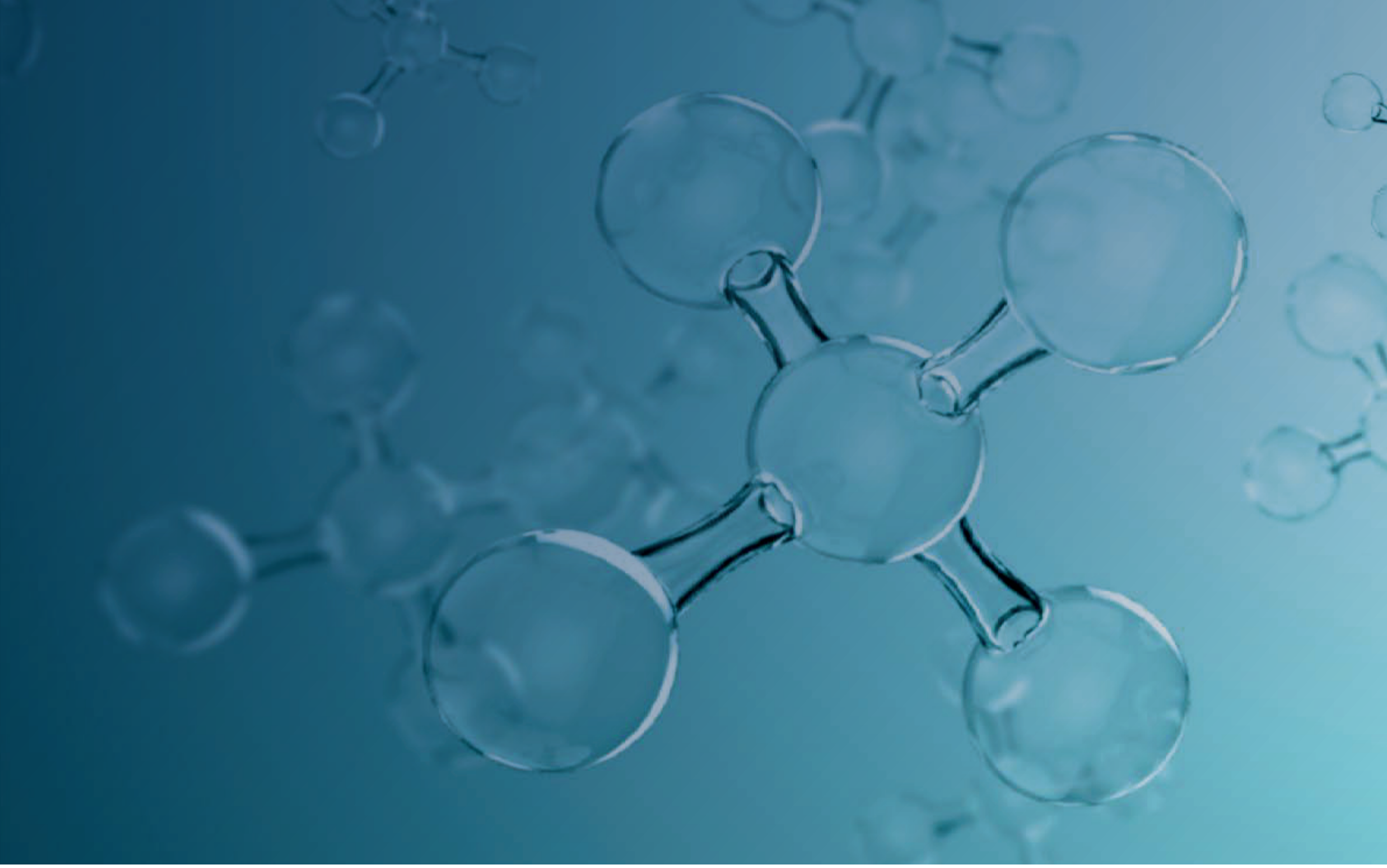
When registering, please type SAIEE in the coupon section on the booking page to receive this discount. Book before 20 September 2023, and members will receive an extra 10% discount on top of the members discount, equating to a 20% discount.

Secure your place at the conference by clicking here.

Should you have any questions, please don't hesitate to contact us at conferences@idc-online.com. wn

Hydrogen Safety & Hazardous Areas Conference

4th & 5th December, 2023
Sandton, South Africa



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Education Partner
EIT Engineering Institute of Technology.

Sponsor
ABCSA Australian Business Chamber of Commerce (Southern Africa)

Media Sponsor
SHEQ MANAGEMENT

Why ERP solutions are the building block for South Africa's manufacturing sector

Enterprise Resource Planning streamlines processes in assembly manufacturing across procurement, work order management and quality control

Despite South Africa's manufacturing sector coming up against load-shedding and a biting economy, there is still cause for optimism.

The country's manufacturing output rose 2.5% year on year in May while the industry has also been identified as a key part of the National Development Plan (NDP).

Furthermore, South Africa's vehicle manufacturers continue to impress.

Renai Moothilal, executive director of the National Association of Automotive and Allied Manufacturers recently told a Creamer Media webinar that the sector's network is highly sophisticated and the country enjoys a proud history in vehicle production that enhances its reputation globally.

What will be crucial to manufacturers' success going forward is ensuring that they keep up to date with the latest technology and be able to negotiate an increasingly complex business environment.

A big part of that will be streamlining processes so they can be managed more effectively.

According to South African business solutions company Times 3 Technologies (T3T), Enterprise Resource Planning (ERP) solutions will be central to this process.

Integrated ERPs effectively consolidate functions such as human resources, finance and accounting, inventory, sales, distribution and manufacturing, as well as other complementary areas such as project management into a single database that allows different departments to access and share information in real time. The result is improved decision-making and optimisation of operations.

T3T has identified important ways in which ERP solutions can help the manufacturing sector. These include:

INVENTORY MANAGEMENT

Real-time visibility into inventory helps manufacturers maintain optimal stock levels to ensure that raw materials and finished goods are available when needed.

PRODUCTION PLANNING & SCHEDULING

Detailed production plans and schedules based on demand forecasts, resource availability and lead times can be produced to optimise on-time delivery.

QUALITY CONTROL

Quality data allows manufacturers to identify quality issues and take corrective action quickly. Not only are products improved but wastage also becomes a thing of the past.

MANAGEMENT OF SUPPLIERS

An integrated ERP solution offers insights into supplier performance, lead times and costs. This means manufacturers can make informed decisions about sourcing and build strong relationships with reliable suppliers.

SHOP FLOOR CONTROL

By integrating with shop floor systems, the ERP solution provides real-time data on machine performance, progress and employee productivity. The outcome is that opportunities for improvement can be identified and taken.

MANAGING COSTS

Being able to monitor expenses related to materials, labour and overheads is another huge advantage. Particularly in battling economies, the ability to implement cost-saving strategies is gold.

REGULATORY COMPLIANCE

South Africa is awash with industry-specific regulations and standards. Thanks to ERP solutions, document compliance-related business can be tracked closely to ensure adherence to prescribed controls.

T3T is a Platinum Business Partner for software solutions giant Sage in South Africa and works with the company to develop add-ons that are particularly relevant to the manufacturing sector.
Its Sage X3 add-ons, for example, unlock even greater automation and functionality with Sage X3 software.

Among the standout features is Cloud Connected Currency Upload, a function that caters to manufacturers that handle various currencies on a daily business and require the latest exchange rates.
This removes the risks and financial repercussions associated with manual inputting.

Another add-on is Bulk Stocktake Import, which simplifies the upload of stock count Information into Sage X3.

Manufacturers also stand to benefit from T3T's Delivery Manifest Add-On, a module created to integrate driver, logistics, and warehouse functionality into a single function within Sage X3.

Ultimately ERP solutions and add-ons work in concert to streamline any manufacturing process.

The outcome is improvement in everything from financial reporting to customer service. wn

Zest WEG helps Power Kipushi's new dawn

As part of Ivanhoe Mines' refurbishment of the historic Kipushi Zinc-Copper Mine in the Democratic Republic of Congo (DRC), Zest WEG will be supplying a range of electrical and energy solutions. Ivanhoe Mines acquired its 68% interest in the Kipushi Project in November 2011; the balance of 32% is held by the DRC's state-owned mining company, Gécamines.

According to Luveshen Naidoo, Business Development External Sales Engineer for Mining and Industrial at Zest WEG, this includes a 14 MW power plant, motor control centres (MCCs), WEG medium voltage (MV) variable speed drives (VSDs) and a WEG 1,200 kW MV motor for the mine's ball mill. The company is also the preferred supplier of low voltage (LV) motors, and will supply these to a range of mechanical Original Equipment Manufacturers (OEMs) servicing the mine. Delivery of the equipment is expected to begin in the third quarter of 2023.

"Our diesel powered plant, which will provide the mine with backup energy, has been designed to comprise 12 generator sets – each rated at 1,587 kVA and 400 V," says Naidoo. "Assembled at Zest WEG's specialised Cape Town facility, the plant includes MV switchgear, six 3150 kVA ONAN type 400V / 6.6 kV step-up transformers, a 40,000 litre fuel tank and an automated fuel system"

He highlights that splitting the plant design into smaller generating units ensured engines and alternators were readily available, securing a quicker delivery time. The configuration of the plant in this way also gives the mine greater energy security in the case of maintenance or breakdown. The gensets can also be transported to site using conventional trucking, without the need for abnormal load vehicles.

The MCCs are being supplied for use in an established substation on the Kipushi Zinc-Copper mine, as well as for a containerised substation elsewhere on the site. To accommodate space constraints, the MCCs are designed for a back-to-back configuration with a compact bucket size, he explains.

"This ensures that the equipment will fit in the available space while still meeting the client's specification and stringent IEC standards," he says.

For the mine's SAG mill, Zest WEG is providing the WEG W60 MV motor rated at 1,200kW – a robust unit for the demanding applications and aggressive environments found in the mining sector, says Naidoo. The reduced motor weight holds distinct benefits, he notes, including a compact base plate or plinth onto which it is mounted – and lower installation costs. The motor's IP55 rating ensures the motor is well protected from dust or water ingress.

To meet the client's needs for the MV VSD to drive the ball mill motor, WEG's MVW3000 unit is being supplied – a compact design with an integral dry-type transformer. To facilitate the dissipation of heat, Zest WEG designed a ducting system for this 1,200 kW VSD which will reduce the need for cooling of the substation.

As the client's preferred brand of LV motors, the WEG W22 motor is being made available to Kipushi's mechanical supply OEMs. Among the key benefits of this WEG IE3 motor is its energy efficiency, he says. This preferred brand strategy makes it more cost effective for the mine to keep the necessary consignments of spares for maintenance and servicing.

In putting together its proposals for the client, Zest WEG worked closely with the engineering consultant METC Engineering in the detailed design stage.

First-line support for Zest WEG's equipment will come from Panaco, the company's Value Added Reseller (VAR) in the DRC. The Panaco team can conduct site visits and technical investigations, and has a substantial in-country stockholding to ensure rapid availability of key equipment.

"Our partners at Panaco can generate technical reports to share with Zest WEG to ensure we can provide accurate and necessary specialist support," he says. "We have an aftersales team who can deliver support and solutions remotely or by travelling to site."

He concludes that Zest WEG's ISO9001 quality management systems underpin the high quality standards in all its products, and the company is audited annually to maintain this compliance.

"We also constantly work at reducing the environmental impact of our production processes, with regard to our usage of natural resources and the generation of waste and emissions," he says. wn

Zest WEG is providing key electrical and energy infrastructure to the historic Kipushi Zinc-Copper Mine in the DRC's Katanga province.

Using standardisation to steady a ship as energy sector gears up for unprecedented local demand.

GOVERNMENT'S EMERGENCY LEGISLATION MAY OPEN THE FLOODGATES – HERE'S HOW TO BE COMPLIANT AND THRIVE

South Africa's pending legislation to smooth the way for private energy suppliers to help alleviate the country's power crisis may well prove to be the game-changer so desperately required.

The exemptions contained in the Exemption for Energy Users draft regulations include agreements relating to joint procurement of alternate energy supply for the national grid, sharing of backup or energy generation capacity, and joint financing of shared backup and alternative energy generation capacity, among other key aspects.

The government has also launched what it calls the Energy One Stop Shop, a portal to streamline regulatory processes required for private energy generation and expedite applications from private producers.

"The Energy One Stop Shop and Energy Resilience Fund are critical steps towards alleviating the challenges faced by our industries during this energy crisis," trade, industry and competition minister Ebrahim Patel said at the platform in July.

While the prospect of additional grid capacity is being celebrated by South Africans, private bidders will also know that with so many new players entering the market there is a chance that the system could be hijacked by nefarious parties.

Given South Africa's track record in tender corruption, hawk-eyed government investigators will be on full alert to root out bad apples.

Sibongile Ncwane, legal manager at World Wide Industrial and Systems Engineers (WWISE), says private energy producers should seek to implement globally-recognised standardisation measures to offset any potential red flags being thrown up.

The International Organisation for Standardisation (ISO) has created a standard called ISO 50001:2018 that offers a framework for setting up energy management systems in enterprises.

Its main objective is to assist companies in continuously enhancing their energy performance, including energy use, consumption and efficiency.

But, as Ncwane points out, the standard's principles of transparency, consistent monitoring and management involvement can also aid anti-corruption efforts," she says.

"Organisations should be mindful of the fact that while winning bids and contracts is essential for business expansion, the company's viability and long-term reputation come first. Corruption may result in immediate rewards, but it can also have serious long-term consequences, both legally and reputationally."

From an operational point of view, the benefits of an energy company implementing ISO 50001:2018 are "enormous", she adds.

Aside from the obvious financial advantages of increased energy efficiency, businesses may also strengthen their regulatory compliance, lessen their environmental impact and build their brand as ethical and progressive organisations. A further benefit is that the standard's structure naturally aids companies in coping with market volatility and uncertainty, particularly when these aspects relate to energy sources costs, and availability – a massive plus in the South African context.

Sibongile Ncwane
Legal Manager
World Wide Industrial and Systems Engineers (WWISE)

"The structures and procedures it promotes enable companies to be more resilient and flexible in the face of such difficulties," Ncwane says.

ISO 50001:2018 need not operate in a silo either.

Organisations in the energy sector can use several standards to better comprehend, control and thrive in response to changing demand.

"There are more standards pertinent to many elements of the energy sector beyond ISO 50001:2018, which largely focuses on energy management," Ncwane says. These include:

ISO 14001:2015 - Environmental Management Systems: While not exclusively focused on energy, this standard can help energy sector players minimise their environmental impact, improve their environmental performance and comply with regulations. A strong environmental performance can also attract customers and stakeholders who prioritise sustainability.

Engage with ISO 37001:2016: While ISO 50001:2018 focuses on energy management, ISO 37001 is a standard specifically designed for anti-bribery management systems. Adopting this standard can provide a framework for preventing, detecting, and addressing bribery. wn

How lightning is affected by climate change

Lightning is a fascinating yet deadly phenomenon that affects countries all over the world.

By Nathan Neal

It is easy to forget when residing in countries like the UK, which experiences fewer thunderstorms than many others, that around 200 bolts of lightning have struck the ground across the Earth in the time it takes you to read a sentence.

With around 100 strikes per second, lightning currently hits the ground about eight million times daily, but that number could increase dramatically as global warming accelerates.

As reported in the journal Science, we could expect a 12% increase in lightning activity for every 1°C of warming, meaning countries like the US could see a 50% increase in the number of strikes by the end of the century.

WHAT CAN WE EXPECT FROM OUR WEATHER?

Examining how global warming could impact our weather is not a neglected field of study, but much of the focus has been on hazards such as hurricanes and not the severity of thunderstorms.

This often receives less attention because thunderstorms are more common, and the damage they cause is highly localised. But it must not be forgotten that lightning is hazardous; it can strike and kill people, trigger potentially devastating wildfires, play a part in destructive floods and, in the case of the US, can lead to the creation of tornados.

Thunderstorms happen because of convection, when the heating of the Earth's surface by sunlight and infrared radiation causes water to condense as buoyant air rises.

As CO_2 increases and the land surface warms, stronger updrafts are more likely to produce lightning. In a climate with double the amount of CO_2, we may see fewer lightning storms overall but 25% stronger storms, with a 5% increase in lightning.

HOW BAD COULD THE DAMAGE BE?

Lightning damage is also likely to increase because of its role in igniting forest fires, where dry vegetation, also caused by rising temperatures, creates more 'fuel' for fires, so even a tiny climate change may have enormous consequences.

For example, lightning strikes killed 147 people in just ten days during the summer in the north Indian state of Bihar, with the unprecedented surge in deaths caused by lightning being blamed on climate change.

The last decade has been the hottest in India since records began, with temperatures averaging 0.36°C above normal. The rising temperatures have also been linked to frequent heatwaves followed by delayed but more intense monsoons, with deadly lightning strikes now expected by those who live there.

The distribution of lightning is directly linked to the Earth's climate, which is driven by solar insolation.

The daily and seasonal heating of the continental landmasses results in significant temperature fluctuations, influencing atmospheric stability and thunderstorm development.

Lightning activity is positively correlated with surface temperatures over short periods, and due to projections of a warmer climate in the future, one of the critical questions is what the impact of impending global warming on lightning, thunderstorms, and other severe weather will be.

THE FUTURE IS NOT FORECAST.

While climate change's impact on our weather remains uncertain, researchers agree that implementing simple measures like lightning detection systems and installing grounding systems in buildings could go a long way in avoiding deaths and injuries.

Thunderstorm patterns can't be changed, but the protection is out there, with lightning detection systems acting as the only reliable and consistent way of issuing a lightning warning.

Around 90% of thunderstorms are already producing lightning by the time they are within 12 miles (20 km), making a system an invaluable investment for a future of weather uncertainty. wn

Lightning strikes can affect airline operations and cause costly delays and service interruptions. Strikes to aeroplanes are relatively common but rarely result in a significant impact on the continued safe operation of the aircraft. Lightning protection is used on Boeing aeroplanes to avoid delays and interruptions as well as reduce the significance of the strike. To increase the effectiveness of repairs to damage caused by lightning, maintenance personnel must be familiar with lightning protection measures, proper inspection, and repair procedures.

LIGHTNING STRIKES:

PROTECTION, INSPECTION, AND REPAIR

By | Dr Greg Sweers
Bruce Birch
John Gokcen

When commercial aeroplanes are struck by lightning, the result can range from no damage to severe damage. This will require extensive repairs that can take the aircraft out of service for an extended period.

Having an understanding of the typical effects of lightning strikes and proper damage inspection procedures can prepare operators to act quickly when a lightning strike is reported to apply the most effective maintenance actions.

LIGHTNING OVERVIEW

The frequency of lightning strikes that an aeroplane experience is affected by several factors. This including the geographic area where the aeroplane operates and how often the aircraft passes through takeoff and landing altitudes, which is where the lightning activity is most prevalent.

Lightning activity can vary significantly by geographic location. For example, in the United States, parts of Florida average 100 thunderstorm days per year, while most of the West coast averages

only ten thunderstorm days per year. In the rest of the world, lightning tends to occur most near the equator because the warmth in this region contributes to convection, creating widespread thunderstorms nearly daily.

The world lightning map by NASA shows the geographic distribution of lightning (see fig. 1). Areas of highest activity are shown in orange, red, brown, and black. Areas of low activity are white, grey, purple, and blue.

Lightning activity is lowest over the oceans and polar areas. It is highest over warm continental regions. The numbered scale represents lightning flashes per square kilometre per year.

