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GIBELA

2022 / 2023 ANNUAL REPORT

Gibela Engineering Research Chair at Stellenbosch University


CAPE TOWN
LAKESIDE
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CONTENTS

1 - A PROSPECTUS ON PASSENGER RAIL

Figure 1: The digitalized passenger rail system of the future will innovate and uplift train operations, maintenance, and customer experiences.

Digitalization of the passenger rail industry heralds an era that promises to revolutionise train operations, maintenance, and customer engagement. These new innovative rail services are poised to deliver smart, interconnected, and customer-centric experiences. The industry is witnessing the emergence of key digital trends, including the evolution of smart rolling stock, advanced maintenance strategies leveraging real-time data, the integration of digital twin (DT) technology for unparalleled operational insights, automation and artificial intelligence for efficient condition monitoring, stringent safety and compliance measures through advanced technologies, and the elevation of the passenger experience with digital solutions. These advancements are not just reshaping how rail services are delivered but are setting new benchmarks for efficiency, safety, and customer satisfaction in the future.

1.1 SMART ROLLING STOCK

Digitalization will turn rail assets into “smart” assets. Train sets, rail infrastructure and users will become increasingly connected through the “Internet of Things”. This allows the sharing of real-time data about the asset’s status, health and performance. Trends towards the increased availability of data with coupled use of virtual models (data-driven, physics-based or hybrid) enable a digital visibility which places advanced, cutting edge knowledge at the disposal of decision-makers.

The state, context and/or behaviour of the asset may be mirrored in a digital environment to stakeholders, who may be physically removed from the immediate proximity of the asset, to offer hindsight, insight or foresight to understand asset performance in the operational part of the lifecycle.

1.2 ADVANCED MAINTENANCE STRATEGIES FROM DATA

Uncertainties, associated with emergent asset behaviour can be reduced through increasingly prompt and accurate information on the real-life operational conditions, loads, and operational responses. The increased availability of sensor technologies enables detailed monitoring of vast asset fleets, at increasingly prompt timescales to facilitate asset health management specific to individual asset operational environments. This unleashes the potential to progress a rail fleet to peak efficiency and reliability.

1.3 THE ROLE OF DIGITAL TWINS IN RAIL MAINTENANCE

Digital twin (DT) technology entails the digital reflection of the state and behaviour of a real asset within its operational context for better decision support. This concept may evolve to directly process sensor inputs from live asset operations through digital models to determine critical quantities of interest or to detect and diagnose asset failures. Data trends may be exploited through a wide range of modelling approaches (data-driven, physics-based, or hybrid) to create prognostic forecasts of likely failure horizons or failure outcomes.

1.4 AUTOMATION, AI, AND ENHANCED CONDITION MONITORING

Living DT solutions potentiate the automation of manual, repetitive tasks that require impartiality and relentless vigilance. From this viewpoint, certain maintenance inspections may be performed automatically and consistently in dangerous conditions and with increased frequency than is humanly possible. The geographical independence of inter-connected dashboards enables remote operational interventions and inspections. Expertise may be more widely sourced or even softwarised in sophisticated diagnostics or algorithms. These diagnostics may even be tailored to specific assets or fleets which enhances predictive accuracy, potentiating a more responsive and adaptive maintenance regime.

1.5 ENSURING SAFETY AND COMPLIANCE THROUGH ADVANCED TECHNOLOGIES

Owing to digitalization, safety procedures and protocols can now be algorithmically implemented. This forces unequivocal compliance instead of relying on disciplined, non-deviating implementation by human operators. The relentless functioning of correctly implemented digital systems mitigates the risks associated with human error, such as fatigue or boredom, thereby enhancing the reliability and safety of rail operations. The digital records generated are crucial to post-incident analysis, for ensuring compliance with operational protocols and improvement of future asset designs.

1.6 ELEVATING THE PASSENGER EXPERIENCE WITH DIGITAL INNOVATIONS

The impact of digitalization extends to expectations of significantly improved passenger experiences. Real-time data and analytics will enable rail operators to offer more reliable and timely services, thereby meeting the evolving expectations of modern rail passengers. Passengers may experience digital service offerings including real-time updates on train schedules, services for assisted route planning or online ticketing. Train operators can expect the evolution of driver scoring systems and data-driven operational performance and compliance checks.

Digitalization of the passenger rail industry marks a pivotal shift towards a future where efficiency, safety, and customer satisfaction are significantly enhanced. This digital transformation, while complex, offers a pathway to unparalleled insights, predictive maintenance, and a new level of service reliability. As the industry continues to navigate this digital journey, it remains imperative to balance innovation with the evolving expectations of passengers and regulatory requirements. Ultimately, the successful integration of these digital trends will not only redefine the operational landscape of rail services but also dictate the training requirements for future personnel. Skilful digital implementations will drive the reliability and value of resilient, sustainable, and customer-focused digital services which will define success in the future passenger rail industry.

2 - SPONSOR REMARKS

As the Sponsor of the Gibela Engineering Research Chair (GERC) at Stellenbosch University, it gives me immense pleasure to present this comprehensive report, which reflects on our journey since the establishment of the Research Chair in 2022. This report is not just a reflection of our activities and achievements; it is a testament to the vibrant synergy that can be achieved when academia and industry come together for a common purpose.

The relationship between academia and industry is pivotal, offering a fertile ground for innovation, practical problem-solving, and the advancement of knowledge. The establishment of the GERC was a strategic move towards ensuring that engineers are not only armed with theoretical insights but also with practical, hands-on experience that addresses real-world challenges, particularly in the ever-evolving rail industry. We are proud of this partnership that does not only address our rail-related skills development training pillars but also introduces our young people to what the future of rail will look like.

Our partnership with the Stellenbosch University has been instrumental in this endeavour. Together, we have created an ecosystem that nurtures talent and fosters research that is not only academically rigorous but also industrially relevant. This report will introduce you to the fruits of this collaboration: the student projects, Master's research projects, and PhD projects that are shaping the future of railway engineering.

Equipped with a strong sense of social responsibility, the GERC has not only focused on technological advancement but has also actively addressed social issues linked to rail safety. The outreach programmes in schools near railway tracks have been a cornerstone of our commitment to community engagement, creating awareness about rail safety and inspiring a new generation to consider engineering as a viable and exciting career path.

The research and development showcased within these pages are a reflection of our responsiveness to the challenges and opportunities that lie within the rail space. You will find detailed accounts of our publications, workshops, and the contracted projects that have solidified the bond between Stellenbosch University and Gibela Rail.

As we share our insights and experiences, it is heartening to see how our partnership has thrived, contributing to South Africa's rich railway history. Our collaborations with the National Department of Transport and the Railway Safety Regulator are a clear indicator of the significance of our work and its impact on the national stage.

I invite you to delve into this report and explore the myriad ways in which the Gibela Engineering Research Chair is making a difference. It is a showcase of dedication, innovation, and an unwavering commitment to excellence in the field of railway engineering.

May this report serve as a beacon of inspiration for continued collaboration between academia and industry, and may it pave the way for even greater achievements in the years to come.

DR BUYISWA MNCONO-LIWANI
Corporate Services and Traction Motors Operation Executive
Gibela Rail Transport Consortium


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3 - EXECUTIVE SUMMARY

The Gibela Engineering Research Chair (GERC) at Stellenbosch University (SUN) aims to create a niche in monitoring applications and asset management technologies for Gibela's X'Trapolis Mega passenger trains by leveraging the potential of digital twin technology. To this end, this research group pursues multi-disciplinary engineering topics that foster rail expertise and innovation through a faculty-wide effort. The ethos of the Chair mimics the Gibela brand persona, which is people-centric, optimistic, and future-focused whilst striving for uncompromised precision towards impacts in the local and international ambit of rail research.

The key duties of the GERC are measured in terms of research excellence, training impact and academic leadership. As such, the duties of the Chair entails:

1. The pursuit of high-quality research with the scope to support Gibela in their aim to offer safety, comfort, speed, and reliability for rail commuters on its new trains.
- The GERC is responsible to recruit and develop a high-profile team of research staff and postgraduate students.
- Publish high-quality research articles and reviews in international and local peer-reviewed academic journals and conferences.
- Leverage the financial investment of Gibela to attract additional funding to strengthen the Chair through equipment, personnel, and infrastructure.

2. To train engineers with the necessary skills and knowledge to perform work and research in the rail industry.
- The GERC is responsible to formulate appropriately scoped student projects on a faculty-wide scale.
- The Chair arranges supervision, coordinates project logistics and assesses project outputs at undergraduate and postgraduate level.
- The GERC plans and delivers innovative, research-led projects and taught modules.
- The Chair initiates short- and long-term capacity building initiatives for students and industry, including professional development.

3. To provide academic leadership to the faculty and industry.
- The GERC should keep abreast of rail developments and contribute a strategic vision and outlook on emerging technology.
- Research results should be disseminated to a wide audience by organising and participating in workshops, seminars, and conferences.
- The Chair promotes and arranges outreach projects to stimulate young learners to increase awareness on rail transport and careers in engineering.

4. To assist Gibela in solving engineering problems.
- The GERC offers consultation to Gibela on commercial projects under a separate sub-agreement.

PROF ANNIE BEKKER

4 - GIBELA ENGINEERING RESEARCH CHAIR TEAM

Table 1: Gibela Engineering Research Chair Team

	NAME	DESIGNATION	ROLE
	**Prof. Annie Bekker**	**Research Chair**	Annie Bekker is a professor in the Department of Mechanical and Mechatronic Engineering. She is registered as a Professional Engineer with ECSA and is a NRF C2 rated researcher. She is responsible for the strategic and academic development of the GERC.
	**Pieter Conradie**	**Chief Chair Engineer**	Pieter Conradie supports Chair activities through his earlier experience with the PRASA Chair in Rail Engineering at Stellenbosch University. As an internationally registered professional engineer with ECSA he leads the GERC Professional Development Programme to foster the next generation of engineering professionals at Gibela.
	**Michael Perumal**	**Senior Chair Engineer**	As former employee of Gibela, Michael Perumal brings insight and relational knowledge of Gibela to the GERC. His role ensures logistical, technical and practical support for student projects in terms of safety, equipment and expertise.
	**Dr David Ellis**	**Post-doctoral Fellow**	As post-doctoral fellow, David Ellis is responsible to progress research and academic depth of the GERC. This includes student mentorship, the in-depth pursuit of research questions, development of practical rigs and writing articles for publishing in academic or industrial literature.
	**Olabanji Asekun**	**Social Operations**	Olabanji Asekun assists with project management and undertakes the hosting and all organisational aspects of the GERC social impact events. His expertise further serves audio-visual support and connectivity during Gibela seminars.
	**Susan van der Spuy**	**Finance & Admin**	Susan van der Spuy facilitates payments, financial reporting and travel bookings for all activities related to the GERC.