More jet aeroplane lightning strikes occur while in clouds, during the climb and descent phases of flight than any other flight phase (see fig. 2). The reason is that lightning activity is more prevalent between 5,000 to 15,000 feet (1,524 to 4,572 meters) altitude (see fig. 3). Aeroplanes that fly short routes in areas with a high incidence of lightning activity are likely to be struck more often than long-haul planes operating in more benign lightning environments.

A single bolt of lightning can contain as much as 1 million volts or 30,000 amps. The amount and type of damage an aeroplane experiences when struck by lightning can vary greatly, depending on factors such as the energy level of the strike, the attachment and exit locations, and the duration of the strike.

Because of these variations among lightning-strike events, it can be expected that the more often an aeroplane gets hit

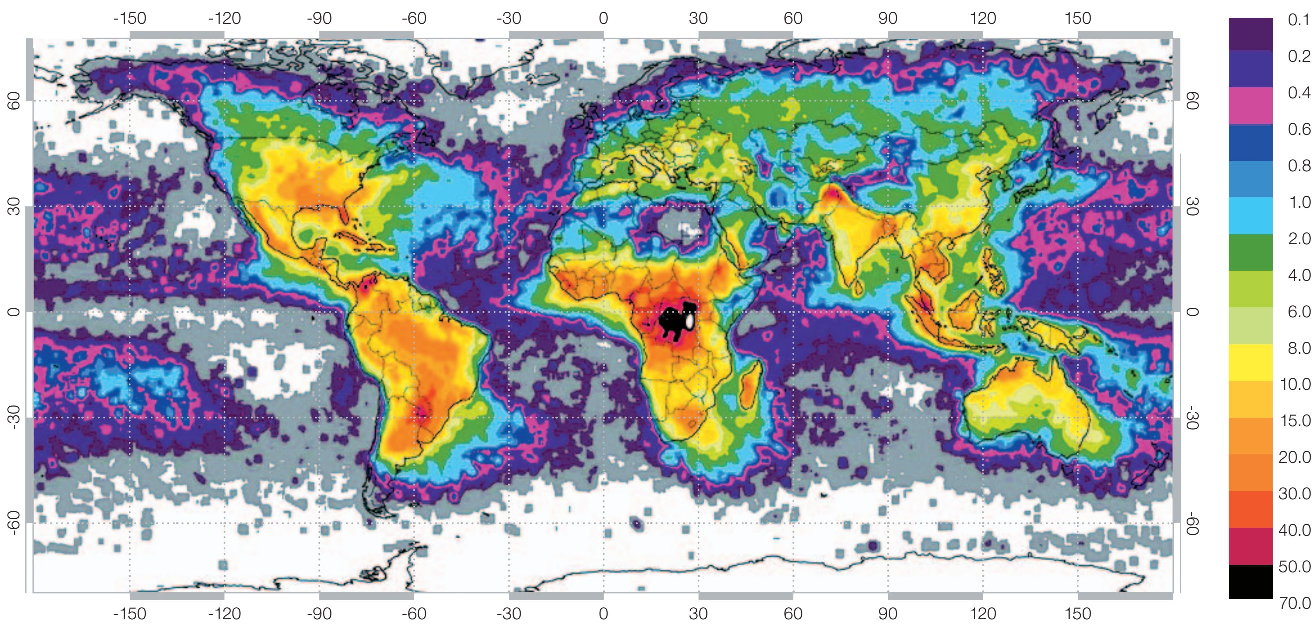

Figure 1: worldwide lightning activity
This map shows the global distribution of lightning April 1995–February 2003 from the combined observations of the national aeronautics and space administration (NASA) optical transient detector (April 1995–March 2000) and land information systems (January 1998–February 2003) instruments. Image courtesy of NASA.

by severe lightning, the more likely it is that some of those events will result in damage levels that may require repair.

Lightning interaction with aeroplanes

Lightning initially attaches to an aeroplane extremity at one spot and exits from another (see fig. 4). typically, first, attachment is to the radome, forward fuselage, nacelle, empennage, or wingtip. During the initial stages of a lightning strike on an aeroplane, a glow may be seen on the nose or wingtips caused by ionisation of the air surrounding the leading edges or sharp points on the aeroplane's structure.

This ionisation is caused by an increase in the electromagnetic field density at those locations.

In the next stage of the strike, a stepped leader may extend off the aeroplane from an ionised area seeking a large amount of lightning energy in a nearby cloud. Stepped leaders (also referred to as "leaders") apply to the path of ionised air containing a charge emanating from a charged aeroplane or cloud. With the aircraft flying through the charged atmosphere, leaders propagate from the aeroplane extremities where ionised areas have formed.

Once the leader from the aeroplane meets a leader from the cloud, a strike to the ground can continue, and the aircraft becomes part of the event. At this point, passengers and crew may see a flash and hear a loud noise when lightning strikes the aeroplane. Significant occasions are rare because of the lightning protection engineered into the aircraft and its sensitive electronic components.

After attachment, the aeroplane flies through the lightning event. As the strike pulses, the leader reattaches itself to the fuselage or other structure at other locations while the aircraft is in the electric circuit between the cloud regions of opposite polarity.

Current travels through the aeroplane's conductive exterior skin and structure and exits out another extremity, such as the tail, seeking the reverse polarity or ground. Pilots may occasionally report temporary flickering of lights or short-lived interference with instruments.

TYPICAL EFFECTS OF LIGHTNING STRIKES

Aeroplane components made of ferromagnetic material may become strongly magnetised when subjected to lightning currents. A large current flowing from the lightning strike in the aeroplane structure can cause this magnetisation.

While the electrical system in an aeroplane is designed to be resistant to lightning strikes, a strike of unusually high intensity can damage components such as electrically controlled fuel valves, generators, power feeders, and electrical distribution systems.

Cloud Orientation	Percent of Total Reported*
Above	<1%
Within	96%
Below	3%
Between	<1%
Beside	<1%

**Sixty-two strikes did not report orientation of clouds during strike event.*

Figure 2: Aeroplane lightning strikes by cloud orientation - most aeroplane lightning strikes occur when an aeroplane is flying in clouds.

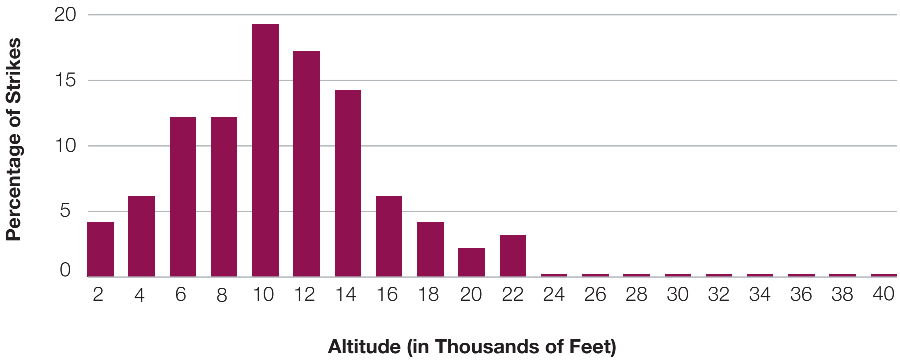

Figure 3: Distribution of lightning strikes by altitude - a survey of U.S. commercial jets showed that most lightning strikes occur between altitudes of 5,000 feet (1,524 meters) and 15,000 feet (4,572 meters).

COMMERCIAL AEROPLANE LIGHTNING PROTECTION

Most of the external parts of legacy aeroplanes are metal structure with sufficient thickness to be resistant to a lightning strike. This metal assembly is their basic protection. The thickness of the metal surface is adequate to protect the aeroplane's internal spaces from a lightning strike.

The metal skin also protects against the entrance of electromagnetic energy into the electrical wires of the aircraft. While the metal skin does not prevent all electromagnetic energy from entering the electrical wiring, it can keep the energy to a satisfactory level.

By understanding nature and the effects of lightning strikes, Boeing works to design and test its commercial aeroplanes for lightning-strike protection to ensure protection is provided throughout their service lives. Material selection, finish selection, installation, and application of protective features are essential methods of lightning-strike damage reduction.

Areas that have the highest likelihood of a direct lightning attachment incorporate some type of lightning protection. Boeing performs testing that ensures the adequacy of lightning protection. Composite parts that are in lightning-strike prone areas must have appropriate lightning protection.

The large amount of data gathered from in-service-aeroplanes constitutes vital lightning-strike protection information that Boeing uses to make improvements in lightning-strike damage control.

Lightning protection on aeroplanes may include:

- Wire bundle shields.
- Ground straps.
- Composite structure expanded foils, wire mesh, aluminium flame spray coating, embedded metallic wire, metallic picture frames, diverter strips, metallic foil liners, coated glass fabric, and bonded aluminium foil.

REQUIRED ACTIONS FOLLOWING A LIGHTNING STRIKE TO AN AEROPLANE

Lightning strikes to aeroplanes may occur without indication to the flight crew. When an aircraft is struck by lightning, and the strike is evident to the pilot, the pilot must determine whether the flight will continue to its destination or be diverted for inspection and possible repair.

Technicians may find and identify lightning-strike damage by understanding the mechanisms of lightning and its attachment to aeroplanes. Technicians must be aware that lightning strikes may not be reported in the flight log because the pilots may not have known that a lightning strike occurred on the aeroplane. Having a basic understanding of lightning strikes will assist technicians in performing effective maintenance.

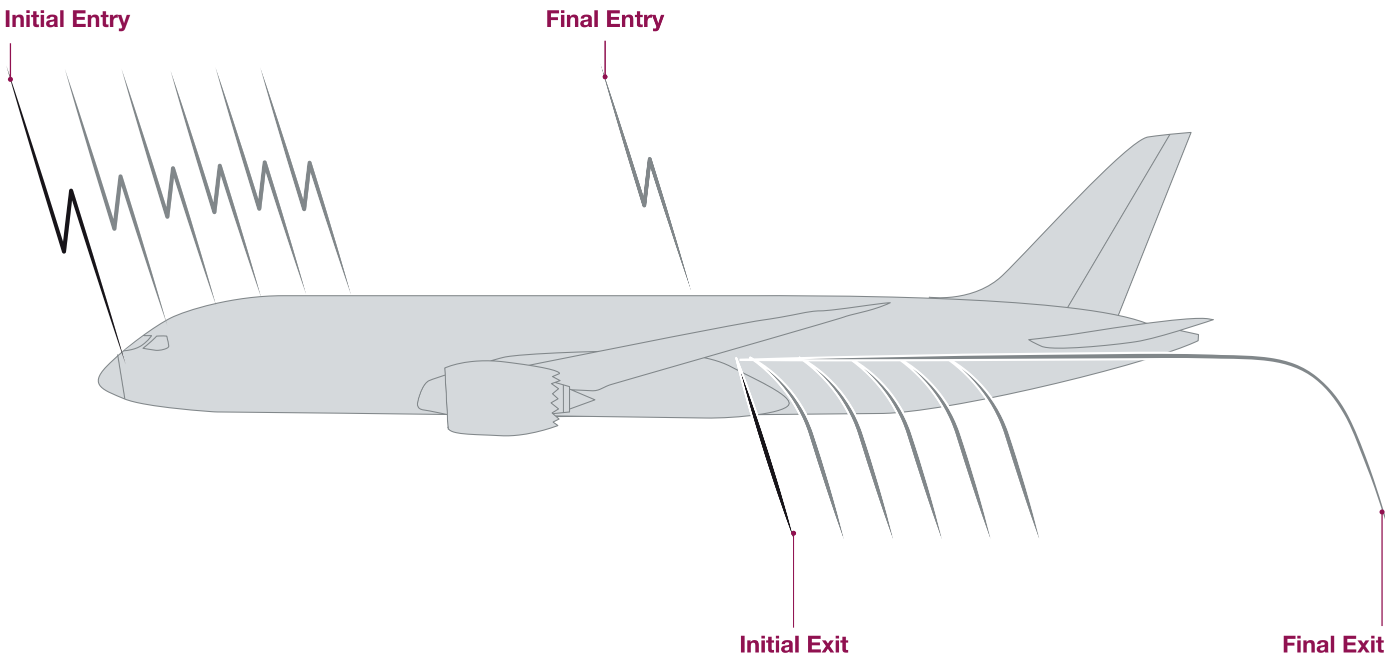

Figure 4: How lightning attaches to an aeroplane
Lightning is initiated at the aeroplane's leading edges, which ionise, creating a strike opportunity. Lightning currents travel along the aircraft and exit to the ground, forming a circuit with the aeroplane between the cloud energy and the ground.

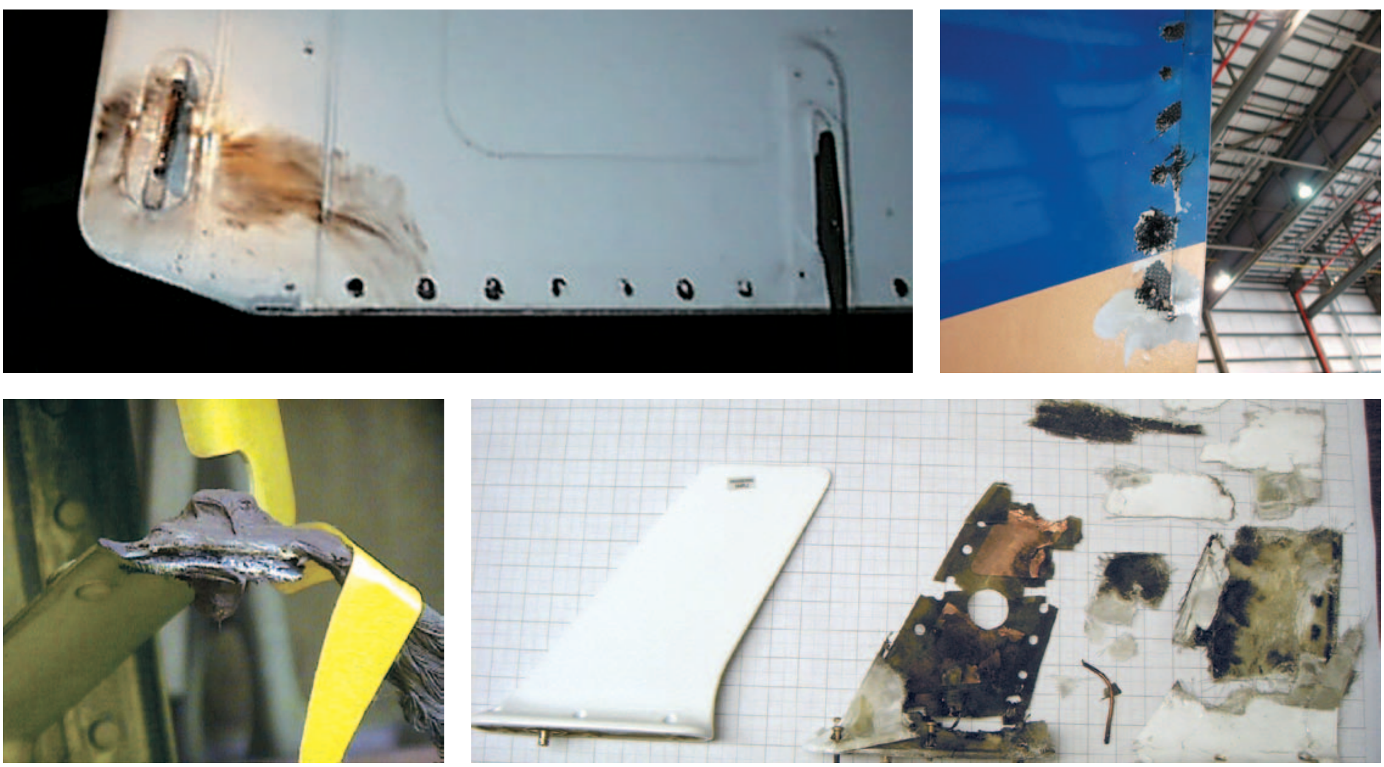

Figure 5: Lightning protection and strike damage
Clockwise from upper left: lightning damage to a horizontal stabiliser, rudder, antenna, and bond jumper.

IDENTIFYING LIGHTNING-STRIKE DAMAGE ON A COMMERCIAL AEROPLANE

lightning strikes to aeroplanes can affect structure at the entrance and exit points. In metal structures, lightning damage usually shows as pits, burn marks, or small circular holes. These holes can be grouped in one location or divided around a large area. Burned or discoloured skin also shows lightning-strike damage.

Direct effects of a lightning strike can be identified by damage to the aeroplane's structure, such as melt through, resistive heating, pitting to structure, burn indications around fasteners, and even missing structure at the aeroplane's extremities, such as the vertical stabiliser, wingtips, and horizontal stabiliser edges (see fig. 5).

Aeroplane structure can also be crushed by the shock waves present during the lightning strike. Another indication of a lightning strike is damage caused to bonding straps. These straps can become crushed during a lightning strike due to the high electromagnetic forces.

Because the aeroplane flies more than its own length during the time it takes a strike to begin and finish, the entry point will change as the flash attaches to other spots aft of the initial entry point. Evidence of this is seen in strike inspections where multiple burns are seen along the aeroplane's fuselage (see fig. 6).

Lightning can also damage composite aeroplane structures if protection finish is not applied or adequately designed. This damage is often in the form of burnt paint, damaged fibre, and composite layer removal (see fig. 7).

LIGHTNING-STRIKE STRUCTURAL INSPECTION PROCEDURES

If lightning strikes an aeroplane, a lightning-strike conditional inspection must be performed to locate the lightning-strike entrance and exit points.

When looking at the areas of entry and exit, maintenance personnel should scrutinise the structure to find all of the damage that has occurred.

The conditional inspection is necessary to identify any structural damage and system damage before return to service. The structure may have burn holes that can lead to pressurisation loss or cracks.

The critical system components, wire bundles, and bonding straps must be verified as airworthy before a flight. For these reasons, Boeing recommends that a complete lightning-strike conditional inspection should be performed before the next flight to maintain the aeroplane in an airworthy condition.

Aeroplane lightning-strike zones are defined by SAE Aerospace Recommended Practices (ARP) 5414 (see fig. 8). Some zones are more prone to lightning strikes than others (see fig. 9). Lightning-strike entrance and exit points are usually found in zone 1.

Still, they can very rarely occur in zones two and 3. A lightning strike usually attaches to the aeroplane in zone 1 and departs from a different zone 1 area. the external components most likely to be hit are:

Figure 6: Damage caused by lightning moving along an aeroplane
When a lightning strike moves along a plane, it can cause "swept stroke" damage.

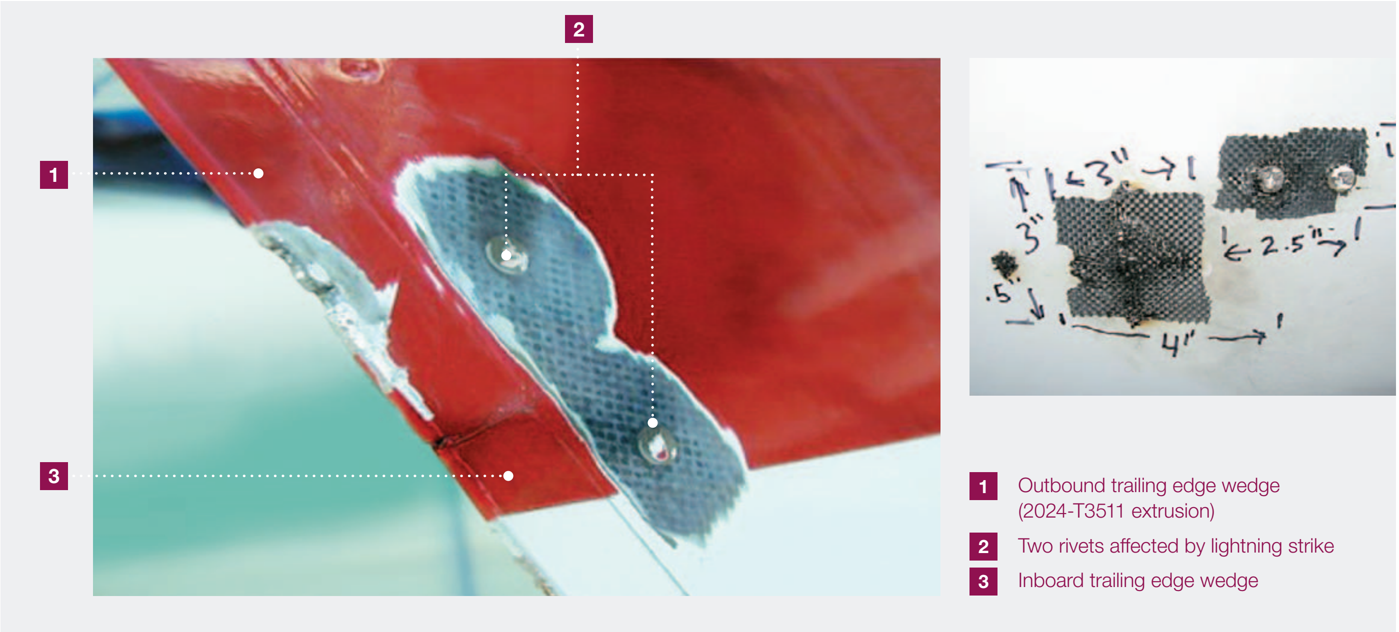

Figure 7: Lightning damage to a composite airplane
composite structures are less conductive than metal, causing higher voltages. this is the type of damage that can occur if a lightning protection finish is not applied or is inadequate.

- Radome;
- Nacelles;
- Wingtips;
- Horizontal stabiliser tips;
- Elevators;
- Vertical fin tips;
- Ends of the leading edge flaps;
- Trailing edge flap track fairings;
- Landing gear;
- Water waste masts;
- Air data sensors (pitot probes, static ports, angle of attack [aoa] vane, total air temperature probe).

In zone 2, an initial entry or exit point is a rare event, but in such a case, a lightning channel may be pushed back from an initial entry or exit point. As an example, the radome may be the area of an initial entry point. Still, the lightning channel may be pushed back along the fuselage aft of the radome by the forward motion of the aeroplane.

A zone 3 examination is highly recommended even if no damage is found during the zone 1 and zone 2 inspections. In summary, any entrance and exit points must be identified in zones 1, 2, or 3 so that the immediate areas around them can be thoroughly examined and repaired if necessary.

LIGHTNING-STRIKE SURFACES EXAMINATION BY ZONE

Boeing provides lightning-strike inspection procedures to ensure external surfaces have not been damaged. Operators should refer to applicable maintenance procedures as the authoritative source for inspection/ repair instructions.

OPERATION TESTS OF RADIO AND NAVIGATION SYSTEMS

The level of checks after a lightning strike to the aeroplane is determined by flight crew information and the aeroplane condition after the incident.

For example, if all the navigation and communications systems are operated by the flight crew in-flight after the lightning strike and no anomalies are found, checks to the operating systems would not usually be required.

For systems not operated by the flight crew in-flight or systems where anomalies were found, additional operational test procedures, as specified in the respective AMM, may be required. Also, even if a system were operated in flight after the lightning strike and no anomalies were found. Still, subsequent inspections showed lightning damage near that system antenna, additional checks of that system may be required.

Logic flow for inspection of internal components in maintenance procedures provided by Boeing follow a similar process (see fig. 10).

LIGHTNING-STRIKE STRUCTURAL REPAIRS

Detailed information and procedures for typical lightning allowable damage limits and applicable rework or repairs can be found in the structural repair manual (Srm) for each aeroplane model.

Zone Designation	Description	Definition
1A	First return stroke zone	All areas of the airplane surfaces where a first return is likely during lightning channel attachment with a low expectation of flash hang on.
1B	First return stroke zone with a long hang on	All areas of the airplane surfaces where a first return is likely during lightning channel attachment with a low expectation of flash hang on.
1C	Transition zone for first return stroke	All areas of the airplane surfaces where a first return stroke of reduced amplitude is likely during lightning channel attachment with a low expectation of flash hang on.
2A	Swept stroke zone	All areas of the airplane surfaces where a first return of reduced amplitude is likely during lightning channel attachment with a low expectation of flash hang on.
2B	Swept stroke zone with long hang on	All areas of the airplane surfaces into which a lightning channel carry subsequent return stroke is likely to be swept with a high expectation of flash hang on.
3	Strike locations other than Zone 1 and Zone 2	Those surfaces not in Zone 1A, 1B, 1C, 2A, or 2B, where any attachment of the lightning channel is unlikely, and those portions of the airplane that lie beneath or between the other zones and/or conduct a substantial amount of electrical current between direct or swept stroke attachment points.

Figure 8: Lightning zone definitions

Aeroplane lightning zones, as defined by SAE aerospace, recommended Practices 5414.

Maintenance personnel should restore the original structural integrity, ultimate load strength, protective finish, and materials after a lightning strike.

In response to customer requests for training, Boeing has developed an SRM repair course to give maintenance technicians and engineers instruction in assessing and repairing aeroplane lightning-strike damage.

SUMMARY

Operators should be aware of the conditions that are conducive to lightning strikes on aeroplanes and avoid exposing aeroplanes unnecessarily to lightning-prone environments. While Boeing aeroplanes incorporate extensive lightning-strike protection, lightning strikes can still affect airline operations and cause costly delays or service interruptions.

A clear understanding of proper inspection and repair procedures can increase the effectiveness of maintenance personnel and ensure that all damage caused by lightning is identified and repaired.

See next page for Figures 9 & 10. wn

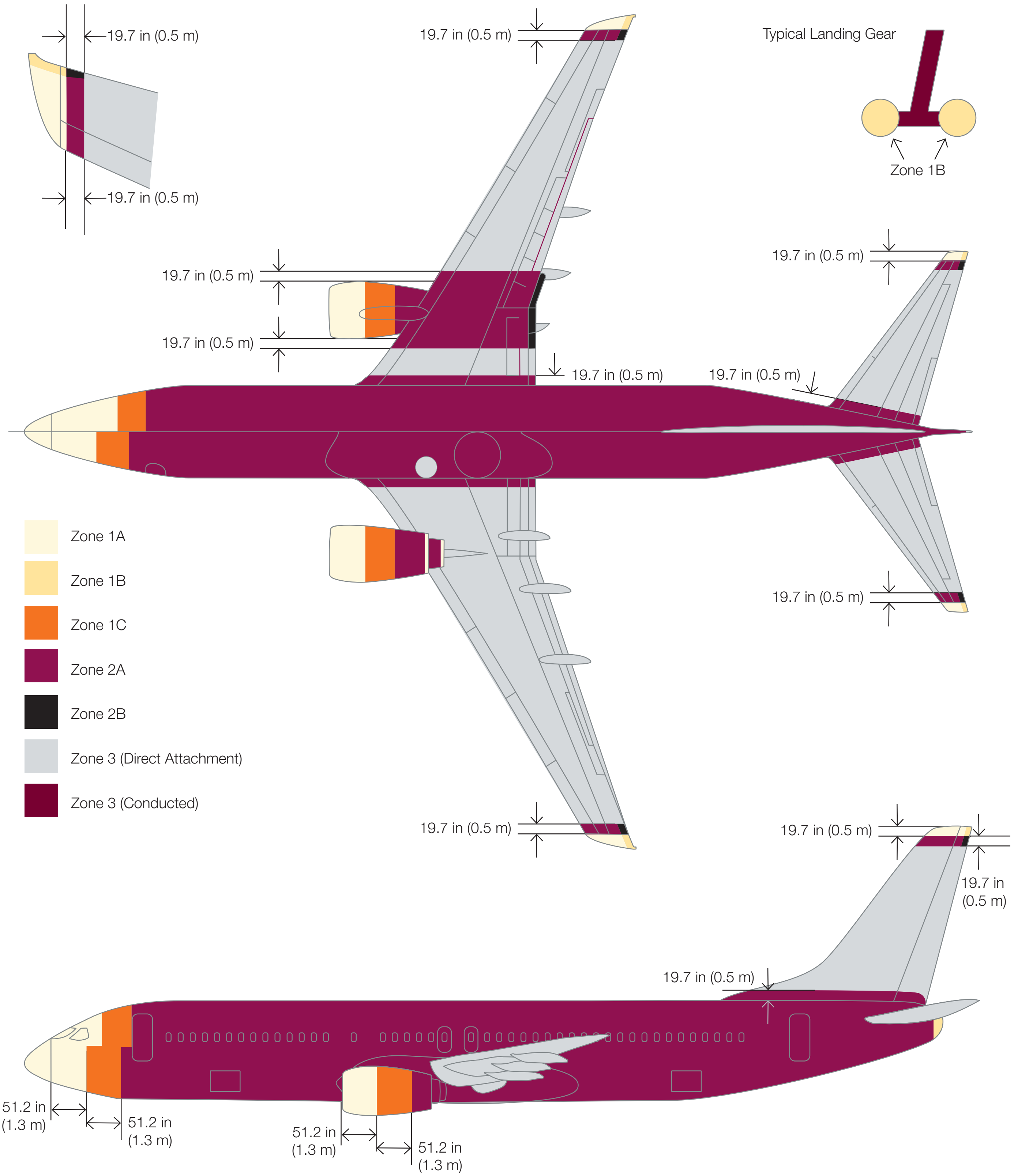

Figure 9: Aeroplane Lightning-zones

Areas of an aeroplane that are prone to lightning strikes are indicated by zone. Zone 1 shows an area likely to be affected by the initial attachment of a strike. Zone 2 shows a swept or moving, attachment. Zone 3 indicates fields that may experience conducted currents without the actual attachment of a lightning strike.

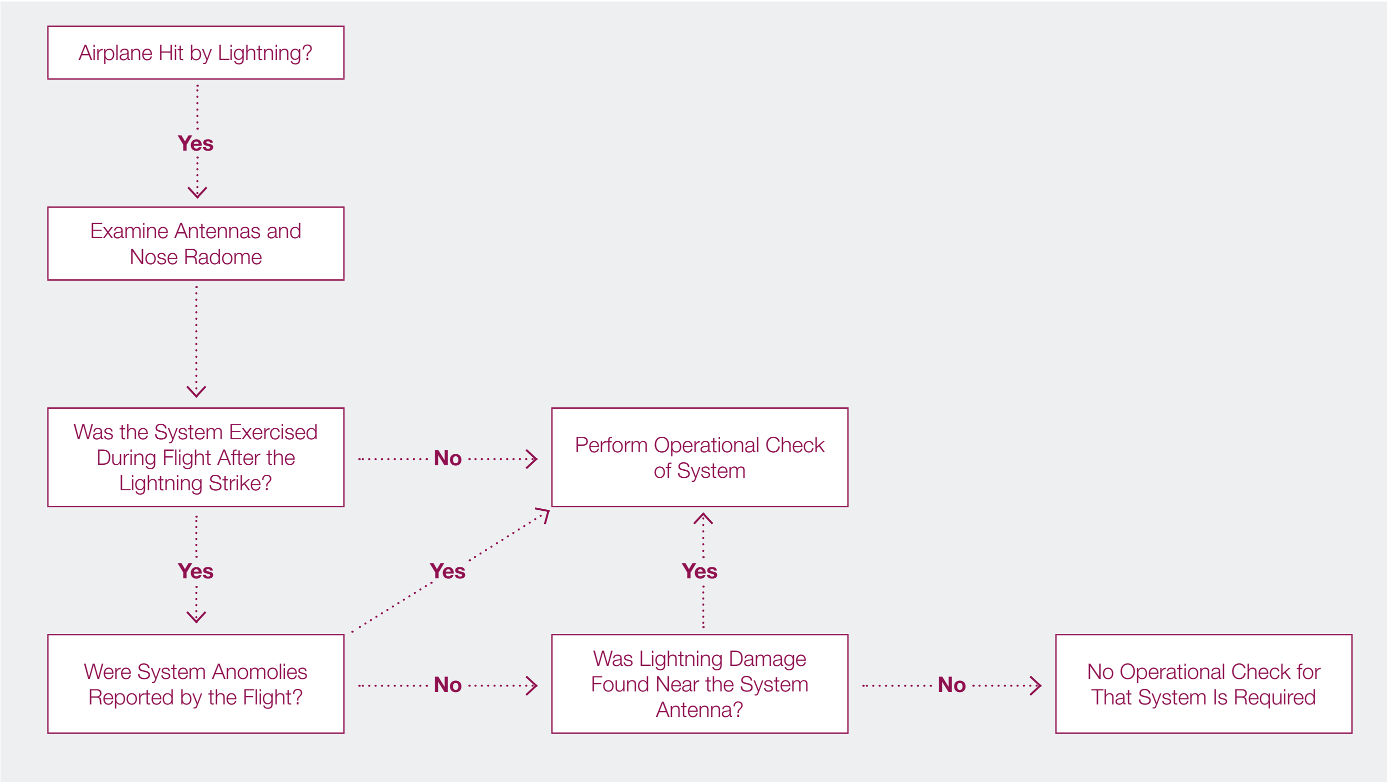

Figure 10: Conditional inspection flowchart of internal components

Boeing recommends that a lightning-strike conditional inspection be performed before the next flight to maintain the aeroplane in an airworthy condition.

AIRCRAFT CHARGING AND ITS INFLUENCE ON TRIGGERED LIGHTNING

Commercial aircraft are typically struck by lightning around once per year, and the vast majority of these events are triggered by the plane itself. The lightning discharge originates on the surface of the aircraft in areas with sharp edges. Whether a discharge develops is in part due to the net electric charge of the plane, which can be acquired both naturally and artificially. Previous work has shown that it is theoretically possible to reduce the likelihood of a lightning strike occurring by manipulating the net charge of the aircraft.

By: C. Pavan, P. Fontanes, M. Urbani, N. C. Nguyen, M. Martinez Sanchez, J. Peraire, J. Montanya, C. Guerra Garcia

In this paper, the authors perform laboratory experiments to validate this hypothesis. These experiments demonstrate that the threshold for lightning could be increased by 30% by charging the aircraft negatively, which means that a plane could fly safely through ambient electric fields that are around 30% higher than those of an uncharged baseline. Theoretical estimates suggest that further improvement may be possible if the aircraft were charged to a more negative state than those tested.

This work gives laboratory-scale experimental evidence that it is possible to reduce the frequency of lightning strikes on aircraft by manipulating their charge and encourages further investigation of the proposed lightning strike risk reduction strategy.

1. INTRODUCTION

Formal studies into lightning effects and aircraft survivability began in the 1940s after the catastrophic accident of a Pennsylvania-Central Airlines DC-3A aircraft (Plumer, 2017). Nowadays, strict protection and mitigation measures are embedded in aviation: the use of expanded metal foil or wire mesh to ensure a fully conductive path and electromagnetic shielding in composite structures, incorporation of lightning diverter strips in the radome, securing of fasteners and joints to avoid arcing and sparking in the fuel tanks, wire bundle shielding, proper grounding, and the use of surge protectors (Sweers et al., 2012). These measures ensure the safety of flight in the event of a strike. They must comply with regulations of the civil certification authorities (the Federal Aviation Administration, FAA, and the European Aviation Safety Agency, EASA). Standard committees (the Society of Automotive Engineers, SAE, and the European Organization for Civil Aviation Equipment, EUROCAE) provide detailed guidelines on testing standards to demonstrate compliance (section 2.1). Although lightning strikes pose no critical safety concerns, they are responsible for costly delays, service interruptions, and repairs.

It is generally quoted that, on average, commercial aircraft is struck by lightning

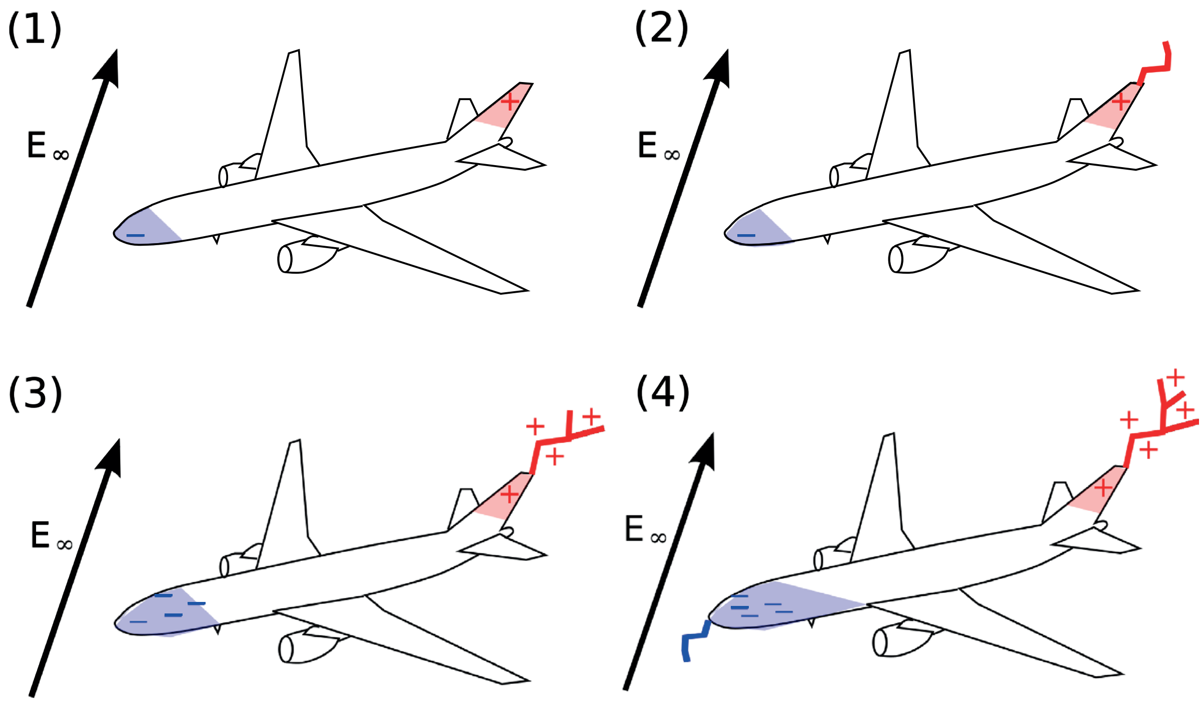

Figure 1: Bidirectional uncharged leader formation from an aircraft exposed to atmospheric electric fields. See the fourth paragraph of section 1 for detailed discussion.

about once per year, a figure that is supported by both instrumented flight campaigns and commercial operations (Fisher & Plumer, 1977). The frequency of lightning strikes that a particular aircraft experiences will, of course, depend on factors such as its flight envelope (geographic area of operation, cruise altitude, duration of the climb, and descent) and size.

From an operational perspective, the highest probabilities for lightning strikes have been observed during climb and descent at an altitude of 5,000–15,000 ft. Most lightning strikes to aeroplanes occur close to freezing temperatures and during precipitation but not necessarily in the presence of an active thunderstorm (Rakov & Uman, 2003).

From an electrostatic perspective, lightning initiation from aircraft, or aircraft-triggered lightning (Moreau et al., 1992), can be explained using the bidirectional uncharged leader concept (Kasemir, 1950; Mazur, 1988; 1989). This mechanism, responsible for about 90% of strikes, was verified using airborne data from the NASA F-106B (Fisher & Plumer, 1984) and FAA CV-580 (Reazer et al., 1987) campaigns.