5 - STEERING COMMITTEE

The GERC is governed by a Steering Committee, which is a properly constituted governing body with fiduciary powers over the Research Chair. The committee comprises employees of Stellenbosch University and Gibela Rail Transport Consortium with the purpose of advising on strategy for the Research Chair and approving the strategic plans presented by the Research Chair Holder.

Table 2: Steering Committee of the Gibela Engineering Research Chair.

COMMITTEE MEMBERS	ROLE	ORGANISATION
Sipho BAMBISA	Steering Committee Chairperson	Gibela Rail Transport Consortium
Nitesh MUNILALL	Industry Technical Advisor	Gibela Rail Transport Consortium
Pholoso KGASOANE	Junior Work Package Controller	Gibela Rail Transport Consortium
Karabo SERUNYE	Economic Development Advisor	Gibela Rail Transport Consortium
Prof Annie BEKKER	Research Chair Holder	Stellenbosch University
Prof Petrie MEYER	Vice Dean - Research and Industry Liaison	Stellenbosch University
Prof Herman ENGELBRECHT	Departmental Head	Stellenbosch University
Pieter CONRADIE	Administrative Support	Stellenbosch University
Tsholofelo MOKOLOPO	Scribe	Gibela Rail Transport Consortium

The Chair agreement mandates quarterly meetings of the Steering Committee. Following the recruitment process, the Research Chair Holder was appointed in August 2022. The dates and locations of formal meetings are noted in Table 3.

Table 3: Date and location of GERC Steering Committee meetings.

DATE		LOCATION
6 September 2022	Introduction of newly-appointed Research Chair Holder, Annie Bekker, at Gibela Manufacturing Plant.	Dunnottar, Gauteng
17 October 2022	Steering Committee Meeting	Online
16 January 2023	Pieter Conradie joins as administrative support for Stellenbosch University.	Online
23 February 2023	Introduction of Nitesh Munilall who replaces Mercy Tshivhilinge as Industry Technical Advisor to the Chair.	Stellenbosch, Western Cape
5 May 2023	Steering Committee Meeting	Stellenbosch, Western Cape
20 September 2023	Introduction of Sipho Bambisa who replaces Joseph Mudau as Steering Committee Chairperson. Introduction of Karabo Serunye who replaces Joseph Mudau as Economic Development Advisor.	Dunnottar, Gauteng
23 November 2023	Steering Committee Meeting	Stellenbosch, Western Cape

6 - GERC STUDENT PROJECTS

The GERC is responsible for formulating appropriately scoped student projects on a faculty-wide scale. Undergraduate students work on GERC topics in their final year of study, on 1-year or 6-months projects. These projects are undertaken on an individual level in collaboration with an academic supervisor. The Chair offers more advanced projects on a postgraduate level for Masters (2 years) and PhD (3 years) candidates. Post-doctoral research fellows investigate advanced topics on a full-time basis after earning a PhD degree. For each topic, Gibela allocates an internal project champion.

Table 5 indicates that a total of 22 student projects were initiated in 2022/2023.
A total of 13 final year projects and two Master's studies have been successfully completed.

Table 4: Summary of final-year and postgraduate projects per Engineering department. Numbers in brackets indicate graduated students.

YEAR	FINAL YEAR				MASTERS			PHD	POSTDOC	TOTAL
	M & M	Industrial	E & E	Civil	M & M	Industrial	Civil	Industrial	M & M	
2022	3 (3)	3 (3)			1 (0)	1 (0)				8
2023	5 (5)	2 (2)			3 (1)	2 (1)		1	1	14
2024	6	2	1	2	4	2	2	1	1	21

Table 5: A summary of academic projects with the GERC.

#	TITLE	STUDENT	SUPERVISOR	DEPARTMENT	GIBELA PROJECT CHAMPION	FIRST YEAR OF REGISTRATION / (EXPECTED) COMPLETION
Final year projects						
1	Machine learning implementation for railway subsystem failure predictions	Nelisa Mabaso	Dr Sydney Kasongo	Industrial Engineering	Luca Lategan	2022/2022
2	Human behaviour on product safety	Chelsea van Heerden	Dr Philani Zincume	Industrial Engineering	Bennie de Ru	2022/2022
3	Modelling of a four-point rail car levelling system	Dauda Sheni	Dr Karel Kruger	Mechanical & Mechatronic Engineering	Dzunisani Simango	2022/2022
4	Using the X'Trapolis Mega trainset for rail track condition monitoring: track gauge	Louw Jacobs	Peter Blaine	Industrial Engineering	Mike Scrooby	2022/2022
5	Quantify, assess and improve the employee satisfaction levels for Gibela's engineering division	Tino Viljoen	Dr Philani Zincume	Industrial Engineering	Mike Scrooby	2022/2022
6	Simulating the performance of the X'Trapolis Mega	Wikus Venter	Prof Mike Owen	Mechanical & Mechatronic Engineering	Mike Scrooby	2022/2022

7	An optical rail wheel measuring solution	Anique Phillips	Pieter Conradie	Mechanical & Mechatronic Engineering	Chuma Ndzala	2023/2023
8	Whole-body vibration calculator for occupants of railway vehicles	Daniel du Toit	Prof Annie Bekker	Mechanical & Mechatronic Engineering	Nitesh Munilall	2023/2023
9	Development of a virtual realit technology welding simulator	Enrico Lubbe	Pieter Conradie	Mechanical & Mechatronic Engineering	Colin Motau	2023/2023
10	Warehouse optimisation	Jakes Oosthuizen	Dr Philani Zincume	Industrial Engineering	Bongeka Ko-bese/Luyanda Xorile	2023/2023
11	Using a model train to identify track defects	Gabriel Adonis	Pieter Conradie	Mechanical & Mechatronic Engineering	Not required	2023/2023
12	Optical based detection of railcar wheel flat spots	Daniel de Villiers	Pieter Conradie	Mechanical & Mechatronic Engineering	Tebogo Tease	2023/2023
13	Operators' safety and productivity in the rail maintenance environment: an ergonomic study	Wayde Francis	Dr Philani Zincume	Industrial Engineering	Dolly Mathebula	2023/2023
	Masters' research projects					
1	Development of a decision-support roadmap for performing a life cycle assessment of rail vehicles	Dirk Roux	Dr Wyhan Jooste	Industrial Engineering	Not required	2022/2023
2	An open-source digital image correlation software system in python	Ed Brisley	Prof Gerhard Venter & Pieter Conradie	Mechanical & Mechatronic Engineering	Not required	2022/2023
3	Investigating machine learning solutions to aid in railway rolling stock predictive maintenance efforts	Nelissa Mabaso	Prof Jacomien Grobler & Prof Annie Bekker	Industrial Engineering (Part-time)	Dolly Mathebula	2023/2025
4	Investigation of 2D multi-body track and train dynamics	Michael Perumal	Dr Brendon Nickerson & Prof Annie Bekker	Mechanical & Mechatronic Engineering (Part-time)	Nitesh Munilall	2023/2025
	PhD research projects					
1	A longevity escape velocity model for rail rolling stock	Pieter Conradie	Dr Wyhan Jooste	Industrial Engineering (Part-time)	Not required	2017/2024
	Post-doctoral Fellow					
1	Wheel flat detec-tion using HHT	Dr David Ellis	Prof Annie Bekker	Mechanical & Mechatronic Engineering	Not required	2023/2024

6.1 FINAL YEAR PROJECTS

6.1.1 MACHINE LEARNING IMPLEMENTATION FOR RAILWAY SUBSYSTEM FAILURE PREDICTIONS

Operational and maintenance data from 59 X' Trapolis Mega trainsets were investigated for two days, comprising 1022 features and 73509 records. Using Big Data techniques and the CRISP-DM process model, the study aimed to establish a baseline dataset. Through trend analysis, essential features were identified for modelling. Machine learning techniques such as decision trees, random forest, and others were applied to predict subsystem failures. Evaluation metrics such as accuracy and F1-score were used, with the random forest model emerging as the most effective, achieving 97.55% accuracy and F1-score.

The random forest model demonstrated low computational complexity, facilitating efficient data processing. Validation with Gibela affirmed the model's reliability, leading to actionable recommendations. This work demonstrates potential to leverage data analytics and machine learning for enhanced decision-making in railway operations, particularly as an avenue to advance predictive maintenance strategies. Encouraged by the results, the study suggests Gibela proceed with implementing machine learning for real-time subsystem failure predictions in operational scenarios, thereby potentially optimising operational processes and minimising downtime.

6.1.2 HUMAN BEHAVIOUR ON PRODUCT SAFETY

The primary aim of this study is to analyse the state of safety of Gibela by studying incident reports, and to determine the level of safety awareness, both from an organisational level as well as an employee level. A practical case study was undertaken to identify incident causes and to assess employee safety culture in order to propose improvements to enhance safety transparency. The work involved a literature review, data collection, site visits, and thematic analysis. Findings indicate effective accident reporting but inconsistent details. While a safety culture exists, concepts such as product safety and non-technical skills are misunderstood, overshadowed by technical emphasis. Training is proposed to bridge this gap and integrate safety into all processes.

Future research and recommendations emphasise mandatory safety training, specific to the rail context, highlighting non-technical skills and fostering open communication. Recommendations aim to mitigate accidents, considering rail company values and employee needs. Overall, the project underscores the importance of human behaviour and workplace dynamics in ensuring product safety, benefiting both society and the rail company by emphasising human dependency and workplace relationships.

6.1.3 MODELLING OF A FOUR-POINT RAIL CAR LEVELLING SYSTEM

The differential loading of rail cars results in non-level floor angles which are compensated for by a levelling process. On the X'Trapolis Mega train, levelling involves adjustment of the rods attached to levelling valves until a suitable setpoint is achieved, using a linear mechanism in a non-linear system. A model was developed to predict the displacement responses of a rail car and its active suspension from input deflections and floor angles.

The proposed model was validated through physical measurements during a levelling test scenario of a real trainset at Gibela Paarden Eiland Depot. Levelling tests on trains are scarce, leading to a limited understanding of the non-linear characteristics of the rail car air suspension and levelling valves. A four-point levelling model was proposed, controlling air spring pressure by adjusting rail car point heights. The proposed suspension model was not successful in capturing the levelling dynamics and failed to accurately represent the test data obtained from the physical train. A specific source of error related to inaccurate modelling of the flow characteristics of the levelling valve which causes significant errors at higher deflections of the air suspension. Additionally, further practical levelling tests would supply more robust validation of a newly-developed model.

6.1.4 RAIL TRACK CONDITION MONITORING: TRACK GAUGE

The expansive rail network in South Africa, spanning over 22,000 km, faces ongoing track defects requiring meticulous maintenance efforts. Traditionally, manual inspections are conducted, a time-consuming process prompting the need for more efficient solutions. It is hypothesised that modern technology poses potential for the automated monitoring of track defects. Such systems potentially eliminate the need for labour-intensive manual inspections and minimises the risk of undetected cumulative track damage. A case study was initiated to monitor rail track gauge, using machine vision and algorithms to enable real-time defect detection.