The sequence of events that precede a lightning strike is shown schematically in Figure 1:

(1) The aircraft is polarised when exposed to atmospheric electric fields, resulting in the amplification of the local electric fields at its extremities.
(2) A positive leader is triggered due to the lower inception and propagation thresholds for the positive polarity.
(3) Charge conservation forces the aircraft to more negative charge levels, further enhancing the local electric fields at the negatively charged extremities.
(4) Finally, the threshold for negative leader inception and propagation is reached, and a negative leader follows.

Suppose the leaders connect with others originating from clouds or the ground, a damaging high current arc forms. Viewed from this electrostatic perspective (Lalande et al., 1999a), to first order, the probability of aircraft-triggered lightning will only depend on the geometry of the vehicle, the external fields, the atmospheric conditions (which will modify the inception thresholds), and the net vehicle charge.

In this work, the influence of the vehicle's net charge on leader inception is experimentally demonstrated, confirming recent theoretical estimates by (Guerra-Garcia et al., 2017, 2018). These results are relevant since aircraft can acquire net charge from several sources including friction with the runway during takeoff, corona discharges from static dischargers or other electrically stressed regions, charged species in the engine exhaust, and charge transfer by collision with particles in the atmosphere (Vonnegut & Little, 1965). In addition, the results from this work may open up a pathway towards an effective means of reducing the risk of aircraft-triggered lightning through charge control (Martinez-Sanchez et al., 2019).

The paper is organised as follows. It begins with an overview of aircraft lightning leader attachment testing standards, followed by a description of the modifications incorporated to allow for the exploration of the effect of the vehicle's net charge. Next, experimental results of the dependence of lightning inception on aircraft charge are presented and compared to a theoretical model. The paper closes with a discussion on how the electrostatic perspective of aircraft-triggered lightning can assist the development of lightning detection and prediction, and ultimately, risk reduction technologies.

2. TESTING PROCEDURES

2.1 Overview of Lightning Leader Attachment Testing

Aircraft components must undergo a variety of tests for susceptibility to environmental damage. In particular, testing standards representative of flight conditions leading up to and during a strike are described in the SAE standard ARP5416 (SAE Aerospace, 2005) and the equivalent European standard EUROCAE ED-105 (EUROCAE, 2005). The impact of strikes to aircraft are typically classified as either direct effects, encompassing any risks associated with the lightning discharge itself, or indirect effects, which arise from interactions between the electromagnetic fields generated by the discharge and components of the aircraft.

Direct effects mostly correspond to physical damage to the external surfaces of the plane, while indirect effects include damage to sensors and electronics (Plumer, 2012; Uman, 2008). The risks associated with lightning strikes can also be broken up chronologically since, in most cases, the lightning channel attachment location will be swept along the aircraft as a result of its motion. This can result in lightning damage occurring on areas of the plane that are not leader trigger points themselves (Lalande & Delannoy, 2012). In general, aircraft are divided into zones based on how they typically experience lightning strikes. The locations corresponding to the initial leader connection and first return stroke are referred to as zone 1 per guidelines given in SAE standard ARP5414 (SAE Aerospace, 2012). While a determination of the extent of this zone requires in-depth analysis and testing, it generally encompasses most of the aircraft extremities, which will enhance the local electric field and favour leader initiation. Examples include the aircraft nose, wingtips, nacelles, and empennage. Zone 2 corresponds to regions susceptible to subsequent return strokes as the lightning channel is swept along the aircraft and zone 3 to regions experiencing current flow without arc attachment (SAE Aerospace, 2012).

Lightning leader and swept channel attachment tests are conducted by applying different high voltage waveforms across a gap containing the components to be tested. The voltage required depends on the size of the gap but will be on the order of hundreds of kilovolts to a few megavolts. The currents produced in these tests are relatively low (for the experiments reported, the generator provides about 800A); hence, these tests are used to determine leader attachment locations only and not for deciding potential damage (SAE Aerospace, 2005). Damage assessment is performed by applying a sequence of high-current waveforms directly to the component. These current waveforms replicate the many individual current pulses resulting from first return stroke, continuing current and subsequent return strokes following the initial leader connection (SAE Aerospace, 2005).

In this work, the primary concern is lightning initiation; the relevant testing standards to determine the initial attachment of a lightning leader is described in section 5.1.1 of ARP5416(SAE Aerospace, 2005). The background electric field amplitude dependence with time, recommended for this test, is a D-type waveform as specified by SAE standard ARP5412 (SAE Aerospace, 2013). This waveform has a rise time of 50–250 μs and decay to half-maximum time on the order of 2ms.

It is designed to increase at a slow enough rate to allow streamer to develop and propagate from the aircraft, which results in a more significant variation of lightning attachment points to the model (Plumer, 2012; SAE Aerospace, 2013).

The experimental setup to demonstrate the influence of net charge on aircraft-triggered lightning is based on this standard and is described in section 2.2.

2.2 Experimental Setup

Lightning leader attachment tests make use of a conductive model aircraft suspended between two electrode plates, one grounded, one at high voltage, to simulate the effect of a robust ambient field on a vehicle in flight.

A diagram of the experimental setup is shown in Figure 2, and a plan view showing the approximate locations of the sensors is shown in Figure 3. A high-voltage plate 2m in diameter was suspended 145cm above a grounded base. The high-voltage electrode was connected to a 1MV Marx generator through a resistor with a spark gap on either side. Between the resistor and the spark gap to the electrode, a damped capacitive voltage divider was connected to measure the applied

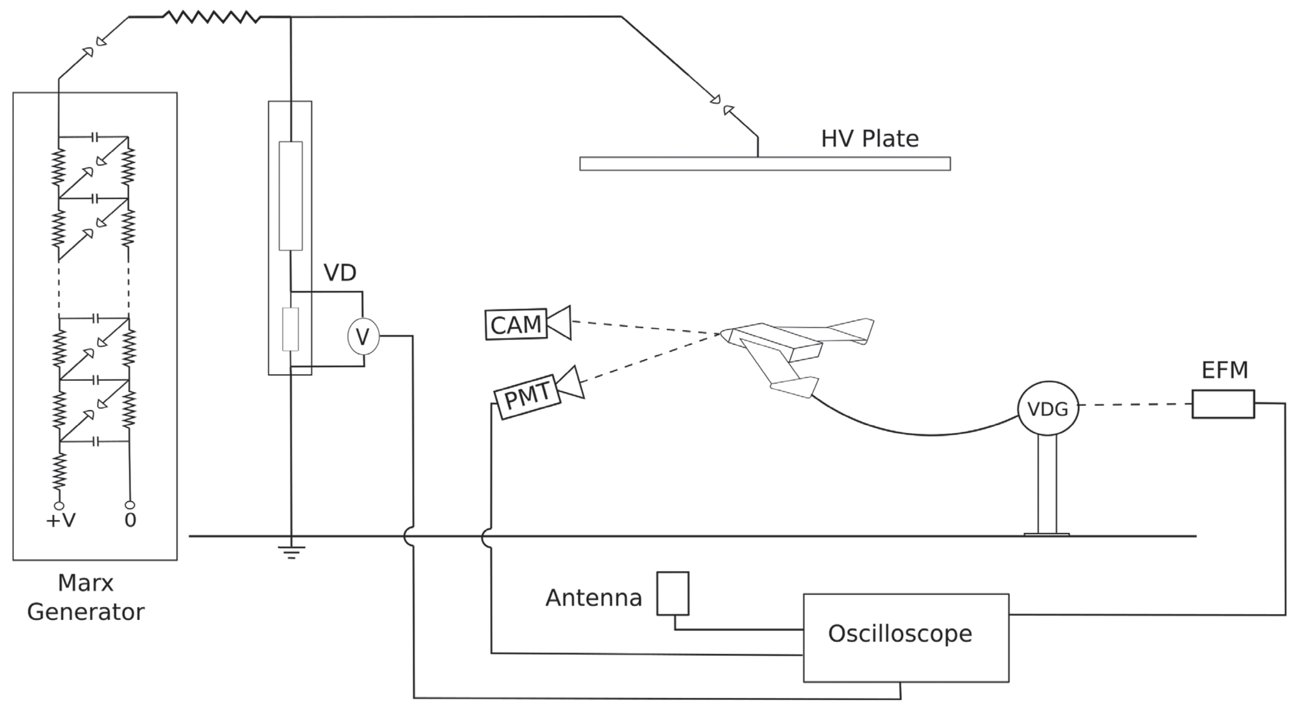

Figure 2: Diagram of experimental setup to demonstrate the effect of model net charge on first leader inception. Dashed lines are non-contact line-of-sight measurements. PMT = photomultiplier tube, EFM = electric field mill, VD = voltage divider, VDG = Van de Graaff generator, CAM = camera.

voltage. Two lengths of kevlar rope were strung through the difference between the high-voltage electrode and ground plate, and the test model was rested on them. The rope was secured at either end to PTFE (polytetrafluoroethylene) blocks, which were anchored to the ground. The test model was pitched up with an angle between the nose and the ground of approximately 50degrees. The shortest distance between the model aircraft and the high-voltage plate was 26cm measured at the aircraft nose, and the shortest distance between the model and the ground was 78cm measured at the winglets. This orientation was chosen to favour positive leader formation from the nose of the model (rather than, for example, the wingtips) so that there would be a repeatable location on which to focus optical sensors. The model itself was electrically connected via conducting wire to a Van de Graaff generator, which provided a means of charging the floating body to tens of kilovolts (negative) relative to ground.

The Van de Graaff generator was operated using batteries to keep it separated from the building electrical system and in this setup could sustain a model potential of up to −40kV. The Van de Graaff generator remained on for the duration of the test. The smooth spherical geometry of the Van de Graaff top electrode provided an excellent reference surface on which to focus an electric field mill to get a non-contact measurement of this potential. This sphere was mounted on top of an insulating post designed to allow voltages of up to −400kV relative to the grounded base without electric breakdown or significant current conduction.

The model aircraft used for this experiment was the frame of a hobby aircraft constructed to dimensions given by Bixler and Sponholz (2016). The model was a blended-wing-body design approximately 52cm in length with a wingspan of 104cm and a radius of curvature of 2.5cm at the nose. The entire model was wrapped in aluminium foil to ensure conductivity.

In this work, three different high-voltage waveforms (applied to the upper plate) were tested including a D-type waveform (with rise time 90 μs, waveform 1) and two waveforms with longer rise times (waveforms 2 and 3 with rise times of 330 μs and 800 μs, respectively). The rise time is here defined as the time to peak. Negative amplitude waveforms were applied in this experiment so that the aircraft model would be positively charged relative to the high-voltage plate. Thus, the positive leader would originate from the model aircraft. The waveforms are shown in Figure 4 with a normalised peak amplitude to compare the rise and decay times; in the experiments, the peak amplitude was varied as part of the up and down method described in section 2.4. Figure 4 shows both the idealised waveforms and actual measured signals. Note that the measured signals show spikes

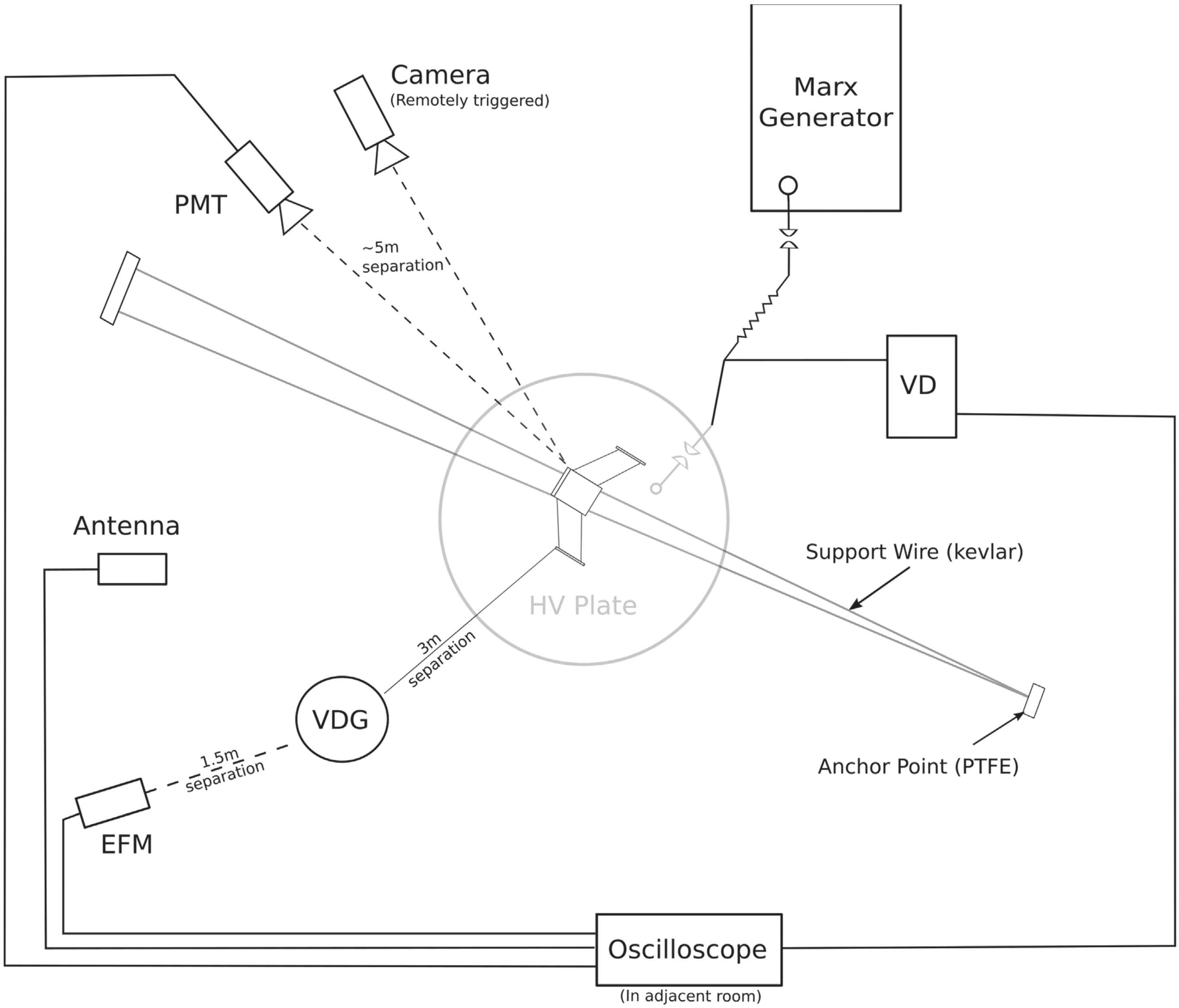

Figure 3: Plan view of the experimental setup showing the approximate location of sensors relative to the aircraft model.

during the initial rise and the decay. These spikes are the result of the spark gap to the HV plate turning on and off. The voltage measured through the voltage divider is equal to the voltage on the plate while this spark gap is closed; for example, in waveform 3, between approximately 0.3 and 2.7ms. In all cases where a breakdown was observed, it occurred near the waveform peak, and at a time when the spark gap was closed.

Five sensors were used for diagnostics. First, a voltage divider was connected to the high-voltage side of the circuit at the location indicated in Figure 2 to measure the applied potential. Second, a camera set to capture long-exposure (3s) images and equipped with a UV lens was pointed at the model. This device was used to determine whether any discharge had occurred visually. Supplementing this, a photomultiplier tube (PMT) with a UV band-pass filter Swas pointed at the location on the model, where the first leader was expected. This measurement was able to time-resolve the discharge. However, the very intense luminosity would often saturate the detector after the leader connection between the model and the high-voltage electrode. Also used to detect the leader was an antenna, which measured variations in the ambient electric fields caused by leader propagation/current flow. The antenna was a flat plate antenna with gain –60 dB and bandwidth 400 Hz to 500 MHz. The final sensor was an electric field mill (EFM), which was pointed at the Van de Graaff generator and as far as possible from the parallel plate electrodes. The primary purpose of this sensor was to determine the level of charge on the model, as charged by the Van de Graaff generator. The field mill was calibrated by applying a known voltage to the spherical electrode of the Van de Graaff generator using a high-voltage power supply and measuring the output signal. The field mill was calibrated to be accurate for electrode voltages between 0 and –50kV since this was the typical range applied using the Van de Graaff generator.

2.3 Interpretation of the Sensor Data

Each sensor is capable of detecting leader formation on its own and also provides unique information when the output of all sensors is combined. An example of a positive leader trace is shown in Figure 5. The leader is first identified by the PMT and the antenna at point A. The signal is attributed to a leader, and not streamers, due to the high luminosity: Streamers are typically less bright than leaders. Since a voltage change is not measured in the high-voltage plate, this indicates that the leader is originating at the aircraft model. This is consistent with the physics of real aircraft-triggered lightning (Lalande & Delannoy, 2012; Plumer, 2012). After approximately 5μs (point B), the upper plate voltage begins to change. This indicates that the leader has bridged the gap and that current is flowing from the high-voltage plate to the model. The transit time across a gap on the order of 25cm gives a leader speed of 5.104*m/s*. A leader speed on the order of 104*m/s* is consistent with other laboratory measurements (Andreev et al., 2008; Les Renardieres Group, 1973; Plumer, 2012) and further evidence that the signal being observed is a positive leader. Note that the sensitive PMT saturates due to the bright leader between points A and B. At point B when the even brighter spark connects, the PMT starts reading over-range, which is why the signal cuts out. The current flow lasts a few microseconds during which the antenna picks up significant changes in the surrounding electric fields relative to those occurring during leader propagation.

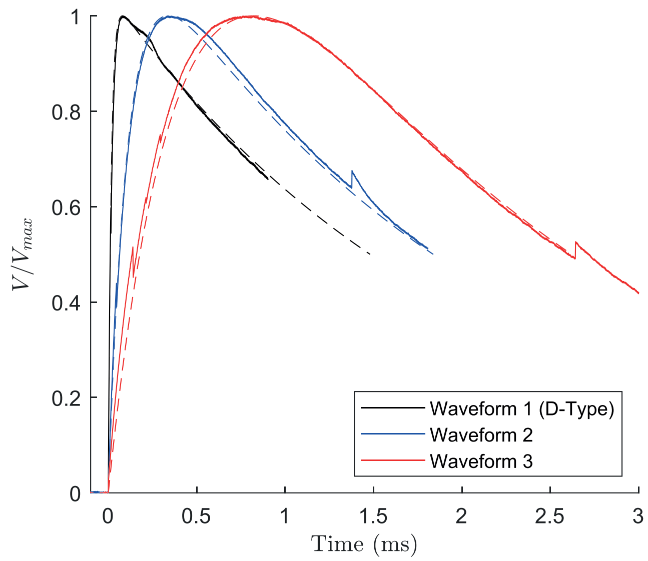

Figure 4: Voltage waveforms used in tests with normalised amplitude. Dashed lines are idealised waveforms; solid lines are measured signals. The rise times, defined as the time to peak, are 90, 330, and 800 s for waveforms 1, 2, and 3, respectively.

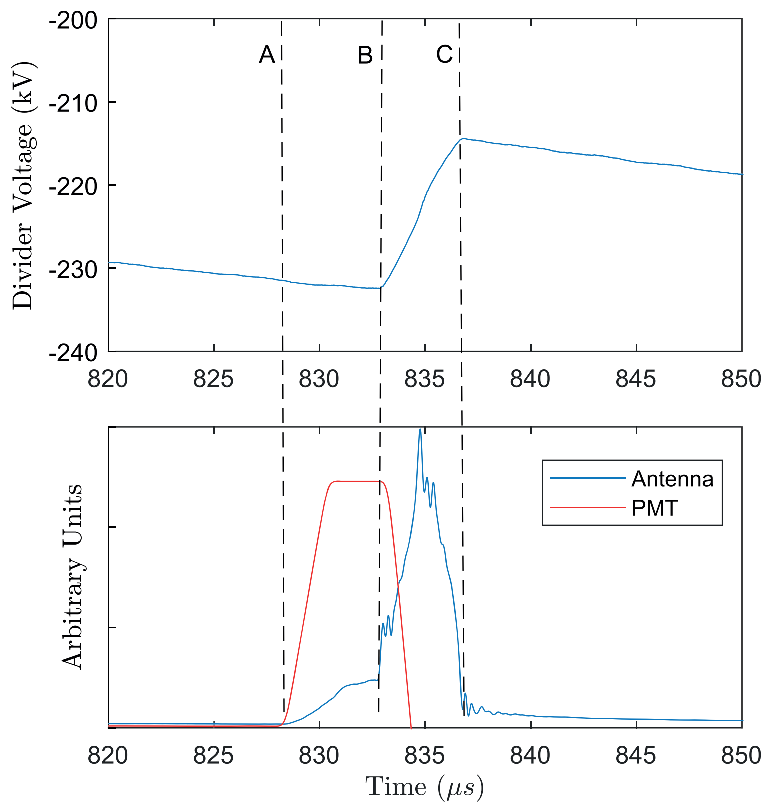

Figure 5: Sensor signals representative of positive leader inception and propagation. (A) Leader initiation point; (B) leader connection to HV plate; (C) spark termination.

After the model and plate have equilibrated, the current flow stops, and the system begins to settle (point C). To visually confirm what type of discharge had occurred (none, aborted leader, or gap-bridging leader), the long exposure UV-sensitive camera was used. This camera was set to 3s exposure and triggered immediately before the high-voltage impulse. An example of an aborted leader is shown in Figure 6, and an example of a gap-bridging leader (spark) is shown in Figure 7.

Note that the positioning of the model within the discharge gap, as shown in Figure 7 was selected to hinder the propagation of the second leader. Second leader propagation was undesirable because it would lead to a full breakdown in the gap, which would saturate the camera and PMT and make analysis difficult, as well as potentially damage the Van de Graaff generator. In the configuration chosen, the second leader is unlikely to form for two reasons. First, the theoretical model of section 4 shows that, even after the connection of the positive leader with the high voltage plate, the negative inception threshold is not reached (see section 4.2). Second, the peak amplitudes delivered by the Marx generator in the tests were below the breakdown value of the insulating post supporting the Van de Graaff high voltage electrode, so a breakdown in that gap is also avoided.

Figure 6: Representative photograph of aborted positive leader originating from the model (3s camera exposure). The total length of this aborted leader, measured along the leader path and accounting for its tortuosity, is 44cm.

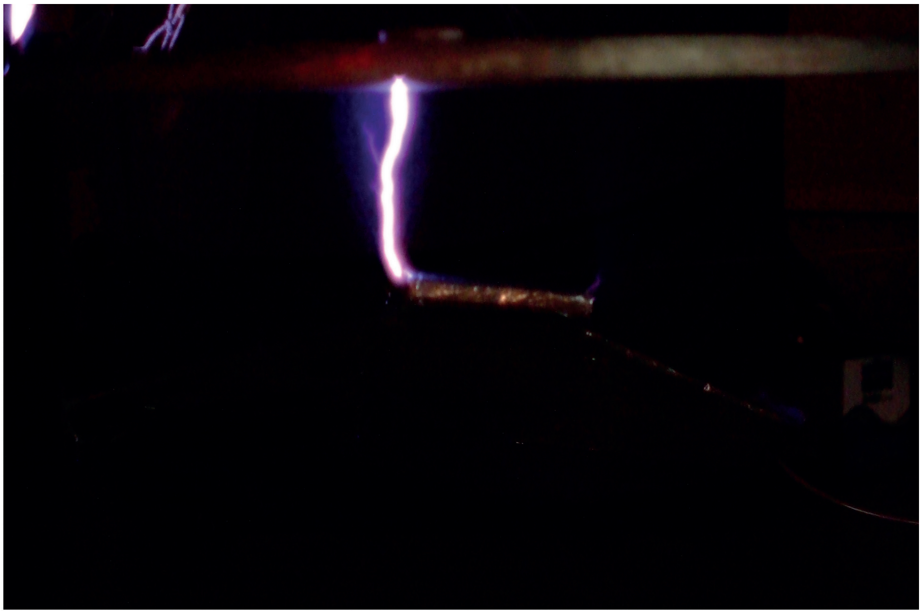

Figure 7: Representative photograph of gap-bridging positive leader originating from the model (3s camera exposure). The gap bridged by the leader in this configuration was 26cm.

2.4 Determination of the Breakdown Threshold

The breakdown threshold can be defined in a few different ways. In testing electrical insulation, typical methods consist of applying a series of voltage shots and using statistical analysis techniques to determine the voltage at which the insulation has a 50% chance of breaking down. Some of these methods are discussed in Kuffel et al. (2000), and this is the method typically used by Labelec, the facility where the experiments were performed. In regards to leader formation, it is possible to identify the precise voltage at which the first leader is incepted using the analysis discussed in section 2.3 and shown in Figure 5. In every case where a leader was observed, the measured voltage of the upper plate electrode at the moment of leader inception, point A in Figure 5, was recorded. The average of these measurements was used as the threshold for leader formation. An up and down method similar to the one described in Kuffel et al. (2000) with at least ten shots was applied to the Marx generator. This was necessary because the leader initiation voltage depends on the voltage rise rate as will be shown later in this work, so it was important to vary the peak value of the waveform.

3. EXPERIMENTAL RESULTS

3.1 Net Charge Effect on Breakdown Voltage

Tests were performed using each of the waveforms shown in Figure 4, with a minimum of 10 shots per configuration. In the cases where a leader bridged the gap between the model and the plate (Figure 7), the leader inception voltage was determined since these cases correspond to a viable positive leader. The results were averaged across all tests in a given configuration.

The value reported for the model voltage was measured around 100μs before the Marx generator was triggered, using the field mill pointed at the Van de Graaff generator. The model charge did not vary significantly in the interim between the Marx generator being triggered and the positive leader generation (point A in Figure 5), with absolute differences typically less than 500V. For the example in Figure 5, the difference between the model voltage before the Marx generator is triggered, and that measured at point A is less than 1%.

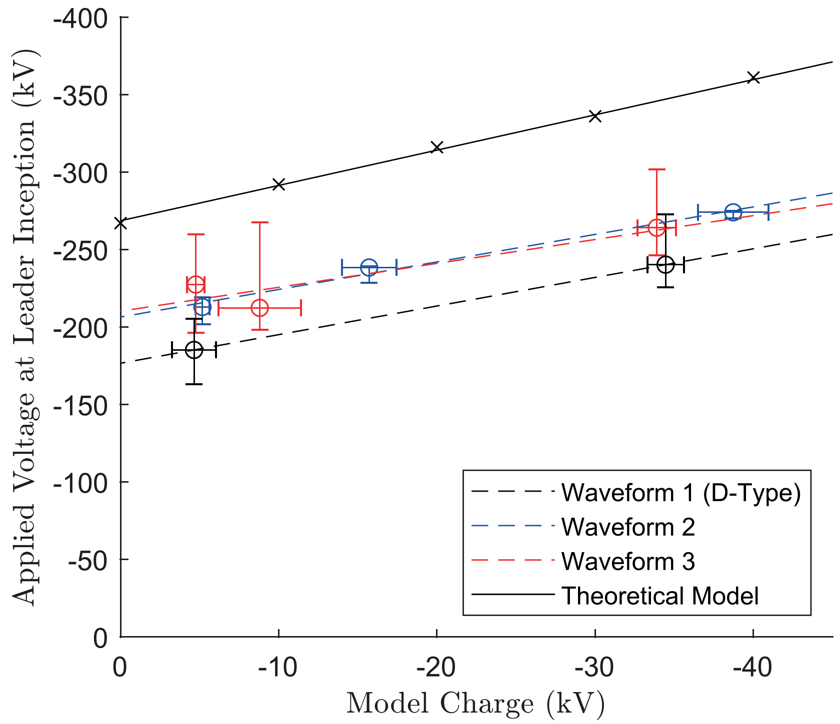

Figure 8: Measured breakdown threshold for 3 voltage waveforms as a function of model voltage. Error bars on charge correspond to the maximum and minimum charge levels observed during the tests. Positive error bars on voltage correspond to the highest peak voltage the gap withstood, and negative error bars correspond to the lowest voltage at the start of a gap bridging leader.

Table 1
Slope of the Breakdown Versus Model Charge Curve for the Different Waveforms (Rise Times in Parentheses)

Waveform	Slope (kV/kV)
1 (90μs)	1.85
2 (330μs)	1.78
3 (800μs)	1.54
Theoretical model	2.28

Figure 8 shows that as the model acquires a more negative charge, the threshold for first (positive) leader formation increases in magnitude. This outcome confirms the influence of vehicle net charge on the likelihood of lightning strike occurrence, as predicted by Guerra-Garcia et al. (2018). A direct comparison with the theoretical model is discussed in section 4.2.

A linear fit to the data is shown, and the slopes are recorded in Table 1. The fit has a positive slope greater than unity for all three waveforms tested. In all cases, the slope of the curves shows reasonable agreement with the theoretical breakdown curve, with the discrepancy in slope and breakdown voltage attributable to different model geometry and other uncertainties in the model discussed in the original paper (Guerra-Garcia et al., 2018).

It is interesting to note that in those tests with a model aircraft that had been grounded, a potential of approximately –5kV developed on the model during the time between grounding and the start of the voltage pulse. For safety reasons, the grounding (which was done manually) had to be performed well in advance of the high-voltage shot. One possible explanation for this baseline charge is charge conduction by the insulating support cables, which were found to have nonzero conductance when a high voltage was applied across them.

The charge could accumulate in these cables during the last voltage shot and be conducted to the model. Residual space charge from the previous voltage shot could also be a factor in creating the baseline charge. It is of interest to note that, as far as the authors know, the standard recommended practices do not discuss the need of grounding the model in between tests and the present results show the criticality of this good practice.

When extrapolating the test results to the airborne scenario, some discrepancies may exist related to the effect of negative coronae that will be developing on the negatively charged model before the high-voltage impulse, due to the model's high voltage relative to the surroundings. An estimate of the onset voltage of these coronae is discussed later (section 3.3). In the tests, the presence of these negative ions in the vicinity of the model could be modifying the conditions for leader initiation in a way not entirely consistent with the airborne situation. Note that this ion cloud is not expected to interfere with the EFM measurement, since the measurement is taken about 3m away from the model (see Figure 3).

Another difference between the lab and airborne situations is the effect of nearby grounded objects causing the experimental setup to deviate from the idealised situation wherein the aircraft is exposed to a uniform applied field and is far away from other objects.

3.2 Effect of Voltage Rise Rate

In reality, aircraft-triggered lightning will occur both for aircraft exposed to a rapid rise in the ambient field (e.g., due to nearby lightning, Saba et al., 2016) and for aircraft flying into sufficiently high ambient fields (in-flight experiments report ambient fields about 50 kV/m at the moment of triggered-lightning, Rakov & Uman, 2003). Considering that a typical airliner flies about 250 m in 1 s, and this may be of the order of the motion required to enter the area of influence of a cloud charge centre, the conditions might be slow in the second scenario compared to the waveforms tested. However, fast waveforms need to be used in laboratory tests to compensate for static electrodes and simulate to some extent that a fast-moving aircraft can escape regions of space charge, created by local corona phenomena, modifying the conditions for leader formation. E.g., it has been observed that initiation of upward leaders from rotating blades of windmills occurs more readily than from static towers due to the redistribution of the ion charge cloud that locally shields the electric fields in static towers (Montanya et al., 2014).

When comparing the three waveforms tested, with rising times ranging between 90 and 800 μs, the threshold for leader formation is reduced when the rate of voltage rise is increased. This effect is most noticeable when comparing waveform 1 (90 μs, D-type) to waveforms 2 (330 μs) and 3 (800 μs) and is seen for all charging levels. The breakdown threshold, at comparable charging levels, for waveform 3 was about 30 kV in magnitude less than for the faster waveforms. As discussed in section 2.1, it is known (Les Renardieres Group, 1973) that the rate of field rise has an impact on breakdown characteristics, and it appears that extending the rise time beyond that of the standard D-type waveform increases the breakdown threshold.

The data for waveform 3 shows some unexpected results, notably the large error bars and inconsistent trend at low voltages. Part of the issue here is the slow ramp in waveform 3, which was difficult to achieve experimentally. These tests yielded a signal that indicated that the spark gap between the Marx generator and the high-voltage plate electrode would turn on and off during the voltage ramp, while in the other tests performed the circuit to the plate remained closed after the initial connection was made. One instance of this spark gap switching can be seen in the rise portion of waveform 3 when compared to the idealised waveform in Figure 4. The result was a voltage applied to the plate electrode that occurred in steps, rather than a smooth ramp, obstructing the interpretation of the results.

More interestingly for the range of rising times tested, it is shown in Figure 8 and Table 1 that the variation of the breakdown potential with model charge (the slope of the line) is only weakly related to the rate of rising of the input voltage, and the weak dependence observed is within the margin of error of the experimental data. This means that a negatively charged model hinders positive leader inception by about the same amount regardless of the rate of rising of the external field.

3.3 Model Aircraft Discharging

For the chosen aircraft model, it was challenging to maintain a voltage on the model beyond a few tens of kilovolts, without a continuous current supply. At voltages on the order of –10 to –15kV, the sharp corners on the model (or possibly wrinkles in the aluminium foil) would begin to corona emit, dissipating the

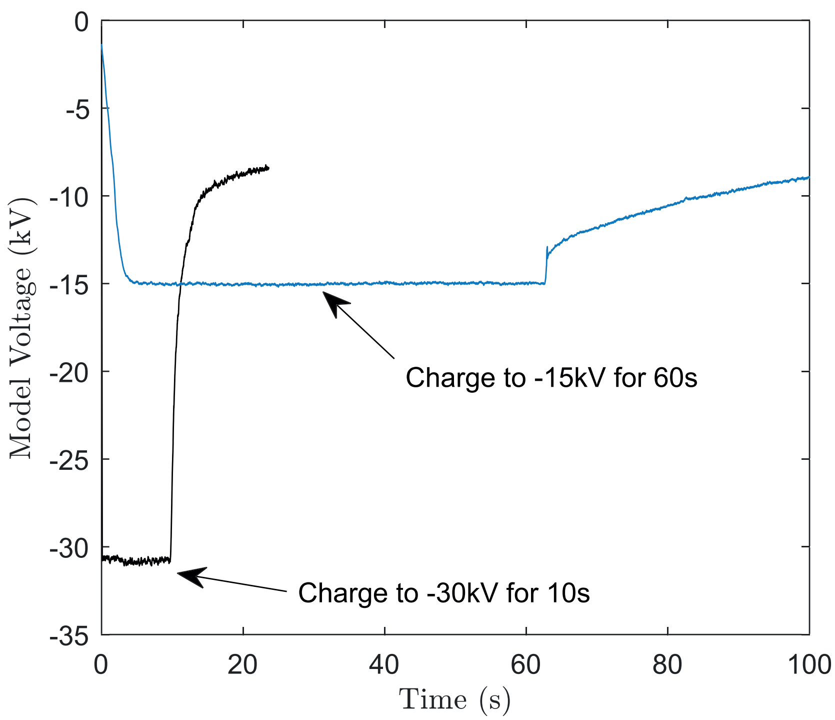

Figure 9: Model discharging curves for model charged to −30 and −15kV.

Table 2
Time Constants for Model Discharging

Initial charge (kV)	$\tau_{\text{fast}}(s)$	$\tau_{\text{slow}}(s)$
−30	0.92	31
−15	0.29	74

charge. This effect was observed visually through long-exposure photographs taken with a UV-sensitive lens, as well as through a non-contact measurement of the model voltage, once the charging source was disconnected. An example of this measurement is shown for two tests in Figure 9. In both cases, immediately after the charging source was disconnected, the model aircraft began to discharge rapidly. The slope of this discharging curve became less steep when the model had dropped to around −10 or −12kV depending on the test. This is interpreted as a termination of the corona emission mechanism from the aircraft extremities and the dominant discharge mechanism switching to conduction through the support cables. The time constants corresponding to the fast and slow discharging mechanisms, τ_{fast} and τ_{slow}, can be estimated by fitting the data in Figure 9 by a double exponential decay:

$$V = V_{\text{fast}} \exp(-t/\tau_{\text{fast}}) + V_{\text{slow}} \exp(-t/\tau_{\text{slow}}).$$

An estimate of these time constants is given in Table 2. There are two important conclusions to be drawn from this figure. First, to maintain a model voltage beyond −10kV requires an active charging strategy that remains connected at the moment of the high-voltage impulse. Second, while conduction through the insulating support cables is significantly less rapid than the corona discharge mechanism, it is nonzero during high-voltage testing.

4. DISCUSSION GUIDED BY COMPARISON TO ELECTROSTATIC MODEL

4.1 Computational Model Description

A physics-based numerical model is used to explain the experimental observations. The model is described in detail in (Guerra-Garcia et al., 2017, 2018) and is based on the numerical zoning methods developed by Lalande et al. (1999a) that combine an electrostatic simulation of the aircraft to semiempirical criteria for leader inception. The semiempirical leader inception criteria used are based on the critical charge concept of Gallimberti (1979): A leader is incepted if the charge accumulated within the impulse corona that precedes the leader exceeds a certain threshold q_{cr}. The corona charge is estimated from the electrostatic model through a volumetric integral (Arevalo et al., 2012) assuming that the electric field within the corona is constant and equal to the stability field value E_{cr}, (Gallimberti, 1979).

The main difference between this model and those previously reported in the literature is that it makes no assumption on the polarity of the first leader to be incepted and uses different thresholds for the positive and negative polarity. The thresholds used for the positive leader inception are q^+_{cr}=1μC,E^+_{cr} = 450 kV/m; and for the negative leader: q^-_{cr}= -4μC, E^-_{cr} = 750kV/m consistent with laboratory measurements by Castellani et al. (1998) and Niemeyer (1991) and theoretical work by Gallimberti et al. (2002), among others). For self-consistency, the model is briefly described in what follows.

4.1.1 Determination of Breakdown Voltage and First Attachment Point

The prestrike electrostatics of the model aircraft at a pitch angle of 50 degrees placed between two large parallel plates at a distance of 145cm, as pictured in Figure 2, is solved by solving Laplace's equation.

The bottom plate is grounded, and a negative high-voltage potential is applied to the upper plate. The geometry of the model used is that in Guerra-Garcia et al. (2018), scaled to have the same wingspan as in the experiment to have a comparable electrical capacitance of value C = 41pF in the numerical model.

The prestrike electrostatics are solved for a given net charge of the vehicle (in the computational model, the net charge and voltage are related through the capacitance), and the voltage of the upper plate is gradually increased in amplitude.

At each upper-plate voltage level, the criteria for both positive and negative leader inception are tested on all possible attachment points (namely nose, wingtips, and rear end). Once the criterion for leader inception has been reached at any given point, the first attachment point and the applied voltage for leader inception has been obtained.