The proposed solution involves the use of a train-based camera system to capture track data while in motion. Algorithms such as Canny Edge Detection Algorithm and Gaussian blur were used to process onboard camera footage. A laboratory deployment was built comprising a trolley, equipped with a microprocessor, camera, and GPS tracker. Camera footage and GPS coordinates were subjected to post-processing using Python and OpenCV packages to detect gauge defects. Results demonstrate promising accuracy, with an average difference of 2 mm between calculated and actual gauges across tested sections.

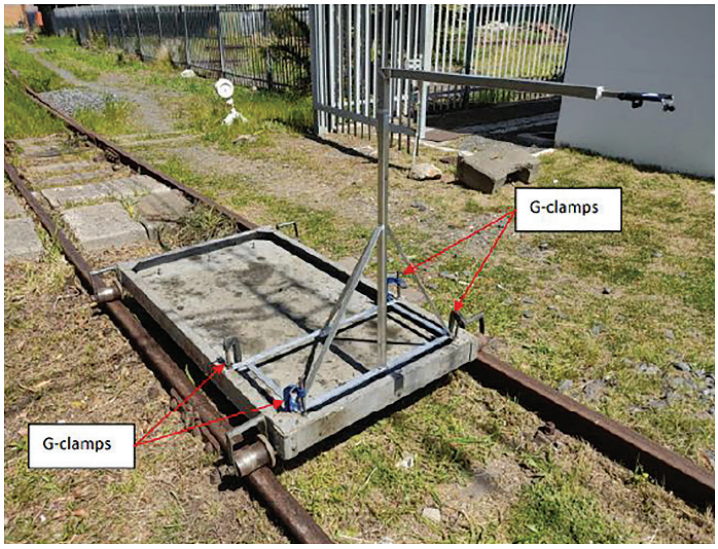

Figure 2: Experimental rig to simulate a train based camera system capturing track data.

6.1.5 QUANTIFY, ASSESS AND IMPROVE THE EMPLOYEE SATISFACTION LEVELS FOR GIBELA'S ENGINEERING DIVISION

The overall satisfaction level of employees in Gibela's engineering department was investigated in recognition of its pivotal role in organisational success. Literature indicated that a suitable framework of models for satisfaction assessment could be combined to evaluate employee satisfaction levels, namely the Working Environment Model, Role Perception Model, and Rewards Model.

Satisfaction drivers, such as extrinsic rewards, quality of supervisory feedback, job autonomy, social climate, intrinsic rewards, and job attractiveness were identified. A survey comprising 23 questions was derived from the identified satisfaction drivers. Among the drivers, extrinsic rewards, quality of supervisory feedback, job autonomy, and social climate emerged as areas to grow employee satisfaction. Recognising and meeting employee needs is emphasised as crucial for fostering retention and maintaining a positive work environment. Growth in employee satisfaction is anticipated to enhance company performance and promote employee well-being through meaningful organisational adjustments. Elevating the overall satisfaction level of employees can contribute significantly to their overall life and work fulfilment, thereby fostering a more engaged and productive workforce.

6.1.6 MEASUREMENT OF RAIL CAR AERODYNAMIC LOAD COEFFICIENTS

In rail transportation, derailments occur when rail vehicles veer off their tracks. A common cause is attributed to wind-induced lateral forces. Computational fluid dynamics (CFD) simulations are typically used in multi-body cross-wind modelling to determine safe operational conditions prevent overturning. South Africa utilises narrow-gauge rails, and with the light steel construction it leaves the Gibela X'Trapolis Mega susceptible to an increased risk of overturning. Presently the company has not yet validated CFD results that recommend safe speed ratings for this new train in varying wind conditions. The present project aims to manufacture a six-component force transducer to experimentally determine aerodynamic load coefficients of a rail car model in Stellenbosch University's Subsonic Wind Tunnel.

The model, based on Gibela's conceptual X'Trapolis design, and the force transducer were developed to measure all six aerodynamic coefficients simultaneously. The designed transducer allowed for testing of different rail car geometries and successfully measured forces under controlled conditions, exhibiting similar trends to existing literature. Results align with expectations and published data, confirming the transducer's qualitative and quantitative success. Further validation would require a train model with increased geometric refinement to enhance confidence in the transducer's accuracy. Testing with a detailed rail car model would provide Gibela with precise load coefficients necessary for CFD validation, ensuring safer train operations under varying wind conditions.

6.1.7 AN OPTICAL RAIL WHEEL MEASURING SOLUTION

The study addresses the need for a reliable non-contact monitoring system for rail wheel wear assessment, minimising human intervention and enabling inspections during train motion. The proposed system aims to streamline wheel profile measurements, ensuring compliance with safety standards and facilitating communication of results to maintenance personnel. Through experimentation with Laser Light Technology (LLT) and a dynamic wheel setup, the study confirms the feasibility of non-contact, dynamic wheel profile scanning. Integration of a data acquisition system allows real-time data communication and storage. Validation tests comparing LLT measurements to MiniProf results demonstrate consistency, albeit with minor discrepancies requiring optimisation. A techno-economic analysis reveals a 16% budget overrun due to additional work hours and logistical delays. An end-of-life strategy proposes recycling and reusing materials.

The prototype's potential contributions include improved rail car safety, extended lifespans, reduced maintenance costs, and data-driven decision-making. Future development includes refining measurement accuracy and creating a trackside installed monitoring system for real-time inspections. This project lays the groundwork for advanced rail wheel monitoring systems, enhancing safety and efficiency in railway maintenance operations.

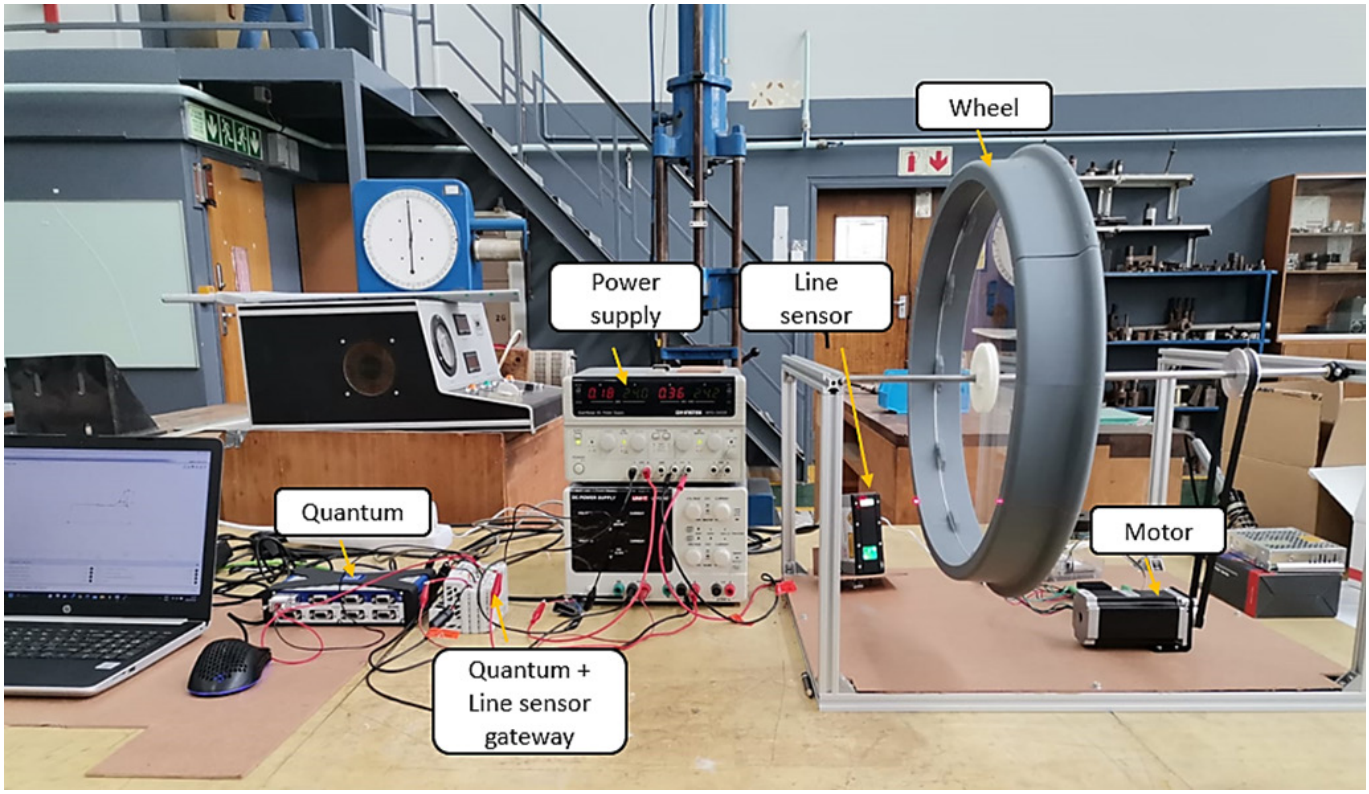

Figure 3: An experimental rig for the evaluation of wheel profile measurements.

6.1.8 WHOLE-BODY VIBRATION CALCULATOR FOR OCCUPANTS OF RAILWAY VEHICLES

Whole-body vibration (WBV) is an important factor in rail service delivery. In train drivers, excessive exposure may contribute to occupational disorders such as back pain and sciatica nerve damage. Factors such as wheel flat spots, deteriorated track conditions, and vehicle dynamics significantly influence ride comfort.

An automated WBV measurement and processing system was developed, integrating Industry 4.0 technologies to enhance situational awareness of dynamic passenger comfort and occupational vibration exposure. An in-field measurement was performed on trainset 145 for two cycles of transit between Fish Hoek and Cape Town.

The methodologies for WBV comfort analysis in ISO 2631-1 and EN 12299 were compared, revealing discernible differences in filter designs and data evaluation methods. A custom algorithm was developed to filter acceleration signals to represent human perception, enabling the evaluation of ride comfort based on ISO 2631-1 and EN 12299 standards.

Results manifest a linear relationship between the standards, with EN 12299 displaying heightened sensitivity to outliers.

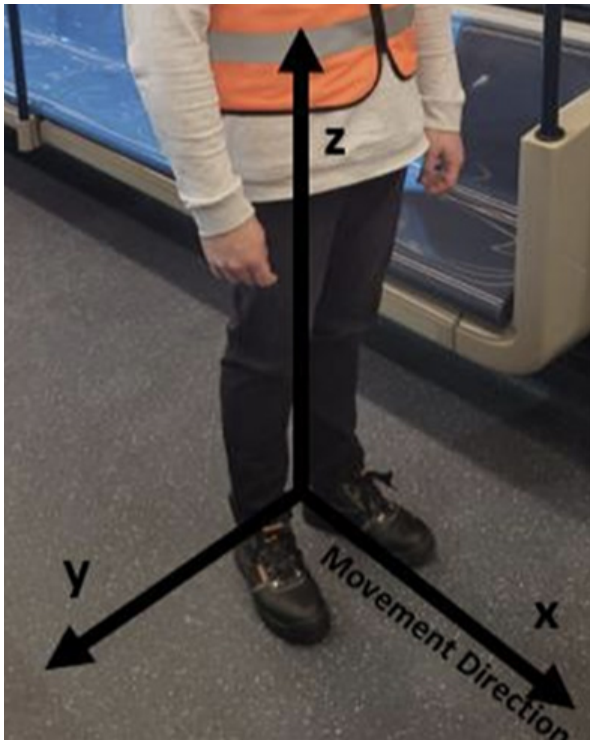

Figure 4: Defining the axis system for WBV measurements in the context of a rail car.

The custom WBV calculator processes data in real-time, generating comprehensive PDF reports featuring visualisations of ride comfort evaluations and route mapping. While most system requirements are met, pending tasks include implementing remote operation and cloud storage capabilities. This work lays the basis for further human-centric developments in keeping with the emergence of Industry 5.0 where human factors are integrated in advanced technology.

6.1.9 DEVELOPMENT OF A VIRTUAL REALITY TECHNOLOGY WELDING SIMULATOR

A virtual reality (VR) welding simulator was designed and developed as a modern approach to traditional welder training, aiming to enhance efficiency, reduce costs, and improve skills acquisition. Traditional welding training, dating back to the 1880s, is labor-intensive and costly due to the diverse welding processes, positions, and materials involved.

The emergence of VR technology presents an opportunity to streamline training processes and address these challenges. The VR welding simulator, designed specifically for metal inert gas (MIG) welding, integrates a physical MIG torch with a tracker to immerse welders in a virtual welding environment. Svantek vibration measurement instrumentation evaluates hand steadiness during welding, while users can manipulate virtual welding parameters.

The system calculates critical welding metrics such as working angle, travel speed, and center-to-weld distance, providing an overall welding score to assess weld quality post-completion. Validation of the VR simulator involved three anonymous participants from varied welding backgrounds, showcasing improved welding abilities in two out of three welders following a tensile test on welded specimens.

The introduction of VR technology complements traditional welding training methods, offering a realistic and immersive experience akin to industry-standard augmented reality simulators.

Despite the enduring principles of fusion welding, VR-based simulators are positioned to revolutionise welder training, offering enhanced accessibility, affordability, and performance evaluation.

The development of VR welding simulators signifies a paradigm shift in welding education and skill development, leveraging cutting-edge technology to meet evolving industry demands.

Figure 5: Virtual welding simulator environment.

Figure 6: MIG welding torch with tracker.

6.1.10 USING A MODEL TRAIN TO IDENTIFY TRACK DEFECTS

The efficacy of an onboard track monitoring system is investigated to enhance railway defect detection and maintenance. Track defects were researched and replicated on a model-scale track.

A model-scale train was equipped with an onboard monitoring system using an ESP32-CAM module. The efficacy of machine learning was investigated to perform automated rail defect detection. It was found that machine learning algorithms could be trained to detect labelled defects. Implementation on full scale would need to focus on sufficiently visible track anomalies owing to the pixelation rate of practically implementable onboard camera systems.

Figure 7: Gabriel Adonis, demonstrating his model train project at the GERC seminar, November 2023.

6.1.11 OPTICAL-BASED DETECTION OF WHEEL FLAT SPOTS

The potential of machine vision technology is explored in a trackside monitoring environment. A prototype machine vision system was configured from off-the-shelf components. The prototype was first evaluated in a laboratory environment, where it was compared to experimental measurements on an MTS universal test machine. Dynamic laboratory measurements show that bright, even lighting is important for target tracking reliability. Under good lighting conditions, dynamic measurements are just as accurate and precise as static measurements using the same setup. Subsequently, a trackside system was devised using machine vision and targets to measure rail and sleeper movement relative to the subgrade (field test design & field results). During field deployment, three separate targets could be simultaneously tracked using a single camera.

6.1.12 WAREHOUSE OPTIMISATION

There is an increasing demand for storing train parts in Gibela's warehouse in Midrand, South Africa. During 2022, Gibela relocated its inventory from a warehouse spanning six thousand square meters to its current facility, which offers a reduced space of two thousand square meters, resulting in the current warehouse facing difficulty in storing all the required inventory parts. In addition, the current facility is experiencing obstruction in walkways and docking locations, resulting in safety hazards to employees in the warehouse. This project aims to optimise Gibela's warehouse through applying various strategies to utilise vertical space and create an efficient working environment. In addition, there is a need to improve the safety and flow of materials throughout the warehouse. Research on warehouse optimisation and challenges warehouses face are documented in the literature review. In addition, various optimisation strategies and lean principles applicable to warehouses are discussed to gain in-depth knowledge to address the problem of this project. An as-is assessment on the current state of Gibela's warehouse is conducted through independent observations while working at the warehouse. Throughout the as-is assessment, an in-depth understanding of the warehouse layout, storing methods and equipment used is obtained to identify and document areas for improvement. The 5S lean principle, storing methods, layout design, and space utilisation calculations are used to design recommended solutions that address the issues currently faced in Gibela's warehouse. Validation on the recommended solutions is documented through constructive feedback from subject matter experts.

6.1.13 OPERATORS' SAFETY AND PRODUCTIVITY IN THE RAIL MAINTENANCE ENVIRONMENT: AN ERGONOMIC STUDY

Gibela is a rail transportation company in South Africa that manufacturers, produces and maintains the deployment of the newer commuter train models for the enhancement and sustainability of the rail transporting services. With continuous rollout, the company recognises the need for newer maintenance activities and practices at the rail depot, in accordance with the newer models. Upon recognising the need, the company identified that the operator safety and productivity from an ergonomic perspective is of utmost importance, citing newer methods of identifying and mitigating ergonomic factors that occur during these activities.

This project follows a qualitative approach to addressing the need by collectively using literature theory as well as the development of an Ergonomic Workplace Assessment (EWA) framework to identify and highlight those areas of improvement in a rail maintenance setting. The literature study focuses on concepts that relate to the importance of operator safety and productivity as well as various ergonomic risk factors experienced in the rail maintenance environment such as physical exertion, work body posture, cognitive work, musculoskeletal disorder and the workplace environment and tooling conditions. The literature study is followed by a complete analysis of the observational data collected from the practical research conducted, as well as a set list of Kaizen events to evaluate improvement strategies.

6.2 MASTER'S RESEARCH PROJECTS

6.2.1 DEVELOPMENT OF A DECISION-SUPPORT ROADMAP FOR PERFORMING A LIFE CYCLE ASSESSMENT ON RAIL VEHICLES

The transportation sector is a prominent contributor to global CO2 emissions, with South Africa emerging as a leading energy consumer in Africa. In South Africa, rail transport is segmented into freight and commuter services. The introduction of the X'Trapolis Mega aims to modernise South Africa's railway, with the added benefit of providing commuters with a green, energy-efficient mode of transportation.

Although rail offers a low-carbon means of transportation it remains to evaluate the environmental impact of the X'Trapolis Mega in a holistic analysis using the Life Cycle Assessment (LCA) methodology. LCA allows for the examination of environmental repercussions throughout a product's lifecycle, from material extraction to end-of-life disposal.

Despite its widespread use, LCA studies concerning rail vehicles face challenges, including data availability and standardisation issues. Limited research focusing on passenger train environmental impacts in South Africa exacerbates these challenges. The present work contributes a structured LCA-based roadmap, adhering to ISO 14040 standards, proposed to guide rail vehicle manufacturers in conducting comprehensive LCAs. This underpins the methodology through which Gibela may pursue LCA of the X'Trapolis Mega.

6.2.2 AN OPEN-SOURCE DIGITAL IMAGE CORRELATION SOFTWARE SYSTEM IN PYTHON

Digital Image Correlation (DIC) is a popular computer vision-based optical measurement technique typically used for material characterisation and load response tests. In this project, an open-source software system in Python was developed for full-field DIC measurements. An overview of the numerical implementations underpinning local and global planar-DIC solvers for displacement measurements is provided. It is shown that the planar-DIC implementations accurately recover complex, sub-pixel level displacements, by testing the software on the synthetic image sets made available for the DIC challenge 2.0.

The local-DIC implementation achieves metrological performance on par with the benchmark, while the global counterpart achieves metrological performance in the mid-range of the codes participating in the challenge.

Strain filters implementing a Gaussian smoothing scheme and linear polynomial fit, respectively, to subsequently filter the displacement data are shown to achieve metrological performance on par with the benchmarks. Stereo-DIC combines the independent planar measurements from two cameras in a triangulation routine to estimate a depth component, and thus 3D full-field displacement data. The stereo-DIC implementation is validated against displacements as set by a secondary measurement system, namely, high-precision optical translation stages. Additionally, the quantification of measurement uncertainty in stereo-DIC measurements is explored. A tensile test case study is performed to illustrate the influence of different user-defined software settings on the resolution characteristics of the full-field displacement and strain measurements obtained by stereo-DIC.

6.3 PHD RESEARCH PROJECT

6.3.1 A LONGEVITY ESCAPE VELOCITY MODEL FOR RAIL ROLLING STOCK

In recent years, the concept of asset life extension has become popular in lieu of other end-of-life management strategies, such as replacement or decommissioning of assets. Life extension models are evident in many types of equipment in various industries, and most of these models are based on integrated health indices or condition assessments of the equipment. Although some research has been carried out on life extension in rail infrastructure, no research which addresses life extension in rail rolling stock has been found in mainstream databases, leaving an opportunity for research. Therefore, the main purpose of this research is to develop a life extension model for rail rolling stock, to address this opportunity in literature.

The model will be based on the longevity escape velocity model, found in the gerontology approach to human ageing. Gerontologists, believe that metabolism causes damages (wear and tear) on an ongoing basis and the accumulated damage eventually causes pathology and age-related degeneration. The key is that the lower the age of the person when treatments arrive, the more likely the person is to get out of the life expectancy decline and become biologically younger.

It is therefore postulated that the concept of the longevity escape velocity model in humans can be applied in rail rolling stock. If 'treatments' (adapted maintenance strategies, upgrade interventions and refurbishments) are applied to rail rolling stock early enough in their life, the rail rolling stock is likely to get out of the life expectancy decline and the ageing process can be decelerated. In light of humans becoming biological younger, a similar index for rail rolling stock could not be found in a literature search of mainstream databases, and it is suggested that a health index be developed for rail rolling stock.

7 - SOCIAL RESPONSIBILITY

Every year, the Rail Safety Regulator (RSR) investigates many rail incidents, such as collisions between trains, derailments, accidents at level crossings and station platforms and people struck by trains (PSBT). PSBT incidents are the most concerning and often caused by people's ignorance or recklessness.