4.1.2 Propagation of First Leader and Second Attachment Point

Once the first leader is incepted, it propagates along the local electric field line with a constant charge per unit length, $\lambda^+ = 65\ \mu C/m$ for the positive leader and $\lambda^- = 108\ \mu C/m$ the negative leader, as measured by Les Renardieres Group (1973). As the leader propagates, the net charge of the model, *Q* is biased in the opposite polarity:

$$Q(t) = Q(0) \mp \lambda l(t),$$

Where the minus sign corresponds to the case of a positive leader preceding, time zero corresponds to first leader inception, and *l(t)* is the length of the leader at each moment. At each time step, the criterion for the opposite polarity leader inception is tested on all possible attachment points. As the model is biased in the direction that favours the opposing polarity leader, the first leader is propagated in time until the second leader is triggered.

4.2 Computational Model Results and Comparison to Experimental Data

The computational model is used to explain the experimentally measured influence of model net charge on self-triggered lightning (section 3.1).

Table 3 shows the influence of model potential ϕ_M (note that it relates to the net charge *Q* through the self-capacitance) on the voltage applied to the upper plate, V_{app}, to trigger a bidirectional leader. The first leader and its polarity, as well as the second leader and the length of the first leader at second leader inception l_1^{crit}, are also reported. The first five rows correspond to the range experimentally tested.

For an uncharged model, $\phi_m = 0$, the first leader to be incepted is the positive one, since the threshold values in the positive polarity are lower than in the negative polarity. The experimentally measured voltage for positive leader inception is approximately 30–35% lower than the model predicts. The first attachment point predicted by the model, as in the experiment, is at the nose of the vehicle. As the positive leader propagates, it biases the vehicle to negative values facilitating the inception of the negative leader.

The model predicts the initiation of the negative leader occurs when the first leader is $l_1^{crit} \approx 22$ cm long. This translates to the model being biased to

$$\breve{\phi}_M(l_1^{crit}) = C^{-1}Q(l_1^{crit}) = -347\text{kV}.$$

The implications for the experiment are that, since this magnitude is higher than the peak amplitudes delivered by the Marx generator in the tests and the gap between the vehicle and upper plate is comparable to the critical distance, the second leader will not be triggered from the model, even after the first leader connects to the upper plate.

As the model aircraft charge, *Q*, and potential, ϕ_m, are made more negative, the conditions for the positive leader inception are made more difficult, and those for negative leader inception are favoured. This increases the applied voltage to trigger the first leader and a reduced first leader propagation length to bias the aircraft to the level required for a second leader inception. Despite the offset in the breakdown threshold in the uncharged case between the experiment and model (Figure 8), the slope of the breakdown voltage to charging level curve is in reasonable agreement, see Table 1. Note that, aside from the simplifications of the model, the geometries of the vehicles and experimental setup are not identical, and the empirical parameters are only roughly known.

Table 3 is extended to determine the net vehicle charge that makes leader inception hardest: This is the optimum condition in terms of lightning avoidance, and it is marked in bold font. Beyond this level, at ϕ_m = -170kV, the conditions are such that the positive leader is suppressed, and the negative leader becomes more likely; the applied voltage required to trigger it can again be reduced. For net charge levels above this value, the positive leader precedes; for lower net charge levels, the negative leader is incepted first. Therefore, the optimum corresponds to the case when both leaders are simultaneously incepted.

Note that in the experimental setup it was not possible to reach such high vehicle net charge levels since the charging strategy needs to compensate for any natural coronae formed at the

Table 3
Breakdown Conditions as a Function of the Aircraft Model's Electrostatic Potential (or Equivalently, Its Net Charge), Results of Electrostatic Simulation

ϕ_M [kV]	Q [μC]	First Leader	Second Leader	V_{app} [kV]	l_1^{crit} [cm]
0	0	(+) Nose	(–) Nose	–267	21.9
–10	–0.4	(+) Nose	(–) Wing tip	–292	21.2
–20	–0.8	(+) Nose	(–) Rear end	–316	20
–30	–1.2	(+) Nose	(–) Rear end	–336	18.8
–40	–1.6	(+) Nose	(–) Rear end	–361	17.5
–50	–2.1	(+) Nose	(–) Rear end	–381	16.3
–60	–2.5	(+) Nose	(–) Rear end	–402	15.1
–70	–2.9	(+) Nose	(–) Rear end	–420	14
–80	–3.3	(+) Nose	(–) Rear end	–445	12.6
–120	–4.9	(+) Nose	(–) Rear end	–526	7.5
–150	–6.2	(+) Nose	(–) Rear end	–583	3.8
–170	**–7.0**	(+) Nose	(–) Rear end	**–624**	**1.2**
–190	–7.8	(–) Rear end	(+) Nose	–616	0.9
–200	–8.2	(–) Rear end	(+) Nose	–599	1.7
–225	–9.2	(–) Rear end	(+) Nose	–551	3.5

extremities of the vehicle (see section 3.3). In the experimental scenario, this charging speed was limited by the velocity of the charging belt of the Van de Graaff generator.

5. LIGHTNING DETECTION, PREDICTION, AND RISK REDUCTION

The experiments reported in this paper have shown that aircraft net charge has a strong influence on lightning inception. In addition, electrostatic signals and models could be used for lightning detection, and prediction and ultimately, a charge control system could be implemented to minimise the risk of a strike (Martinez-Sanchez et al., 2019).

One key element to the successful implementation of such a charge control strategy is the ability to charge the aircraft during a flight to the desired levels. Lalande et al. (1999b) indicate that charges on the order of a millicoulomb can naturally develop on aircraft flying in an environment conducive to lightning strikes.

The capacitance of the plane in question was on the order of a nanofarad, which implies a voltage on the order of a megavolt (typically negative relative to the surroundings). More interestingly, artificial charging of a B-17 research aircraft was demonstrated by Stimmel et al. (1946) and Waddel et al. (1946) using the emission of positively charged droplets from the aircraft surface to a potential of about –0.5MV, which corresponds to a net charge of –0.4mC. Other experiments using smaller aircraft and ion emission have demonstrated artificial charging to 20–40 μC levels (negative) (Jones, 1990). Note that the charging levels that led to a measurable impact on the breakdown conditions for the 1m wingspan model vehicle in the laboratory setup were of the order of 1 C (negative) or ~30kV. The modelling work in section 4 suggests a scaling of this charge quadratic with a size or equivalently a linear scaling of the potential with size: E.g., a ~30m wingspan aircraft would require charging levels of the order of 1mC or ~1MV (Guerra-Garcia et al., 2018).

Another necessary element of this strategy is the ability to have a reasonable prediction of leader inception before it occurs. Currently, aircraft operations in lightning conditions are informed by the onboard weather radar, communications between pilots, and contact with Air Traffic Control (ATC). Moreover, flight operations manuals rarely mention lightning but rather thunderstorms alone.

Aircraft weather radar typically displays storm cell information, although modern, proprietary, technologies integrate distinct "lightning icons." These technologies are designed to detect electrical discharge activity that the radar cannot see and map the lightning activity onto the weather radar display of the pilot (Honeywell, 2016).

Contact with ATC provides additional weather data (mainly related to thunderstorm development) but may also include direct lightning observations by Lightning Detection Networks (LDNs). For example, the National LDN detects cloud-to-ground flashes with an efficiency of 90–95%.

Information of lightning detectors based on RF emissions are often included in METAR (MEteorological Terminal Aviation Routine) weather reports as an indicator of the nearby presence of a thunderstorm (Transportation Research Board and National Academies of Sciences, Engineering, and Medicine, 2008). Note that the information based on weather reports and LDN summarise the current or recent scenario, rather than what comes ahead. Prediction technologies include monitoring the growth and motion of convective systems that can develop into thunderstorms using nowcasting techniques by measuring, using radar and satellites, storm properties (Mäkelä et al., 2013). The FAA uses these for both en route and terminal air traffic management.

Note that around 40% of lightning strikes reported by airline pilots are experienced with no thunderstorms in the immediate area (Sweers et al., 2012), which suggests that the presence of thunderstorms alone is not a good indicator of the incidence of aircraft-triggered lightning.

Other existing technologies, not currently used to predict lightning to aircraft, include Total Lightning Systems that can detect both cloud-to-ground (CG) lightning and intra-cloud (IC) lightning. Optical detectors onboard geostationary meteorological satellites (e.g., the Geostationary Lightning Mapper onboard the Geostationary weather satellites GEOS-16 and the Meteosat Third Generation Lightning Imager MTG-LI) can provide this information.

In addition, electric field mills can be used to alert of a possible threat (predicting rather than detecting a strike after it occurs). For that reason, electric field mills are a vital component of the launch evaluation systems employed at NASA's Kennedy Space Flight Center. Only research aircraft have carried electric field mills onboard, and these sensors are not routinely used in aviation (Fisher & Plumer, 1984).

6. CONCLUSIONS

This paper presented an experimental study of the effect of aircraft net charge on its susceptibility of being struck by lightning. The threshold background electric field for leader initiation was shown to increase (in magnitude) as the aircraft accumulated a more significant amount of negative electrical charge.

Note that the trend applies to the specific orientation of the electric field-tested (vertical field, vehicle pitched at 50˚. This effect was observed for different rates of rising of the ambient electric field (from 90 to 800 μs), including one that is consistent with standard lightning leader attachment tests. Use of slower waveforms, e.g., representative of an aircraft entering an area of influence of a cloud charge centre, was hindered by experimental constraints. For the waveforms tested, the breakdown threshold increased approximately linearly with the amount of charge applied to the aircraft model and showed reasonable agreement with simulations.

These results verify both the validity of the methods employed in those simulations and the potential of using charge control as a means of reducing the risk of aircraft-triggered lightning.

When implemented as part of a more extensive system of lightning detection and prediction, active charge control of aircraft is a promising strategy to help prevent costly strikes from occurring.

Empowering Industrial Transformation

- A CALL TO ACTION FOR THE ELECTRICAL ENGINEERING FRATERNITY

In the dynamic landscape of modern engineering, the clarion call made by the ECSA President and published on the 17th of May 2023 on Engineering News resonates as a potent reminder of our collective responsibility as a community of engineers. As Deputy President of the South African Institute of Electrical Engineers (SAIEE), I stand firmly behind the vision to drive industrial transformation within our fraternity. We must embrace this opportunity to champion change, foster collaboration, and lead the charge towards a future characterised by innovative prowess and sustainable development.

By Eng. Pascal Motsoasele PrEng FSAIEE, SAIEE Deputy President

The articles titled "Involvement of the Engineering Fraternity in Decision-Making Bodies: Key to Infrastructure Development and Maintenance" (cited on-2022-03-17) and "Industrial Transformation in the Engineering Environment" (See wattnow pape 50) are not only insightful but also serve as a compass guiding us toward an engineering renaissance.

These articles emphasise the vital role played by the engineering community in developing and maintaining critical infrastructure, underscoring the importance of informed decision-making and proactive involvement.

In response to the ECSA President's rallying cry, we must outline a roadmap for the industrial transformation that the electrical engineering fraternity must pioneer. We must embrace vital strategic initiatives that empower us to digitally transform our operations and advance our field to new heights.

1. EMBRACE DIGITALISATION

We stand at the nexus of the digital age, where technology reshapes every aspect of our lives. Adopting digital tools, Industrial-Internet-of-Things (IIoT) solutions and advanced data analytics is imperative for electrical engineering companies. Smart sensors, artificial intelligence (AI), machine learning (ML), predictive maintenance algorithms, and real-time monitoring systems can revolutionise how we approach electrical infrastructure management, ensuring optimised performance and minimised downtime.

2. CULTIVATE A CULTURE OF INNOVATION

Innovation is the bedrock of progress. We must encourage a culture that fosters creativity and embraces experimentation to drive transformation.

This could involve hosting hackathons, innovation challenges, and cross-functional workshops, where diverse minds converge to ideate and bring disruptive solutions.

3. COLLABORATION WITH IT DEPARTMENTS

Collaborative efforts with IT departments are one of the most potent avenues for industrial transformation. The synergy between electrical engineering and information technology (IT) can lead to groundbreaking developments. By partnering with IT teams, we can leverage their cybersecurity, data management, and cloud computing expertise to enhance our operations and fortify our digital infrastructure.

4. SKILL UPGRADATION AND TRAINING

To fully exploit the potential of digital transformation, our engineers must continually upskill. Workshops, seminars, and online courses covering topics such as artificial intelligence, machine learning, and cybersecurity will equip our professionals with the tools to drive the fourth industrial revolution forward.

5. SUSTAINABILITY AND GREEN ENGINEERING

Industrial transformation should go hand in hand with sustainability. We must be advocates for green engineering practices, integrating renewable energy sources, energy-efficient technologies, and eco-friendly designs into our projects. This benefits the environment, aligns with global trends, and enhances our competitiveness.

As we embark on this transformative journey, the SAIEE pledges unwavering commitment to this cause. Together, we will champion industrial transformation, ensuring the electrical engineering fraternity becomes a beacon of progress and innovation within the broader engineering landscape. By embracing digitalisation, nurturing innovation, collaborating across disciplines, promoting continuous learning, and prioritising sustainability, we will shape a future that transcends boundaries and ushers in an era of unparalleled growth. Let us heed the call of the ECSA President and rise to the occasion. The time is now to own our space, lead with vision, and propel our fraternity to new heights of excellence. Together, we shall illuminate the path toward a brighter, digitally transformed future. wn

The engineering sector has been experiencing a rapid transformation in recent years, with the convergence of Operational Technology (OT) and Information Technology (IT). While this convergence has the potential to unlock significant benefits, it also presents several challenges, particularly cybersecurity and the need for specialised engineering skills. This opinion piece aims to provide a comprehensive overview of industrial transformation in the engineering sector, with a particular focus on the role of OT in leading this transformation.

Refilwe Buthelezi PrEng
President – Engineering Council of South Africa

Industrial transformation in the engineering sector is a crucial issue that has recently gained significant attention. The rapid advancement of technology and the growing need for more efficient and sustainable solutions have led to a convergence focus between operational technology (OT) and information technology (IT). However, it is essential to understand the differences between these two technologies before discussing their convergence.

DISTINGUISHING OT AND IT

IT and OT are often used interchangeably but are distinct areas of expertise with different goals and requirements. IT focuses on collecting, storing, processing, and sharing data and information using computing systems and networks.

IT is typically concerned with systems designed to be secure, reliable, scalable, and integrated with other systems. IT is governed by a range of industry standards and regulations, including ISO 27001, Control Objectives for Information Technologies (COBIT), and the General Data Protection Regulation (GDPR).

On the other hand, OT is concerned with controlling and automating physical processes in industrial environments. It involves using specialised hardware and software, such as programmable logic controllers (PLCs), sensors, and human-machine interfaces (HMIs), to monitor and control the physical systems that drive the industry. OT is mission-critical and requires specialised engineering skills and technical know-how to operate and maintain effectively. It is governed by industry-specific standards and regulations, such as ISA-95, IEC 62443, and the NIST Cybersecurity Framework.

IT-OT CONVERGENCE

IT-OT convergence refers to integrating IT and OT systems and technologies to achieve improved performance, efficiency, and flexibility in industrial environments. The convergence of IT and OT allows for the collection, storage, and analysis of real-time data from OT systems, which can optimise operations, reduce downtime, and improve overall efficiency.

To some extent, IT-OT convergence has been embraced by supporters and proponents in various engineering industries.

Supporters of IT-OT convergence argue that it offers significant benefits, including increased visibility into industrial processes, improved operational efficiency, and enhanced decision-making capabilities. Proponents also cite the potential for cost savings and reduced downtime through predictive

Industrial Transformation in the Engineering Environment

maintenance and more effective asset management.

However, there are also concerns about the security and reliability of IT-OT systems, as well as the potential for increased complexity and risk associated with their integration. There are challenges around integrating legacy systems and the need for specialised skills and expertise to effectively manage and operate IT-OT systems.

REGULATORY FRAMEWORK FOR IT-OT CONVERGENCE IN SOUTH AFRICA

The engineering industry in South Africa is regulated by the Engineering Profession Act (EPA) and governed in tandem with public interest guidelines from the Council for the Built Environment Act (CBEA) [1],[2]. These acts provide a regulatory framework for the engineering profession in South Africa and the ethical and professional conduct expected of engineers. In March 2021, the Engineering Council of South Africa (ECSA) published in the Government Gazette the Identification of Engineering Work (IDoEW) [3]. The IDoEW and the enabling provisions enshrined in the EPA seek to promote safety, professionalism and compliance with the Codes of Conduct for Registered Persons and the Overarching Code of Practice for the Performance of Engineering Work.

However, there is no specific regulatory framework governing IT-OT convergence in the engineering sector. This is a concern, as the integration of IT and OT systems can create new vulnerabilities and increase the risk of cyber-attacks, which the world can ill-afford in critical infrastructure installations and service facilities in sectors such as manufacturing, mining, transportation, oil, gas, water, and electricity. The lack of regulatory guidance on IT-OT convergence leaves the engineering industry in South Africa vulnerable to potential risks and challenges associated with this convergence. In the United States, since about 2020, water utility entities have been targeted for cyber-attacks because of how decentralised their systems are nationally, making the IT-OT convergence an area of policy focus countrywide.

Nonetheless, it is essential to be critical of the IT-OT convergence ideal and recognise the importance of OT's autonomy as a regulated mission-critical engineering environment charged with the safety of plants, humans, animals and the environment. Engineers design with safety in mind. Critical parameters such as network availability and least latency are crucial for emergency preparedness and disaster recovery. Performance characteristics such as systems reliability, redundancy, longevity and maintainability are key design considerations and take centre stage in OT operations [4]. OT systems require specialised knowledge and expertise that IT personnel cannot easily replace.

BEST PRACTICES FOR IT-OT CONVERGENCE

Global best practices around IT-OT convergence in engineering industries highlight the importance of a risk-based approach to IT-OT integration. This approach involves identifying and assessing the potential risks associated with IT-OT convergence and implementing appropriate controls to mitigate these risks. Furthermore, best practices emphasise the importance of having a clear understanding of the roles and responsibilities of IT and OT personnel in managing and maintaining integrated systems.

While both IT and OT functions play essential roles in an organisation, the OT functions should lead the industrial transformation of utilities for several reasons. Firstly, OT connects, monitors, manages, and secures an organisation's industrial operations, making it a critical component of the industrial transformation process [5].

OT systems are designed to interact with physical equipment, such as generators, transformers, and other machinery, making them well-suited to lead the transformation of industrial utilities. Secondly, an OT service delivery transformation enables engineering companies to respond to the changing industry landscape and acquire the necessary technical capabilities to meet the evolving demands of the market [6].

The OT functions have a deep understanding of the industrial processes and operations of the utilities, making them better equipped to make informed decisions about the transformation process. Lastly, while IT serves as the connectivity technology backbone of an organisation, it primarily deals with data-centric systems such as databases, networks, and software applications [7]. Therefore, the IT functions may not possess the same level of understanding of the operational technology systems and processes essential for transforming industrial companies. Additionally, engineering work is regulated, and thus, compliance with the relevant Acts of legislation is mandatory.

CONCLUDING REMARKS

Industrial transformation in the engineering sector is a complex issue that requires a risk-based approach to IT-OT convergence. While there are potential benefits to integrating IT and OT systems, significant risks must be managed appropriately. IT and OT functions should work collaboratively, with OT functions leading the industrial transformation due to their specialised engineering skills and technical expertise and IT functions serving to support these engineering functions.