As part of Social Responsibility, the GERC promotes and arranges rail safety education and awareness campaigns for primary school learners. The purpose is twofold: 1) to teach learners aspects of rail safety to reduce PSBTs, and 2) to stimulate learners in engineering as a career by exposing them to Science, Engineering and Technology (SET).

In collaboration with the Division for Social Impact (DSI) from Stellenbosch University (SU), Gibela Rail Transport Consortium and the RSR, awareness campaigns were hosted in the Western Cape and Gauteng in 2022 and 2023. Six campaigns have been hosted to date, reaching nearly 500 learners, summarised in Table 6.

Table 6 A summary of safety education and awareness campaigns hosted by the GERC.

DATE	VENUE	SCHOOL	# OF LEARNERS
22 September 2022	Winelands Light Rail Stellenbosch University	Belhar Islamic Primary School SPARK School	60 Grade 6 learners
8 December 2022	Wineland Light Rail Stellenbosch University	AF Louw Primary School Bruckner de Villiers Primary School	80 Grade 6 learners
21,22 June 2023	Centurion Society of Model Engineers University of Pretoria	Mogale Primary School Isiziba Primary School	80 Grade 7 learners each day (total 160)
6,7 December 2023	Winelands Light Rail Stellenbosch University	Rietenbosch Primary School Klipheuwel Primary School Luzuko Primary School	97 learners (Grade 5 to 7) 40 Klipheuwel, 40 Luzuko (Grade 5 to 7)

7.1 RAILWAY SAFETY CAMPAIGNS 2022

In September 2022 learners from Belhar Islamic Primary School and SPARK School were hosted at Winelands Light Rail near Koelenhof. Learners were taught were taught rail safety, and afterwards, they were introduced to SET at the SUNSTEP facility at Stellenbosch University. In December 2022, AF Louw Primary School and Bruckner de Villiers Primary School were hosted at the same venues.

7.1.1 INTRODUCTION TO SET AT SUNSTEP

The first introduction to SET was run at Stellenbosch University's Department of Mechanical & Mechatronic Engineering. Here, learners were exposed to a hands-on practical workshop led by SUNSTEP in a university laboratory environment. Each learner was supplied with a soldering iron, circuit board, batteries, a speaker, resistors, capacitors, a light emitting diode (LED), and wiring.

Mentors briefed students on safety and guided them through a step-by-step process to assemble their electronic alarm buzzers. Learners connected an audible buzzer sounds in tandem with a flashing LED. As one ventured through the halls of the engineering workshops, it was filled with a cacophony of buzzers as young learners demonstrated their operational alarm circuits.

Figure 8: Learners build their own buzzer circuits in a Stellenbosch University laboratory environment.

Figure 9: Learners build their circuits step-by-step.

Figure 10: The circuit has pins with numbers which must be carefully connected.

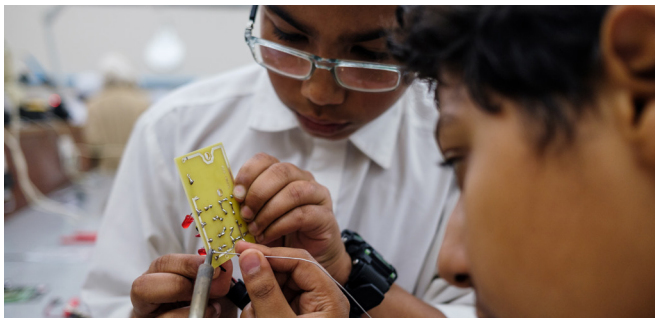

Figure 11.1: Learners set up the devices through step-by-step instructions.

Figure 11.2: Learners eagerly waiting outside Stellenbosch University's Department of Mechanical and Mechantronic Engineering.

7.1.2 RAIL SAFETY PROGRAMME AT WINELANDS LIGHT RAILWAY (WLR 2022)

Winelands Light Railway is a charming miniature railway park near Koelenhof, Stellenbosch. Here, owner Andries Keyser, operates a miniature railway system using one-third-scale, hand-built electrical and steam-operated locomotives. A miniature rail track runs on a short, immersive journey from a "station", over a bridge, through a "game park" and a tunnel.

For their visit to WLR, learners were transported by bus and welcomed at the park's "station". Following an introduction by Mr Olabanji Asekun (GERC, Outreach) learners were engaged through informative talks with spot prizes. Mr Loyiso Jiya (Head of Communications, Gibela) kicked-off with an interactive story on rail transport and the manufacturing of 600 X'trapolis Mega trainsets which will renew the passenger fleet for the Passenger Rail Agency of South Africa (PRASA). From the trains themselves the discussion moved to rail safety. The Railway Safety Regulator probed learners about topics including the safe crossing of railway tracks, safe behaviour at a station platform and safety when onboard a train. Teams of learners participated in a competition quiz to identify rail hazards from an infographic.

Learners were then invited to leave their seats and walk to a set location next to the miniature rail track. Here, an immersive car and train crash demonstration was staged, allowing the learners to witness the importance of safety measures firsthand.

Next, learners were invited to personalise their commitment to railway safety, by signing a safety pledge with Operation Lifesaver Inc. (OLI), a respected international non-profit organisation recognised for its role in rail safety education. Since 1972, OLI has been dedicated to preventing collisions, injuries, and fatalities on and around railroad tracks and highway-rail grade crossings.

After the formal programme the learners were treated to lunch at WLR and enjoyed the exhilarating train rides around the theme park.

Figure 12: Loyiso Jiya (Head of Communications at Gibela) engaging with learners.

Figure 13: Belhair Islamic School eagerly asking questions.

Figure 14: Students answering safety questions

Figure 15: Learners engaged in the interactive tasks with spot prizes.

Figure 16: Young minds processing the safety talks.

Figure 17: Learners get to watch a staged accident, demonstrating dangers associated with railways.

Figure 18: The learners enjoyed a ride on the miniature railway system.

7.2 RAILWAY SAFETY CAMPAIGNS 2023

In 2023, a three-year agreement was signed with the RSR for funding and support, which increased the number of campaigns to four per year. It also allowed the campaigns to be done in other provinces, therefore not limiting them to the Western Cape. The following campaigns were done in 2023:

In June 2023, two campaigns on consecutive days were held in Gauteng, where the Centurion Society of Model Engineers and the University of Pretoria (UP) hosted learners from Mogale Primary School and Isiziba Primary School. The GERC, Gibela and the RSR arranged the campaigns and managed the programme. At Centurion Society of Model Engineers, learners were educated on railway safety, completed a quiz, signed the pledge from OLI and witnessed a car crash, whereafter they were introduced to SET at the UP's Department of Civil Engineering.

At UP, the learners were introduced to drones with a demonstration by the Departmental Head, Prof Hannes Grabe. In addition, they were shown the realistic behaviour of a robotic dog, how a rail-road vehicle works, and the noise from a tensile test.

Figure 19: The learners at the Civil Engineering Department of the University of Pretoria.

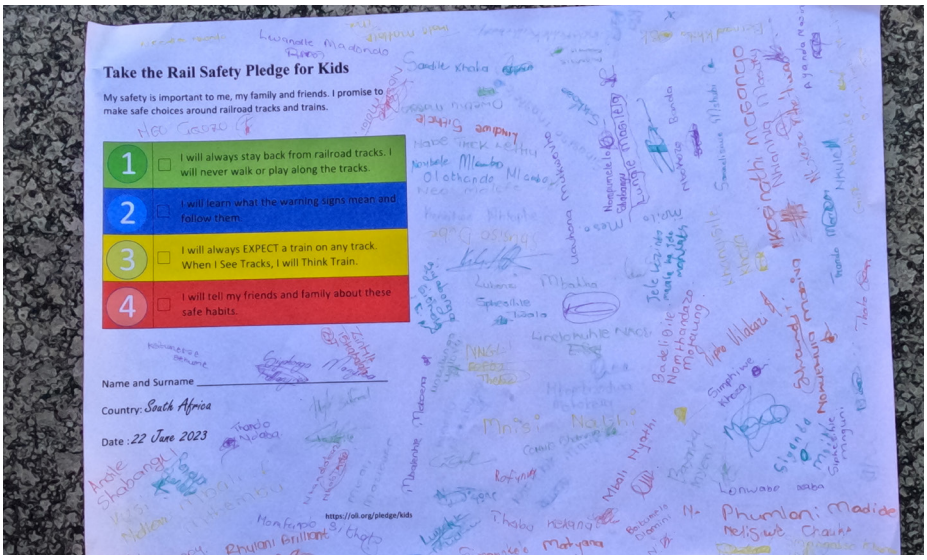

Figure 20: Learners enjoy the activities after signing the Rail Safety Pledge.

Figure 21: A group photo of learners at the park in Winelands Light Rail.

Figure 22: Learners interact with demonstrations in the Geotechnical Laboratory at Stellenbosch University.

Figure 23: Learners visited the Department of Civil Engineering at Stellenbosch University.

8 - PUBLICATIONS

8.1 CONFERENCES

Table 7: A summary of academic conferences attended and presented at.

DATE	CONFERENCE NAME	NUMBER OF DELEGATES	LOCATION	GERC PERSONNEL	
				# PAX ATTEND	#CONTRIBUTION PRESENTED
20 to 23 September 2022	InnoTrans 2022 International Trade Fair for Transport Technology	2,771 exhibitors from 56 countries, ~140k visitors from 137 countries in 42 exhibition halls	Berlin, Germany	2	0
2 to 5 July 2023	EURODYN XII International Conference in Structural Dynamics	600 delegates	Delft, Netherlands	1	0
27 to 31 August 2023	12th International Heavy Haul Association Conference	1,100 delegates, 280 companies, 200 peer reviewed papers	Rio de Janeiro, Brazil	2	2
23,24 January 2024	South African Conference in Applied Mechanics	40 delegates	Stellenbosch, South Africa	4	2

8.2 LIST OF OUTPUTS

Within the current funding period, academic publications amounted to a total of four conference outputs. The references of the respective outputs are listed, along with the abstract. In each case the name of the presenting author is underlined.

8.2.1 BEKKER, A. & ERIKSTAD, S.O. (2023) DIGITAL TWIN SERVICE PATTERNS FOR MAINTENANCE MANAGEMENT OF OPERATIONAL RAIL ASSETS, IN PROCEEDINGS OF THE 12TH INTERNATIONAL HEAVY HAUL ASSOCIATION CONFERENCE, RIO DE JANEIRO, AUGUST 2023, RIO DE JANEIRO, BRAZIL.

Digital twins entail the entangled use of a software representation of a real asset with engineering sensors to communicate the state and behaviour of an asset. This work focuses on how digital twin technology may specifically proffer maintenance management in rail networks and rolling stock through their value-adding property, servitisation. These digital services are structured through a portfolio of digital twin service patterns, which hinge on the generic configuration of digital twin building blocks to deliver a specific value. This idea springboards off the iconic concept, “design patterns” in object orientated programming which entail standardised high-level solutions to commonly recurring problems. Design templates are provided for specific services that mirror asset behaviour, provide virtual sensing, detect anomalies, and match the fingerprint of a specific response. The service patterns are presented through a graphical model that depicts the detail of cyber-physical interactions.

8.2.2 ELLIS, D.R. & BEKKER, A. (2023) WHEEL FLAT DETECTION USING WAYSIDE MEASUREMENTS AND HILBERT-HUANG TRANSFORM, IN PROCEEDINGS OF THE 12TH INTERNATIONAL HEAVY HAUL ASSOCIATION CONFERENCE,RIO DE JANEIRO, AUGUST 2023, RIO DE JANEIRO, BRAZIL.

Identifying wheel flats is critical in preventing train derailments and expensive repairs. This study utilised wayside monitoring and an uniaxial accelerometer, capable of ±500 g peak at 10 kHz, attached to the foot of the rail mid-span between sleepers to capture the vibration pattern. Field measurements were conducted using trains with in-service generated flats and a train provided in as-new condition to establish a baseline response. Time-domain analyses were performed, indicating that the impulsive nature of a wheel flat striking the rail head leads to higher acceleration levels.

To detect wheel flats, empirical mode decomposition and the Hilbert-Huang Transform (HHT) were applied to nonlinear and non-stationary filtered signals. Some of the trainsets made available to the study had documented wheel flats, and in some cases, the wheel sets were subjectively and visually analysed, and notes were made of their condition. The presented method was able to identify and flag in the time-domain the bogie housing the defective wheel at the two different speeds investigated (10 and 30 km/h) for the reported wheel flats. Additional wheel flats were detected; however, without comprehensive reports detailing the condition of individual wheels, a conclusive result could not be established. The findings suggest that the HHT method can successfully identify the vibration signature of wheel flat impacts when measured wayside and justifies further research to unlock its potential for wheel flat detection.

8.2.3 ELLIS, D.R. & BEKKER, A. (2024) IMPROVED ACCELEROMETER PLACEMENT FOR RAILWAY WHEEL FLAT DETECTION USING A SINGLE SENSOR, IN PROCEEDINGS OF THE SOUTH AFRICAN CONFERENCE OF APPLIED MECHANICS, STELLENBOSCH, SOUTH AFRICA, JANUARY 2024.

Wheel flats are circumferential defects that form on railway wheels at discrete locations due to sliding incidents, brake malfunctions, or improper use. These flats can lead to increased noise pollution, rail infrastructure damage, and rolling stock maintenance. Often rolling stock operators rely on acoustic observations from their employees to raise these issues. This research focuses on locating the best wayside position to place a single accelerometer to measure the impulse caused by a wheelset with a flat. Digital signal processing techniques are used to analyse the vibration signal to identify the faulty wheelset on the trainset. Placement on the sleepers and rail at different locations were considered. The location yielding the ideal position for a single sensor is found using beam and rail theory and dynamic simulations. These results are compared to field tests using a train with multiple wheel flats and the results shown.

8.2.4 PHILLIPS, A.K. & CONRADIE, P.D.F. (2024) OPTICAL LASER RAIL WHEEL WEAR MEASURING AND DETECTION, IN PROCEEDINGS OF THE SOUTH AFRICAN CONFERENCE OF APPLIED MECHANICS, STELLENBOSCH, SOUTH AFRICA, JANUARY 2024.

In the rail industry, high stresses in both the wheel and the rail material, surface wear, subsurface defects, and wheel profile wear are inevitable in normal operation. Therefore, standards and specifications are in place to control the technical requirements of railway wheels, which contributes to the safety of passengers. As part of the condition-based maintenance tactic, regular inspections ensure that railway wheels are within specified wear limits and conform to the standards. Currently, inspections are done at set intervals and rely heavily on human involvement and manual equipment, which can lead to the late detection of defects with consequential effects. Therefore, more frequent contactless inspection on railway wheels is proposed. A high-performance class 3R laser scanner is used to detect defects and wear on a railway wheel.

The laser uses optical triangulation with a laser line projected on wheel surface via a linear optical system, and the diffusely reflected light is replicated on a sensor matrix based on the Scheimpflug principle. Using the requirements from the BS EN 15313:2016-wheel standard, the focus is on the wheel rim, where most defects and wear occur. Single and multiple two-dimensional images are generated to identify and quantify the wear and defects. The optical rail wheel wear measuring and detection unit is tested on a half-scale 3D printed wheel model. Defects from the BS EN 15313:2016 standard are replicated on the scale model, and the unit is used to identify the defects.

9 - "SKILL-UP" WORKSHOPS

To date, the Chair has used ad-hoc workshops to upskill personnel through short-term training and development opportunities. These opportunities may be rail-specific or serve the general competency of staff and students in the group.

Table 8: Summary of colloquia

DATE	EVENT	PRESENTER	PRESENTER INSTITUTION
February 2023	Project proposal speed talks by GERC final year students.	Mr Nitesh Munillal, Mr Joseph Mudau	Gibela Rail Consortium
March 2023	Rail Measurement and Research	Prof Hannes Gräbe	Pretoria University
July 2023	HBM equipment and automation of a data ingress pipeline	Mr Dylan Naidoo	TANDM Ltd.
November 2023	Presentation workshop	Mr Eduard de Kock	Stellenbosch University Language Centre

Figure 24: The GERC team joined Prof Hannes Gräbe at the Paarden Eiland Depot to workshop practical trackside instrumentation from Stellenbosch University.

9.1 PROJECT PROPOSAL SPEED TALKS BY FINAL YEAR STUDENTS

During an afternoon workshop staff and students within GERC received an overview of the activities and business of the Gibela Rail Consortium from Mr Nitesh Munilllal (Head of Engineering, Gibela).

Following this session, five final year students with GERC projects presented their project titles, scope, and objectives in speed talks. The afternoon session was spent to gain input and discussion on the planned work with industry input from Gibela.

9.2 RAIL MEASUREMENT AND RESEARCH BY PROF HANNES GRÄBE

Professor Hannes Gräbe, from the Department of Civil Engineering at the University of Pretoria, presented a summary of research conducted through a decade of TRANSNET funding. The colloquium followed the format of a two-day workshop. The workshop was attended by full-time personnel of the GERC, postgraduate students and the newly recruited final year students.

Day 1 focussed on a presentation overview of research at Pretoria University which mainly focussed on rail measurements to monitor track and substructure condition.

Day 2 was organised as a practical session where Prof Gräbe was invited to witness and comment on trackside data collection by Stellenbosch University at Paarden Eiland Depot. The opportunity was leveraged to issue personnel with Personal Protection Equipment and to complete the site Safety Induction in preparation for the year ahead.

9.3 HBM EQUIPMENT AND AUTOMATION OF A DATA INGRESS PIPELINE BY MR DYLAN NAIDOO

The GERC invested in test and measurement equipment, supplied by local company TANDM. The equipment entails sensors, data acquisition tools and software to serve a variety of trackside monitoring and onboard measurement solutions. The acquisition contract includes dedicated support hours by TANDM, specifically Application Engineer, Mr Dylan Naidoo.

In order to serve the final year projects schedule, a one-day workshop was hosted at the Department of Mechanical & Mechatronic Engineering of Stellenbosch University. The purpose of this workshop was to train GERC staff and students in the use of the newly acquired equipment. The session focussed on the initiation of acceleration measurements, synchronisation with GPS data, and automation of data ingress to capture data from the track in a remote office environment.

9.4 PRESENTATION WORKSHOP BY MR EDUARD DE KOCK

The GERC reaped timeous benefit from a condensed presentation workshop offered by Mr Eduard de Kock from the Stellenbosch University Language Centre. The purpose of the workshop was to prepare students for final year oral exams and the Gibela Research Seminar.

The interactive content covered strategies to increase audience engagement and some hands-on implementation in an informal setting. It was concluded that this workshop should occupy a regular slot in the GERC calendar with much benefit derived.

9.5 PROFESSIONAL DEVELOPMENT PROGRAMME

Engineering practitioners can register with the Engineering Council of South Africa (ECSA) as Professionals in the following categories:

- Professional Engineer
- Professional Technologist
- Professional Technician

As part of the GERC offering, mentorship is provided for candidates who wish to register as Professionals. The mentorship includes assistance in writing the required ECSA reports (training reports, engineering report and administrative reports), as well as identifying gaps in the experience of the candidates.

The ultimate goal is to establish a self-sufficient Professional Development Programme (PdP) in Gibela, driven internally by internal mentors.

Generally, there are three types of candidates (for the rest of this section, employees enrolled on the PdP will be referred to as candidates):

- New graduates who need experience.
- Candidates with experience who might need a project(s) to cover specific outcomes.
- Mature candidates who have more than ten years of experience.

Generally, technologist and technician candidates can register after three years of experience, and engineers can register after four years. It must be noted that very specific experience is needed, which must be at an appropriate level of complexity and responsibility for the registration category. This needs to be assessed before a candidate can submit their application.

In late 2022, a pilot programme was launched, and a Computer Engineer from Gibela was enrolled on the PdP. After the first set of training reports was delivered, it was decided to expand the PdP and onboard more candidates. In late 2023, four engineers and three technologists were enrolled on the PdP from a mixture of mechanical, electrical, and electronic disciplines. The PdP is currently being tested on these candidates and hopes to deliver the first applications to ECSA at the beginningof 2025.

10 - CONTRACTED PROJECTS

10.1 GIBELA LOCALISATION PROJECT

As part of the drive towards localisation, Gibela requested the GERC to investigate the possibility of increasing the local content of components used on the X'Trapolis Mega trainset. This study formed part of a broader range of studies to increase the local content of the X'Trapolis Mega trainset to meet contractual obligations. A list of components was drawn up, classified into "Priority" and "Non-Priority" items, and a systematic process was drawn up to investigate the components.

The process consisted of five phases: 1) market research, 2) technical evaluation, 3) new technology new markets, 4) historical market study and cost impact of establishing markets, and 5) perform phases 1 to 4 for non-priority components.

The list of components was reduced to five priority components, which would be the initial focus, which included 1) external door threshold, 2) flexible hoses, 3) electrical cables, 4) HVAC components and 5) paint, pigments, and epoxy.

The GERC recruited a multi-disciplinary team comprising industrial, electrical, mechanical and fire engineers from the Engineering Faculty of Stellenbosch University. Work commenced from January to April 2022, where nearly 1,000 hours were afforded to research industrial, electrical, mechanical and fire engineers, industry interviews and reporting.