The engineering industry associations, such as the South African Council for Automation and Control (SACAC), the Africa Utilities Technology Council (AUTC), and voluntary associations recognised by ECSA, such as the South African Institute of Electrical Engineers (SAIEE) and the Society for Automation, Instrumentation, Mechatronics and Control (SAIMC), must ensure that appropriate standards and regulations are in place to govern IT-OT convergence in member engineering companies and that OT functions lead the industrial transformation effort in compliance with the spirit, letter and intent of the law. wn

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The Case for Engineer General in South Africa

1. Introduction

The need for the Engineer General of South Africa ("EGSA") is not a new subject in South Africa. CESA (Consulting Engineers of South Africa) has been at the forefront in advocating for introduction of the Engineer General to regulate, supervise, mitigate and monitor engineering practices on major developments that are taking place in the country. Engineering league of Progress (ELP) is joining into this noble suggestion and further provide some level of details on the motivation and how it can be implemented in South Africa.

The subject of Engineer General is very timely in that South Africa has already established other "Generals" who oversee, implement and enforce regulations and practices in their respective disciplines. These include Surveyor General, Statistician General, Auditor General, Valuer General, etc. In this context, we may also place Chief Justice in this category of supreme office in a specific discipline.

The common thread amongst the offices of the Generals is that they protect dignity and practices of the discipline, preserve and enforce rules, investigate and issue technical reports when transgressions are observed. The powers and functions bestowed upon the Offices of the Generals ensure that practitioners operate within the set guidelines and remain accountable to an overarching independent body.

2. The Engineering Fraternity and How its Currently Structured

Formal regulation of the engineering profession started in 1968 under the South African Council for Professional Engineers. In 2000, the South African government established the Engineering Council of South Africa ("ECSA") under the Engineering Profession Act 46 of 2000. ECSA has done a good job in encouraging practising engineers to register as professionals and embark on lifelong technical training. While ECSA's role is demonstrable in the regulatory sphere, it has been difficult to get to narrow areas of interest within the engineering fraternity. This situation has resulted in the emergence of prominent groups advocating for specific interests – SAPVIA, CESA, SAWEA, SAESA, WISA and many others. Left unchecked, industry associations often place additional barriers in the form of certifications under the banner of quality control in their narrow specific area of interests.

For the sake of this paper, we present a simplified version of the structure of the engineering profession in South Africa (figure 1).

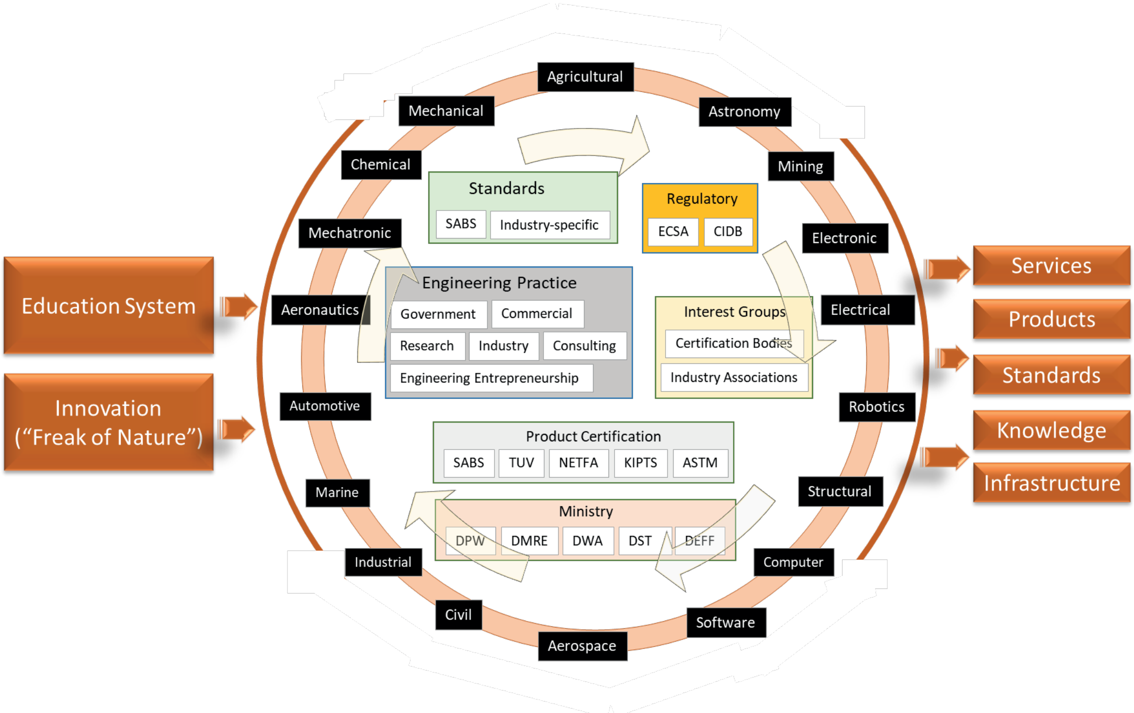


Figure 1: Simplified structure of the engineering profession in South Africa

With reference to the registration of engineering practitioners as professionals, the current data shows a sizeable collective that now associates with ECSA, presented in figure 2.

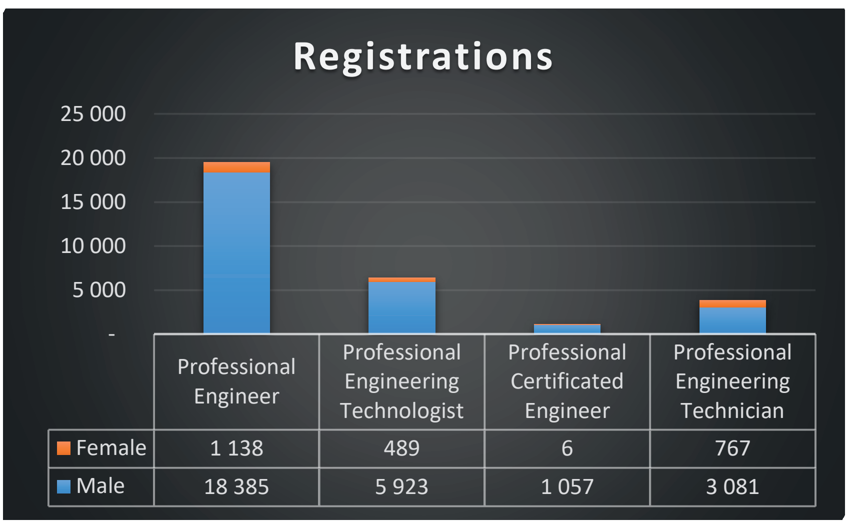


Figure 2: Status of registration of engineering practitioners (Source: ECSA Annual Report, 2019/20)

The underlying assumption is that once engineering practitioners register as engineering professionals (Engineer, Technologist and Technicians), they will practice their trade bound only by ECSA's Code of Practice. Given the number of project and infrastructure failures that have occurred in recent years, it is evident that the engineering profession is missing a big piece at regulatory level. Let alone the emerging trend of non-engineering individuals taking on large-scale engineering projects unabated.

In this paper we submit that this missing piece is the Engineer General.

3. Various Failures in SA that Needed Engineering Investigations

This section explores at high level some of the public engineering incidences that have taken place in South Africa. The section only deals with data that is publicly available.

3.1 Greystone Drive bridge collapse

Figure 3. M1 pedestrian bridge collapse incident

On 14 October 2015, temporary works erected over the busy M1 motorway collapsed onto the passing traffic during construction of the pedestrian bridge. Two people were killed and 19 were injured in the collapse which blocked both the north and southbound traffic. Preliminary reports indicated that the scaffolding couplers were not appropriately tightened or they were of inferior quality to hold the structure properly. The final report on the collapse has not been widely publicised to understand the root cause and the final outcomes and future recommendations or lessons learnt to implement in similar situations.

3.2 *Tongaat Mall Collapse during Construction*

Figure 4: Collapse of Tongaat Mall during construction

Whilst construction of the Tongaat Mall was in progress on 19th November 2013, the superstructure collapsed. Evidence presented at the inquiry highlighted that there was a sagging slab of no less than 7cm, whilst others submitted that the permission to build the mall had not been granted by eThekwini Municipality but the construction continued anyway in anticipation of an affirmative response. Two people died and 29 got injured.

3.3 Various train derailments and collisions

South Africa has experienced several train derailment or collision incidents in recent times. Investigation reports seem to point to operational aspects including judgement errors, aging infrastructure, obsolete control technology and theft of copper cables. The catastrophic nature of such incidents has led to injury or death of passengers and other members of the public. Transportation planning authorities still take the view that trains are the cheapest, most reliable and most preferred form of transport, but reality on the ground and public perception have shifted to the negative.

Figure 5: Train collision incident

3.4 Flooding on N3 Highway near Alexandra to Linksfield, Gauteng

In November 2016, severe flash floods occurred to the extent of sweeping cars away on the highway. It is unthinkable how such a phenomenon can occur when common engineering knowledge posits that factors such as flooding, stormwater volumes, severe weather patterns, collisions and earthquakes would be taken into account during the design stages. In addition, safety factors and benchmarked design parameters would also be considered.

In the absence of an independent national engineering office, there is no investigation that has been pursued to date; no review of original design parameters and therefore, the problem is guaranteed to occur again in the future.

Figure 6: Impact of flash floods in Johannesburg, 2016

3.5 Sasol Explosion in Secunda 2004

It was during Sasol's plant outage in September 2004, undergoing planned maintenance and there were several contractors on site when the blast occurred. Earlier indications pointed to a gas cloud that preceded a blast that resulted in the fire. Several people were injured and 2 died from this incident.

Except within the internal structures of Sasol, there is no investigation report that is available in the public domain or within the engineering fraternity. It is our submission that engineering-related infrastructure failures, whether managed under private or public ownership, need to be thoroughly investigated, reported on by an independent engineering office.

Figure 7: Sasol plant, Free State

4. Infrastructure Programmes in South Africa

The one recognizable characteristic of a growing economy is the size of the infrastructure that is in the strategic radar of national government. What is the size of infrastructure being considered for development by the South African government? The next 2 sections of this paper attempt to provide answers to this question.

4.1 Infrastructure Development Model

Large-scale infrastructure projects are largely driven by national government and cut across all spheres of government. The custodianship of state-driven infrastructure projects lies with state-owned entities (SOE's) and national government departments in most instances. The SA government has identified more than 30 large-scale infrastructure projects that serve a specific purpose and passes all the key criteria in social, economic and technological tests ("Strategic Integrated Projects" or SIPs). The PICC (Presidential Infrastructure Coordination Commission) is the main body tasked with project oversight and delivery in line with government strategic objectives.

4.2 How is Infrastructure Development Funded?

South Africa's Infrastructure Investment Plan has been fairly successful in attracting investment and even signing MOU's with several investment houses including international institutions.

Figure 8: Key players in funding infrastructure projects in SA (Source: Dept of Infrastructure)

4.3 What are the various SIPs?

The National Infrastructure Plan 2050 ("NIP 2050") seeks to create a foundation to achieve the NDP's vision of inclusive growth and sustainable job creation. The NIP 2050 identifies the most critical actions needed for sustained improvement in public infrastructure delivery.

Figure 9 presents a list of Strategic Infrastructure Projects that have been approved to advance to development phase.

SIP 1	Unlocking the Northern Cape Mineral belt with Waterberg as the catalyst	SIP 10	Electricity Transmission and Distribution for all
SIP 2	Durn-Free State-Gauteng logistics & industrial corridor	SIP 11	Agri-logistics and rural infrastructure
SIP 3	South-eastern node & corridor development	SIP 12	Revitalisation of public hospitals and other health facilities
SIP 4	Unlocking the economic opportunities in North West Province	SIP 13	National School Build programme
SIP 5	Saldanha Northern Cape development corridor	SIP 14	Higher Education infrastructure
SIP 6	Integrated municipal infrastructure project	SIP 15	Expanding access to communciation technology
SIP 7	Integrated urban space and public transport programme	SIP 16	SKA and MeerKat
SIP 8	Green energy in support of the South African economy	SIP 17	Regional integration for African cooperation & development
SIP 9	Electricity Generation to support socio-economic development	SIP 18	Water & Sanitation infrastructure Master Plan
SIP 19	Ecological infrastructure for water security	SIP 28	PV and wateer savings on government buildings programme
SIP 20	Energy Sector - risk mitigation	SIP 29	Comprehensive urban management programme
SIP 21	Transport: Road upgrading of key corridors N1, N2 and N3	SIP 30	Digitising of government information
SIP 22	Space infrastructure hub - SANSA	SIP 31	Innovative building materials & removal of alien vegetation
SIP 23	Agriculture & Agro-processing	SIP 32	National upgrading support programme
SIP 24	Human Settlements	SIP 33	Solar water initiatives
SIP 25	Rural bridges "Welisizwe" programme	SIP 34	Student accommodation
SIP 26	Rural Roads upgrade programme	SIP 35	SA Connect
SIP 27	Upgrading & repair of township roads in municipalities	SIP 36	Salvoko Precinct

Figure 9: List of Strategic Infrastructure Plans (Source: PICC & DPW)

The graphs below provide more detail on selected infrastructure projects: SIP 24, SIP 20, SIP 23 and SIP 21.

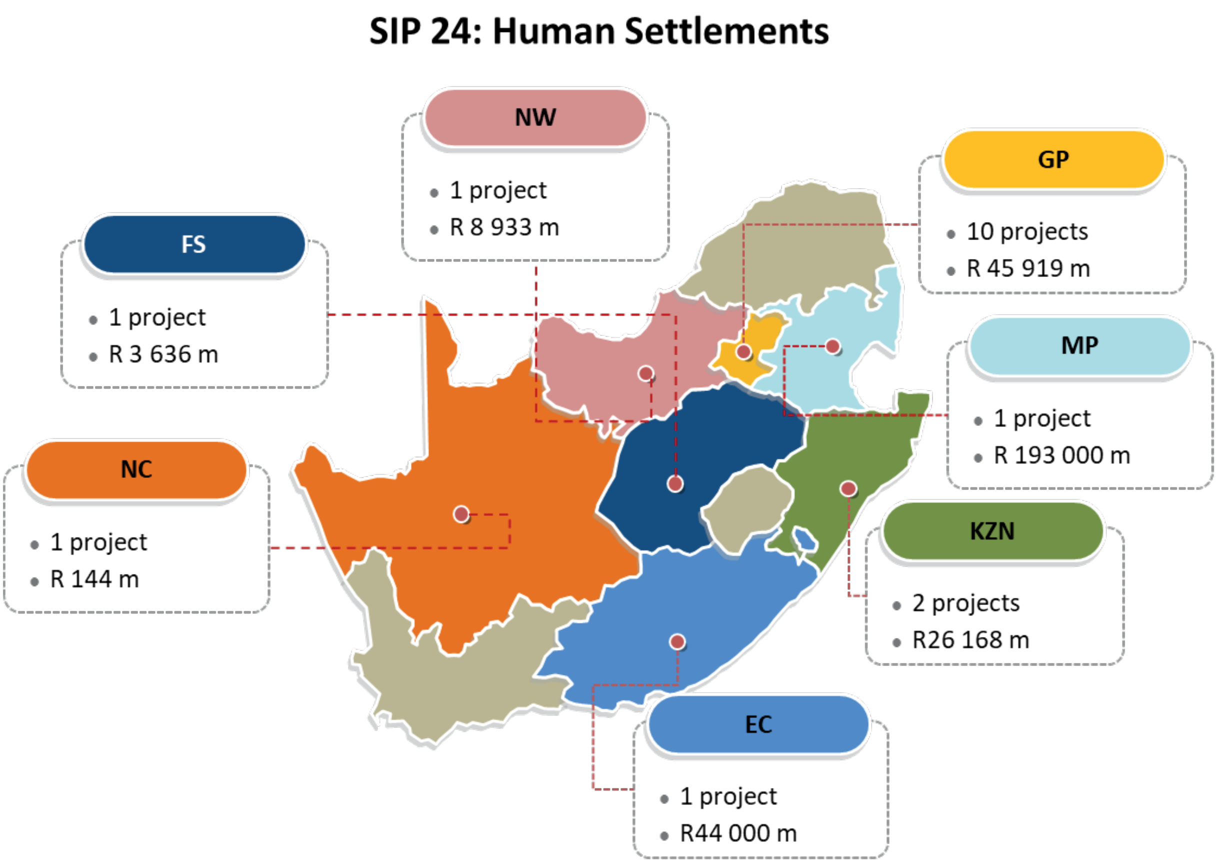


Figure 10: SIP 24 breakdown by geography (Source: PICC & DPW)

SIP 20: Energy Sector - Risk Mitigation	
Emergency Risk Mitigation IPPP (2 000MW)	R 50 000
Embedded Generation Investment programme	R 6 400
Small IPP IPPP (1 000MW)	R 1 800
	R 58 200

SIP 23: Agriculture & Agro-processing	
Marina Tilapia industry (EC)	R 5 124
Natural dehydrated foods (MP)	R 2 320
	R 7 444

SIP 21: Transport - road upgrading of key corridors N1, N2 & N3

NC	
Boegoebaai Port & Rail	R 13 000
	R 13 000

FS	
N3 New alignment via De Beers Pass	R 9 300
N1 Winburg Interchange to Winburg Station	R 417
N1 Ventersburg to Kroonstad	R 704
	R 10 421

LIMPOPO	
N1 Polokwane Eastern Ring Ph-2	R 697
N1 Musina Ring Road	R 651
	R 1 348

KZN	
N2 EB Cloete Interchange	R 3 987
N3 Marianhill Toll Plaza to Key Bridge	R 2 132
N3 Ashburton Interchange to Murray Road	R 1 982
N2 Edwin Swales to EB Cloete Intc	R 1 968
N3 Paradise Valley to Marianhill Toll Plaza	R 1 926
N3 Dardenelles to Lynfield Park	R 1 679
N3 Cato Ridge to Dardnelles	R 1 632
N2 Mtunzini Toll Plaza to Empangeni T-junction	R 1 152
	R 16 458

NATIONAL	
Small harbours development	R 6 000
	R 6 000

Figure 11: Breakdown of SIP 21, 22 and 23 (Source: PICC & DPW)

5. The Case for Engineer General

5.1 Existing Generals in South Africa

South Africa already has Auditor General, Surveyor General and Statistician General, whose roles are primarily concerned with record preservation, discipline-specific research, supervision and control of discipline competencies and providing authentic reports for public consumption and policy direction, within their areas of jurisdiction. The common character amongst these offices is that they produce reliable, authentic data and reports that guide national decision-making and stand as the pillar of support and assurance within each specific discipline.

The Engineering profession is at the very core of all infrastructure development projects, service delivery assets and public goods that involve billions of rands. However, we currently still do not have an independent Engineering Office, recognized in law and responsible for all engineering matters. In the sections below, we explore some of most compelling reasons why the Engineer General in South Africa is long overdue.

5.2 The Sheer Size of Infrastructure Projects in South Africa

While the road ahead is still long, South Africa has developed solid infrastructure over the last millennium. Numerous mega projects are planned for the near-future as captured in the Strategic Infrastructure Projects (SIPs) that have increased from 18 to 36 in the last 8 years.

As at June 2020, the estimated total investment value was R2.3 trillion with a funding gap of more than R500 million. Needless to say, the ravaging impact of COVID-19 has stalled some of the projects and exerted negative pressure on funding already secured.

The sheer size of South Africa's planned infrastructure projects calls for the role of the Engineer General to oversee the engineering aspect and offer technical assurance to investors.

5.3 Assurance to Investors and Governance

Large infrastructure projects are typically funded by both local and international funding institutions. International funders such as The World Bank, International Finance Corporation (IFC), *Kreditanstalt fur Wiederaufbau* (KfW) and *Agence Francaise de Developpement* (AFD) place onerous governance protocols on South Africa as the borrower, not only through finance covenants but also on technical aspects.

The role of the Engineer General would offer the much-needed assurance to investors in terms of technical competency and oversight.

5.4 Past Failures of Infrastructure Projects

South Africa has witnessed devastating infrastructure failures including gas explosions in gold mines, fatal bridge collapses, oil refinery explosions and many others. It is in the interest of investors, business community, the engineering fraternity and the general public to understand the root-causes that led to such catastrophic failures. The Engineer General of South Africa must play this role by conducting swift and meticulous investigations aimed at determining root-causes and recommend improvements in policy, standards and practices. In this instance, the role of the Engineer General can be likened to the mandate of the National Transportation Safety Board which investigates every civil aviation accident in the United States.

Still today there is no publicly available engineering analysis report that details the flaws that caused the Grayston Bridge over M1 highway to collapse and fatally injure two people. The root-cause for frequent failures of boiler units at Eskom's Medupi power stations remains a mystery at least in the eyes of the general public and the engineering fraternity.

The Office of the Engineer General would play a pivotal role as the source of irrefutable investigating authority to uncover shortcomings in the engineering of infrastructure projects and prevent further catastrophic failures whilst also ensuring that new projects follow proven engineering practices.

5.5 Engineering Expertise

The current energy crisis in South Africa has given rise to a new phenomenon wherein commentators with questionable credentials and experience in energy matters, present themselves as the industry experts. Also fiercely contesting the same space of self-proclaimed experts on engineering affairs, is the non-governmental organizations (NGO's) who hold specific interests on industry developments.

The vacuum in national leadership and oversight of engineering matters is the epicentre of this new phenomenon.

As a practical example, the overarching engineering opinions on renewable energy projects have been shaped by investors and groupings representing the interests of investors. The implication is that policy makers are likely to concede to the dominant opinions which may be biased against the greater good of the country or even against real-life experiences in other parts of the world.

The establishment of the Office of the Engineer General would solve these problems as the reliable, quantitative and unbiased source of opinion on all engineering matters of national interest.

5.6 Reliable Engineering Data

In South Africa, engineering data of national, public and professional significance resides with the project stakeholders only – the infrastructure project owner, original equipment manufacturers and engineering consultants. This state of affairs is responsible for the repeat grave technical errors and deficiencies in large infrastructure projects, wasteful expenditure and loss of technical lessons.

Once established, the Office of the Engineer General will act as the reliable and impeccable source of engineering data for all major projects and further enable design standardisation on similar projects.

5.7 Voice of Engineering

When faced with engineering challenges of national importance, policy-makers often resort to the formation of ad hoc committees. The composition of such committees is often founded on equal representation from various interest groups including labour, churches, industry associations and others.

As far as engineering challenges are concerned, the Engineer General will be more than capable to provide well-researched and objective assessments based on reliable technical principles as opposed to personal interests not backed by engineering facts.

5.8 Engineering Skills Outcome from Large Projects

South Africa has embarked and successfully completed mega projects since the 19th century, driven primarily by the State. The need and demand for engineering skills transfer is typically stipulated by the project owners as part of the bidding process. However, enforcement of such stipulations tends to be weak in addition to a weak penalty system for non-compliance by the winning bidders. Consequently, large-scale engineering projects are undertaken and completed with no attention to engineering skills development.

Our submission is that the only entity that will hold unwavering interest in nurturing and development of engineering skills from large projects is the Office of the Engineer General. To this end, we envision the Office of the Engineer General offering lectures and written material as part of review of large engineering projects.

5.9 Operation & Maintenance of Engineering Infrastructure

It is common cause that the backlog on the maintenance of service delivery infrastructure is not only enormous but also growing every year. We envision that the Engineer General will investigate, inspect for compliance and propose technical solutions to policy-makers prior to disastrous failure of service infrastructure.

6. Operationalisation of the office of Engineer General

The position of an Engineer General must always be apolitical in nature and must be closely associated with infrastructure development. We propose that the legal powers of the Engineer General be derived from the provisions of Chapter 9 of the Constitution in the same manner as the Auditor-General ("Chapter 9 Institution").

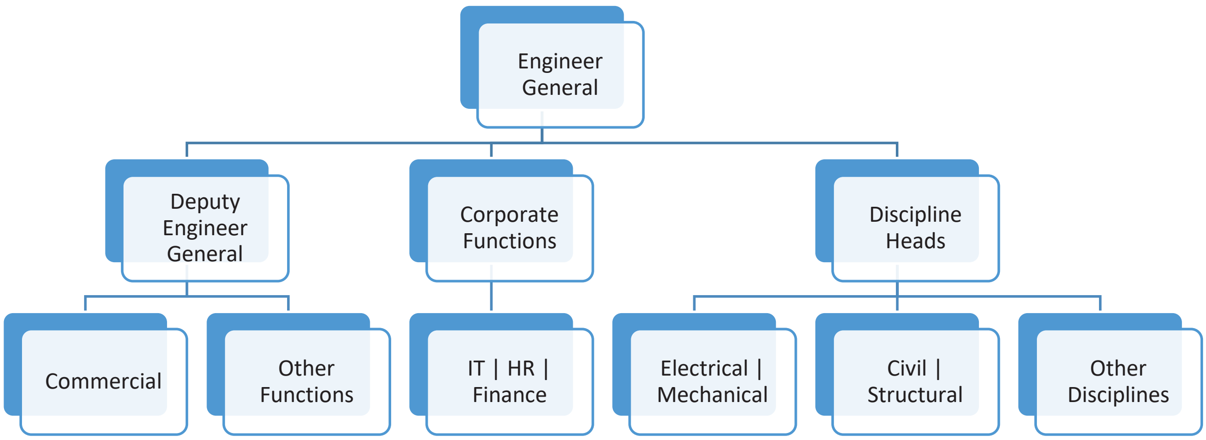
If accommodated within a specific national government department, the Office of the Engineer General would simply be engulfed with politics of that specific department and limited in operational scope. However, as a way to fast track the establishment of the office of Engineer General, we propose that it be housed within The Presidency whilst parliamentary processes start rolling.

LEGISLATION	*Chapter 9 of the Constitution ("Chapter 9 institution")*		
REPORTING LINE (Initial)	*The Presidency*	**REPORTING LINE (Final)**	*Chapter 9 Institution*
MANDATE	*The Engineer General will be the supreme institution for engineering data, oversight, inspectorate and engineering knowledge preservation, established in law.*		

POWERS AND FUNCTIONS	*The Powers and Functions of the Engineer General are to be established in the relevant legislation (proposing Engineer General of South Africa Act). Some of Engineer General's functions will include:*	
	(1)	*Certifying design competency for all mega projects undertaken in South Africa. To be enforced at Project Design as well as Project Completion through certification.*
	(2)	*To act as the most reliable source of engineering data for all mega projects undertaken in South Africa*
	(3)	*Investigating failures of public and private infrastructure projects including enforcement of adopted solutions and referral to other relevant government institutions for further action.*
	(4)	*Enforce development of technical skills on all large-scale projects in line with original commitment by winning bidders*
	(5)	*To protect integrity of the Republic by providing assurance to investors and project owners that the technical engineering of large projects will be evaluated by Engineer General and certified as competent, complete and accurate.*
	(6)	*To provide well-researched technically sound opinions on matters of national importance to inform policy making.*
MISSION	*The Engineer General will hold a Constitutional Mandate and will exist to strengthen our country's democracy by assuring technical competency on all large-scale projects undertaken in South Africa both by government and private sector.*	

ENFORCEMENT OF THE ENGINEER GENERAL'S FUNCTIONS	
EGSA Project Design Certificate	*Technical design has been scrutinized and found to be sound and competent*
EGSA Project Completion Certificate	*The Project has been tested and commissioned according to the original design*
Investigation Reports	*Potential high-risk infrastructure, non-compliant infrastructure and failure of service infrastructure*
EGSA Certification in Bid Proposals	*Assurance provider to national government and project sponsors for large-scale projects.*
Payment Milestones	*Payment for mega projects for technical design and completion to be linked to Engineer General certificates*

ORGANIZATIONAL STRUCTURE



7. Conclusion

During the medium-term expenditure framework (MTEF) of 2020/21 to 2022/23, South Africa spent R815 billion on infrastructure including Energy, Water & Sanitation, Human Settlements, Transport & Logistics, Education, Health and other economic sectors. Due to its good infrastructure and several other factors, South Africa is recognized as the largest and the most developed economy in sub-Saharan Africa.

During the budget speech of February 2023, the consolidated government spending was set at R7.1 trillion for the period FY2023/24 to FY2025/26. All national government economic growth policies are anchored on infrastructure development including Maritime Transport Policy, NDP 2030, Mining Charter 2018, Integrated Energy Plan, National Water Resources Strategy, AgroForestry Strategy Framework and several others.

At the epicentre of economic development, infrastructure development and national progress lies the engineering know-how. The depth of engineering skills and technical engineering of infrastructure have a direct upside on business confidence, assurance to investors and quality of life.

While it is commendable for the South African national government to invest in economic and public infrastructure, it is common cause that there is no single point of accountability when it comes to reliability of engineering skills and technical competence on infrastructure development. In this paper, we make the assertion that the Office of Engineer General is the missing cornerstone of infrastructure development in South Africa.

In this submission, we have drawn attention to the need for the South African government to establish the Office of Engineer General. We further submit that the Engineer General is to be envisioned as the single office of accountability and the voice of engineering wisdom for all engineering matters concerning private, public, social and economic infrastructure. wn

The benefits of the REIPPPP have the potential to extend even further

Touted as one of the world's best renewable energy tenders, South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has paved the way for the private sector and Independent Power Producers (IPPs) to invest in the country's renewable energy market. However, there could be an additional benefit that may not have been considered as of yet, says Nato Oosthuizen, Partner and Renewable Energy Expert at BDO.

BY | Nato Oosthuizen
BDO Energy Expert

Since its inception in 2011, REIPPPP has enabled 89 IPPs to provide a steady stream of over 6000MW of renewable energy to the country. With expectations that energy procured in Bid Windows 3 and 4 will bring a further 100MW and 75MW online in 2024, and with three projects under Bid Window 5 having started construction with an investment value of over R12 billion, we may not be exactly on target, but progress is certainly positive.

But while the country waits – often in increasingly higher stages of darkness – for these projects to reach completion, is there not perhaps an opportunity to shed some light on the local communities where construction is taking place, instead of shedding more of the load?

As part of the REIPPPP bid process, approved IPPs are tasked to contribute towards local community development through socioeconomic and enterprise development, local ownership and local job creation. These requirements have to be fulfilled within a 50km radius of the project and oblige renewable energy companies to engage with the developmental opportunities and needs of communities around their project sites.

Awarded projects are required to spend a certain amount of their generated revenue on Socio-Economic Development (SED) and Enterprise Development (ED) and share ownership in the project company with local communities.

The most critical aspect of the SED and ED element is that initiatives should result in the sustainable economic participation by its intended beneficiaries and discourage perpetual dependence on hand-outs. Many times this simply doesn't happen as initiatives may start off successfully but then dry up as donations get used towards overhead structures or the initiative simply doesn't have staying power and eventually fizzles out leaving communities high and dry.

THE MAJOR IMPACT OF MINI GRIDS

The majority of REIPPPP projects are being implemented in rural areas that are primed with natural resources such as solar or wind. What if, instead of the revenue going to various SED and ED initiatives, the government mandated this money to be specifically spent on electricity related projects within the community – such as building mini grids that supply power to the community. This would result in many of the country's most vulnerable being able to reap the immediate and long term benefit of access to electricity, and become active participants in their own economic freedom.

How? Project development teams have specific skills in creating power

generating facilities and could probably negotiate a good price with the engineering, procurement and construction (EPC) contractor that is building their own plant. That EPC contractor can then build a smaller plant at the same time in the rural communities and the project can claim the costs back from the ED or SED fund. This way the development of mini grids can be pre-funded and accelerated by experienced individuals. Furthermore, the annual operation and maintenance (O&M) of these grids can be maintained by the same O&M provider that services the primary project.

To take it one step further, local community members could be trained to maintain, run and even provide security for the mini grid which would substantially increase skills development and drive local job creation. This approach would provide an opportunity for those who have the competence to become a much larger player in the solution through a two-pronged approach that creates a sustainable renewable energy source, and empowers a local community at the same time.

Probably the most compelling why this approach should be considered is the fact that IPPs are signing a 20-year contract that locks them in to the community for the long term. These are not fly by night initiatives that are swooping in, giving a hand out and then disappearing. These are institutions that have the skill, the staying power and the funds to impact the power crisis by being part of the solution.

PRACTICAL EXAMPLE:

Assume the development of a 100MW solar project where a community trust would be granted a 5% funded shareholding and 2.5% of revenue would be paid to SED/ED contributions for local development.

Rather than giving 5% funded shareholding, construct a 5MW (5% of 100MW) solar plant close to the local community. The funding and repayment of this project costs would be funded by the main project, as it would be allowed to still build a full-size plant of 100MW and earn 100% of the return thereon, rather than having a lower percentage shareholding in the total project. The O&M cost, Insurance, Security, Management fees etc. for running the project can also be paid for by the main project, substituting the payment of previously committed SED/ED costs. The synergies that can be obtained through this cost absorption makes it feasible for a smaller size project to be financially and technically viable.

The ownership of the project can be housed in a Non-profit Organisation. The electricity (or excess) generated by this plant, if not used by the community, can be sold to the local community, municipality or industry at discounted prices with the proceeds of this being used for community projects (i.e. SED/ED type projects). Hence, the community will directly benefit again by paying for electricity (even at reduced prices).

If we have the power to harness resources that spark self-sufficiency, shouldn't we be exploring every way possible to find solutions that can be felt sooner and last exponentially longer? wn

South African Institute of Electrical Engineers

114 YEARS 1909-2023 SAIEE

MEMBERSHIP FEES EFFECTIVE 1 DECEMBER 2023

The Council meeting held on 1 September 2023 approved subscription & entrance fees as from 01 December 2023 as per schedule indicated below.

PLEASE NOTE: In terms of Bylaw 3.2 annual subscriptions are due on 1st December 2023

MEMBERSHIP FEES CAN BE PAID IN MONTHLY RECURRING PAYMENTS

Council agreed to a discount for fees paid before 31 March 2024. Members are therefore encouraged to pay promptly to minimize increase impact.

Grade of Membership	Annual Subscriptions paid before 31 March 2024		Annual Subscriptions paid after 31 March 2024		New Members FEES * see Notes 1 & 4 below.	
	RSA incl VAT (R)	Outside RSA excl VAT (R)	RSA incl VAT (R)	Outside RSA excl VAT (R)	RSA incl VAT (R)	Outside RSA excl VAT (R)
Student	173	150	208	180	208	180
After 6 yrs study	1 800	1 565	2 160	1 878	2 160	1 878
Associate	1 800	1 565	2 160	1 878	2 160	1 878
Member	1 989	1 730	2 387	2 076	2 387	2 076
after 6 years	2 325	2 021	2 789	2 426	2 789	2 426
after 10 years	2 433	2 116	2 919	2 539	2 919	2 539
Senior Member	2 433	2 116	2 919	2 539	2 919	2 539
after 6yrs/age 40	2 637	2 293	3 164	2 751	3 164	2 751
Fellow	2 637	2 293	3 164	2 751	3 164	2 751
Retired Member (By-law B3.7.1)	1 118	972	1 342	1 167	n/a	n/a
Retired Member (By-law B3.7.3)	nil	nil	nil	nil	n/a	n/a

1. The fee for all new applications is R3337.00 which includes an entrance fee of R950.00. On election to the applicable grade of membership the new member's account will be adjusted accordingly and refunds/additional payment made on request. Entrance fee for Students is free and new Student applicants require payment of R208.00.

2. Transfer fee to a higher grade is free for all grades of membership.

3. Members are encouraged to transfer to a higher grade when they qualify. It will be noted that the fees of Member and Senior Member grades after 10 and 6 years respectively are equal to the fees of the next higher grade.

4. Members elected after May 2024 pay a reduced subscription fee.

5. By-law B3.7.1 reads "Where a member in the age group of 55 to 70 years has retired from substantive employment in the engineering profession, such member may make written application to Council for recognition as a retired person and a reduced membership fee".

6. By-law B3.7.3 reads "any member complying with the conditions of B3.7.1 but who has been a member of the Institute for not less than 25 consecutive years, shall be exempt from the payment of further subscriptions." Members who comply with the requirements of By-Law B3.7.3 may make written application to Council for exemption from paying subscriptions".

7. By-law B3.9 reads "any member in good standing who has been a member for fifty (50) consecutive years shall be exempt from the payment of further subscriptions."

8. Members not in good standing by failing to pay their subscriptions by end of June of each year will, subject to Council decree, be struck-off the SAIEE membership role.

9. Members in good standing and no longer in substantive employment and do not receive payment or salary for work done may apply to Council for a reduction in their annual subscriptions.

10. The members monthly magazine ("wattnow") is available on line and members who require a hard copy may acquire same on request and for a nominal fee subject to minimum uptake numbers.

11. Members who wish to pay their membership fees in recurring payments should activate the payments on their banking portal. Members will receive the early bird discount only if their fees are fully paid by 31 March 2024.

2023 SAIEE MEMBER BENEFITS

STUDENT MEMBER

- Jobs portal for WIL
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres

ASSOCIATE MEMBER

- Jobs portal access
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres

MEMBER

- Jobs portal access
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Long standing member gifts
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres

SENIOR MEMBER

- Jobs portal access
- Services Directory
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Long standing member gifts
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres
- Eligibility for nomination as Center Chair

FELLOW

- Jobs portal access
- Services Directory
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Long standing member gifts
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres
- Eligibility for nomination as Center Chair
- Eligibility for nomination as an Office Bearer

MEMBERSHIP UPGRADE DISCOUNT STRUCTURE

LENGTH OF MEMBERSHIP	DISCOUNT UPON UPGRADE
10 - 19 years	5%
20 -39 years	10%
40+ years	15%

SAIEE

Become a member today and start earning the rewards!

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DEPUTY PRESIDENT

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JACOB MACHINJIKE
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Western Cape Centre
Chairman | Heinrich Rudman
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SEPTEMBER 2023

05/09/2023	Blockchain and Money
06/09/2023	High Voltage Measurement and Testing
07/09/2023	KZN Centre site visit: Conlog | Durban
12/09/2023	72nd BP Lecture | Power Quality | Senate Room, Wits University
13/09/2023	Select, Maintain & operate your Rotating Electrical Machines like a Pro
13/09/2023	72nd BP Lecture | Power Quality | KZN Centre
14/09/2023	Anatomy of Wind Turbines
20/09/2023	Fundamentals Of Developing Renewable Energy Plants
20/09/2023	Webinar: Fibre Optic Sensors for Nuclear Reactorsand ATLAS-CERN Detectors
21/09/2023	Writing Good Technical Specifications
26/09/2023	Road to Registration
26/09/2023	Fundamentals of Power Distribution

OCTOBER 2023

01/10/2023	Smart Mobility Africa Summit | Gallagher Convention Centre | Midrand | JHB
03/10/2023	New Engineering Contract (NEC)
04/10/2023	Power Systems Protection
04/10/2023	Transformer Construction, Operation, Maintenance, Testing and Protection
10/10/2023	Hack Lab
10/10/2023	Legal Liability: Mine Health and Safety Act
17/10/2023	SANS 10142-1 -Edition 3
24/10/2023	Substation Design and Equipment Selection
24/10/2023	Project Management for Engineers
31/10/2023	Technical Report Writing

Section & Chapter, Centre Events   SAIEE Academy Online Training   SAIEE Academy Classroom Training