The localisation of each component was addressed through a systematic process with six steps. The first three steps were completed for five components:

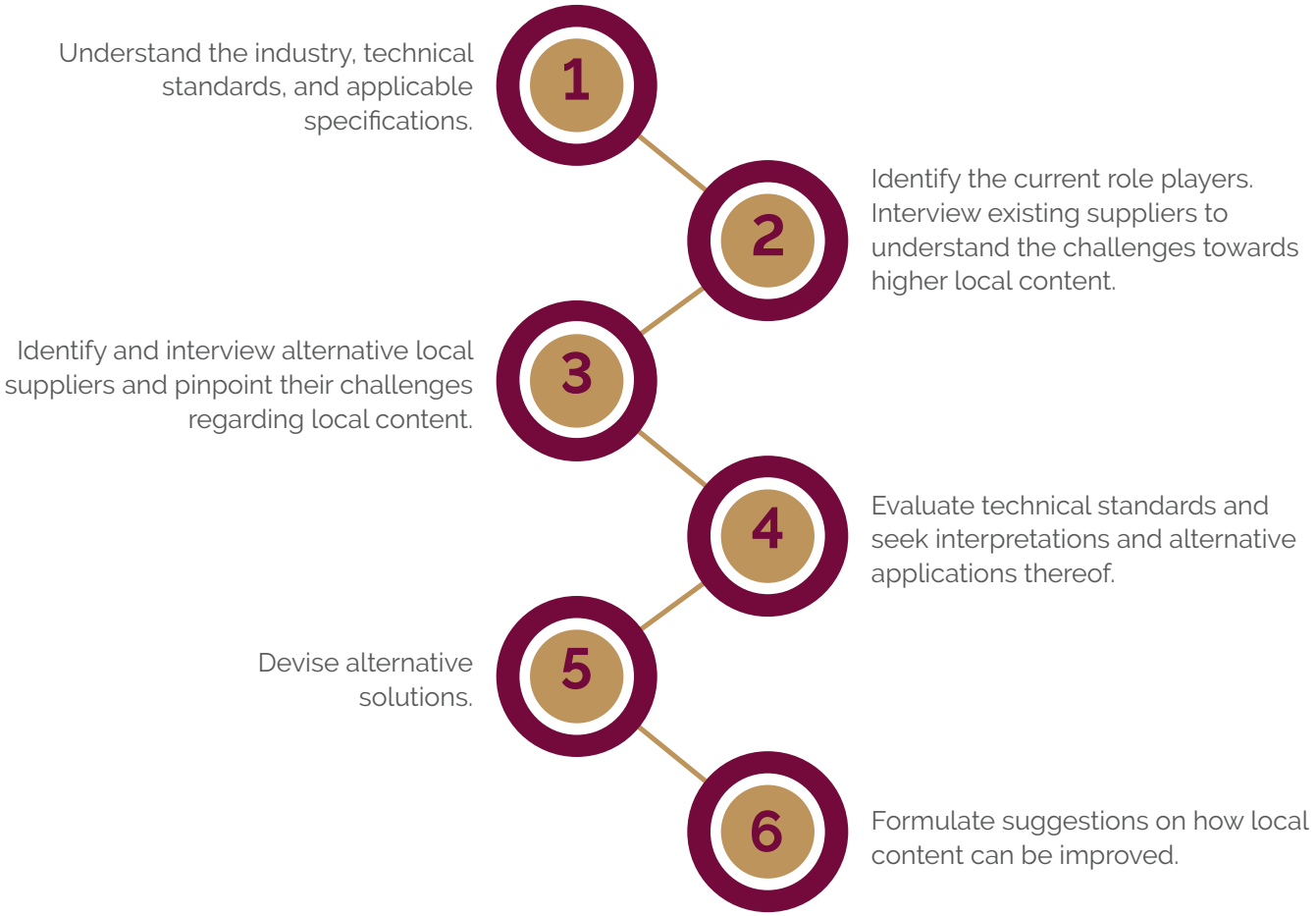

Figure 25: The six step localisation process.

The team, in collaboration with Gibela specialists, acknowledged the instruction from the National Treasury specifying the local content requirements for different components. The local content requirements are only applicable or enforced in contracts with state-owned entities, with the South African Bureau for Standards (SABS) ensuring verification of local content compliance. However, the team noticed that some of the targets set by the resulting agreement between Gibela and PRASA are more stringent than this instruction.

The team, therefore, embarked on an independent study to understand the industry around each component, to interview current suppliers to understand the challenges prohibiting the local content target from being reached, to find alternative local suppliers, to study the technical standards and seek interpretations thereof, to make suggestions on how local content can be improved, and to come up with solutions.

The research results were not conclusive nor positive for all components, and the level of success varied for the different components. It was recommended that the options for each component be critically evaluated by Gibela, discussed, and negotiated with PRASA. Where it is proven that there is no local manufacturer or that it is impossible to increase local content, the instruction from National Treasury should be re-affirmed for the contract.

During the research, it was realised that other rail operators (Transnet, Gautrain, PRASA) have a similar challenge in achieving local content. Therefore, it was advised that the South African rail industry should work together and collectively approach the challenges of local content.

In June 2023, the team presented the research findings to Gibela and the representatives of the Department of Trade, Industry and Competition. The results were well received, and it opened opportunities for further discussions.

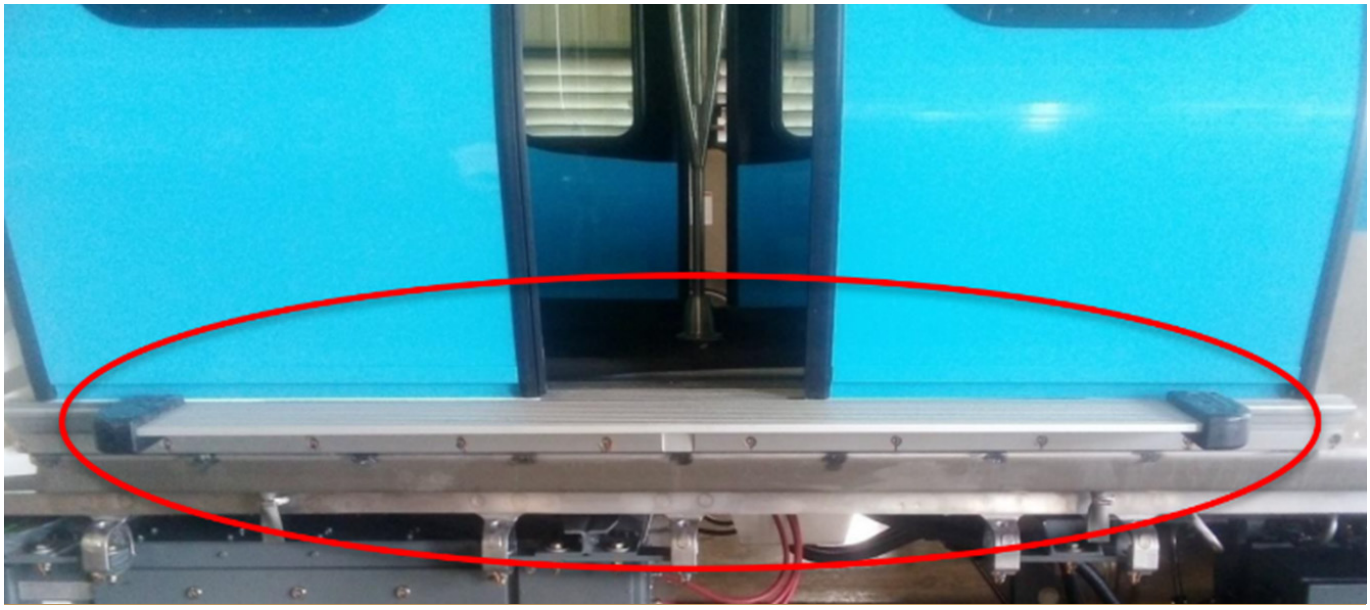

Figure 26: An aluminium door threshold.

Figure 27: A typical flexible hose.

Figure 28: Typical electrical cables.

11 - INTERACTIVE ENGAGEMENTS WITH GIBELA

DATE	EVENT	VISITORS
6 May 2023	Stellenbosch Faculty of Engineering Open Day	Nitesh Munillal Joseph Mudau
20 September 2023	Factory visit to Dunottar	Annie Bekker (Chair) Pieter Conradie (Chief Chair Engineer) Herman Engelbrecht (Head of Department Electrical & Electronic Engineering) Petri Meyer (Vice Dean Research and Industry Liaison)
23 November 2023	Gibela seminar at Lanzerac Estate, Stellenbosch	Sipho Bambisa, Preshni Govender, Loyiso Giya, Dolly Mathebula, Mpho Lelala-Mnguni, Tsholofelo Mokolopo, Collin Motau, Nitesh Munilall, Mike Scrooby, Karabo Serunye
9 December 2023	Mechanical Engineering awards ceremony	Sipho Bambisa

11.1 STELLENBOSCH UNIVERSITY FACULTY OF ENGINEERING OPEN DAY

On the 6 May 2023, Stellenbosch University's Faculty of Engineering hosted its annual Open Day. Open days provide an opportunity for prospective students, their families, and other stakeholders to explore the university's campus, facilities, laboratories, libraries, and resources. This firsthand experience helps visitors understand the physical environment where learning and research take place. Nitesh Munilall accompanied by Joseph Mudau attended the 2023 Open Day.

The duo was exposed to cutting edge campus facilities in the departments of Mechanical and Mechatronic Engineering, Civil Engineering, and Industrial Engineering. Specifically, the Structural Laboratory in Mechanical and Mechatronic Engineering which also houses the Vibration Laboratory. These laboratories showcase university capabilities in the mechanical measurement and testing of assets and structures. These technologies are fundamental to asset monitoring approaches in Gibela Research projects. Monitoring approaches are first tested and developed in a laboratory environment before deployment and evaluation in Gibela's depots. Open day demonstrations showcased the application of measurement tools used in an interactive manner for attendees to assimilate the measurement process.

The tour extended to the Department of Civil Engineering, where Nitesh and Joseph gained insights into groundbreaking research projects addressing challenges in infrastructure and urban development. Additionally, the showcase at the Department of Industrial Engineering demonstrated the capabilities of Stellenbosch University in optimising processes and improving efficiency in various industries. The interactions during the Engineering Open Day served as a platform for knowledge exchange and collaboration. Nitesh and Joseph expressed keen interest in ongoing research projects and queried potential applications of the Faculty's facilities to assist in achieving Gibela's objectives.

Figure 29: Open Day tour of the Structural Laboratory 2023.

11.2 GIBELA RESEARCH SEMINARS

The Chair at Stellenbosch University hosts an annual Gibela Engineering Research Chair Seminar in which all student projects are showcased through professional presentations. The seminar serves dual goals, firstly, to expose students to a presentation in a professional and scholarly environment, and secondly, to interact with Gibela personnel around student work and technical topics. The surroundings were selected to create a comfortable and interactive environment to facilitate mutual discussion, increased industry impact and future project directions. It is foreseen that the seminar will grow to an increasingly stimulating and supportive environment to foster collaboration, feedback, encourage scholarly growth, and a networking platform which will be used to advance knowledge in the rail industry in South Africa.

To date, two Gibela Research Seminars have been hosted at Lanzerac Wine Estate, Stellenbosch. The seminar is registered for CPD (Continuing Professional Development) points and attended by rail industry players from Gibela Rail Transport Consortium, PRASA, Alstom as well as students and academics from Stellenbosch University. In order to increase access, the seminar is also hosted online.

DATE	NUMBER OF STUDENT PRESENTATIONS	KEYNOTE PRESENTER FROM GIBELA	TOTAL NUMBER OF ATTENDEES (ONLINE AND IN-PERSON)	INDUSTRY ATTENDANCE
22 November 2022	7	Dr Buyiswa Mncono-Liwani	85	Gibela PRASA Alstom Industry Experts SUN (22)
23 November 2023	12	Nitesh Munilall	65	Gibela PRASA Industry Experts SUN (27)

Each year the programme has been opened by the GERC Chair, Prof Annie Bekker, followed by keynote presentations from Gibela. In 2022 the keynote talk was delivered by Dr Buyiswa Mncono-Liwani (Corporate Services & Traction Motors Operation Executive) whereas Mr Nitesh Munilall set the scene for the 2023 seminar. From here, the speaking slots were filled with student presentations and interactive questioning from the floor. Sessions following each presentation allowed participants to delve deeper into the research presented. The event was not only an intellectual exchange but also a professional development opportunity, offering 0.6 CPD points to attendees.

A highlight of the seminar includes that the top speaker of each annual event is determined through votes by the audience. Best Speaker Award is decided based on overall presentation skills as well as the perceived quality research content. In 2022, this award was bestowed on Nelisa Mabaso, whereas Enrico Lubbe won the Best Speaker Award in 2023.

In 2023 the seminar was concluded by Prof Petrie Meyer, Vice Dean: Research and Industry Liaison, who stressed the importance of University-Industry relationships. Looking towards the future, the seminar is poised to disseminate the content of research studies and to initiate discussions on future research projects. Such interactions create an avenue to bridge the gap between theory and application. The active participation and involvement of industry and academic professionals display the commitment to spur a vibrant synergy in South African railway research.

Figure 30: The annual GERC Seminar is hosted in Cellar Hall at Lanzerac Wine Estate.

Figure 31: In-person attendees for the 2022 GERC Seminar.

Figure 32: A group photo of 2023 GERC Seminar attendees on the steps of the Lanzerac Cellar Hall.

Figure 33 : Dr Buyiswa Mncono-Liwani opened the 2022 GERC Seminar.

Figure 34: In 2022 attendees were engaged through a Kahoot quiz ice breaker session.

Figure 35: Collin Motau uses the opportunity for questions and discussion.

Figure 36: Nitesh Munilall sets the scene for the 2023 GERC Seminar.

11.3 DEPARTMENTAL ENGINEERING AWARDS CEREMONIES

The Departments of Mechanical and Mechatronic and Industrial Engineering host an annual awards ceremony to conclude the undergraduate academic year. It celebrates the outstanding achievements and contributions of engineering students and recognises students across all four years required to obtain a Bachelor's Degree from either department. The ceremony, held at the Wallenberg Research Centre, brings together the engineering community in a spirit of recognition and camaraderie.

A highlight was the acknowledgment of projects sponsorship by industry partners, with a special mention of Gibela Rail Transport Consortium. Gibela sponsors the "Best Final Year Railway Project" award. This award celebrates a project that showcases exceptional innovation and application within the realm of mechanical, mechatronic, and industrial engineering, specifically in the dynamic field of rail transport. The trophy is a custom manufactured 3D printed replica of the of the face of the X'Trapolis Mega trainset, an iconic symbol of cutting-edge rail technology. These projects not only demonstrated academic prowess but also underscored the practical relevance of engineering in addressing real-world challenges within the rail industry.

The winner of the 2022 "Best Final Year Railway Project in Mechanical and Mechatronic Engineering" was Wikus Venter with the research topic: "Measurement of Locomotive Aerodynamic Load Coefficients". The 2022 "Best Final Year Railway Project in Industrial Engineering" was claimed by Nelisa Mabaso – the title of her project was "Machine Learning Implementation for Railway Sub-System Failure Predictions". Mr Loyiso Jiya was present to award the winners for the 2022 awards ceremony. For the 2023 academic year the winning project was titled "An optical rail wheel measuring solution" by Anique Phillips. Mr. Sipho Bambisa, representing industry partner Gibela Rail Transport Consortium, graced the stage to personally hand over the trophy to Anique Phillips.

Gibela's support highlighted the industry's recognition of the crucial role mechanical and industrial engineering plays in advancing rail technology. This synergy between Stellenbosch University's academic excellence and industry sponsorship exemplified the departments' commitment to fostering meaningful connections, driving innovation, and preparing students for impactful careers in engineering, particularly within the intricate landscape of rail transportation. The awards served as a testament to the departments' dedication to producing graduates who are not only academically proficient but also poised to make substantial contributions to the evolving needs of the industry. A summary of prize-winning projects is provided in Table 9.

Table 9: A summary of GERC student awards.

YEAR	DEPARTMENT	PROJECT TITLE	STUDENT	SUPERVISOR
2022	Mechanical and Mechatronic Engineering	Measurement of locomotive aerodynamic load coefficients	Wikus Venter	Dr Mike Owen
2022	Industrial Engineering	Machine learning implementation for railway sub-system failure predictions	Nelisa Mabaso	Dr Sydney Kasongo
2023	Mechanical and Mechatronic Engineering	An optical rail wheel measuring solution	Anique Phillips	Pieter Conradie

Figure 37: Wikus Venter receives his award from Mr Loyiso Jiya in December 2022.

Figure 38: Dr Kasonga receives the award on behalf of Nelisa Mabaso (2022)

Figure 39: Mr Sipho Bambisa presents Anique Phillips with the trophy for Best Final Year Railway Project in Mechanical and Mechatronic Engineering, December 2023.

11.4 GIBELA VISIT TO STELLENBOSCH UNIVERSITY – FEBRUARY 2023

On the 23rd and 24th of February 2023, the GERC hosted Nitesh Munilall and Joseph Mudau as the Heads of Engineering and Training Departments respectively, at Stellenbosch. This visit served to introduce Mr Munilall as the newly appointed Head of Engineering at Gibela to the University and its capabilities. Significant time was afforded to discussions on Gibela Rail Transport Consortium and Stellenbosch University and the respective core business activities to clarify the role of the GERC.

Figure 40: Formal in-person discussions on Gibela and Stellenbosch University's core business needs and strategy.

Figure 41: Nelius Bekker leads a visit to the Electrical Machine Laboratory at Stellenbosch University.

Gibela visitors were introduced to the capabilities and functionalities of the state-of-the-art Vibrations Laboratory within the Structural Laboratory at the Department of Mechanical and Mechatronic Engineering. A demonstration simulated a measurement set-up identical to the rig used to automate the detection train wheel flats at the Paarden Eiland Train Depot. The visitors were also shown the capabilities of the department in the Mechatronic, Mining and Virtual Reality Laboratories. The tour included a visit to the Department of Electrical and Electronic Engineering where Nelius Bekker launched an impressive indoor lightning display in the High Voltage Laboratory. Another noteworthy location included the Electrical Machine Laboratory where the Faculty houses its motor, generator and turbine developments.

The visit entailed some social and active interactions in the beautiful Stellenbosch environment. This included lunch at Postcard Café and a short, but hilly hike on the slopes of Simonsberg. Networking in this informal setting enabled free discussion. Stellenbosch University aims to build relationships with industry leaders, such as Gibela, as these partnerships can lead to opportunities for internships, employment and research collaborations for students and the Faculty.

Figure 42: Nitesh Munillal, Pieter Conradie, Michael Perumal and Joseph Mudau at the picturesque Postcard Cafe in Stellenbosch.

12 HIGHLIGHTS

12.1 TECHNICAL SITE VISIT FOR INTERNATIONAL RAIL SAFETY COUNCIL (IRSC) CONFERENCE

Figure 43 : Gibela attendees at the IRSC conference technical tour, also enjoying train rides.

In October 2023, more than 150 delegates from around the world came together for the five-day 31st International Railway Safety Council (IRSC) conference held in Cape Town and hosted by the Rail Safety Regulator (RSR). The RSR requested the GERC host a technical tour for 150 delegates as part of the conference activities. The GERC identified Winelands Light Rail as a venue to showcase rail research in collaboration with the Civil Engineering Department from the University of Pretoria.

Delegates were warmly received by student ushers and treated to true South African hospitality. Mr Sisa Lunga Mtwa (Deputy Chairperson: RSR Board) welcomed delegates, whereafter Prof Hannes Gräbe (UP) and Dr Megan Bruwer (SUN) discussed the strategic role of academia in rail research. Following the formalities, delegates witnessed rail experiments which showcased the core of the rail research thrust at the respective institutions.

Together, the demonstrations resulted in a tour comprising:

1. Automatic wheel flat detection on the wheels using rail-mounted accelerometers.
2. Train-based vibration monitoring.
3. Track condition measurement using smart track components.
4. Robotic rail incident investigations using Smwoef, the robotic dog from University of Pretoria, and drones.
5. Rail safety training using virtual reality.

Delegates rotated between the experiments and could interact with the researchers. The feedback showed that the experiments are innovative and much needed to transform the rail industry. There was also enough time to ride the miniature trains of Winelands Light Rail, and some lucky ones got to drive a steam locomotive.

12.2 WESTERN CAPE RAIL SAFETY OUTREACH 2023 ATTENDED BY DEPUTY MINISTER OF TRANSPORT

On 6 December 2023, the Deputy Minister of Transport, Mr Lisa Nkosinathi Mangcu, attended the rail safety outreach in the Western Cape, where learners from Rietenbosch Primary School were hosted at Winelands Light Rail and at SUN.

Figure 44: The Deputy Minister of Transport, Mr Lisa Nkosinathi Mangcu, participating in the activities.

The day turned into a high profile gathering with dignitaries in attendance as listed in Table 10. The dignitaries interactively engaged with the rail safety outreach activities and learners. The Deputy Minister led the charge to sign the Rail Safety Pledge, setting an example to the learners who followed.

He afforded everyone present the day's highlight when he enthusiastically operated a mini steam train. After the activities at Winelands Light Rail, the learners travelled to Stellenbosch University's Faculty of Engineering where they were received in the Department of Civil Engineering. The Dean of the Faculty, Prof Wikus van Niekerk, together with Prof Nico Koopman (Deputy Vice-Chancellor) and university management, received the Deputy Minister and his entourage.

Table 10: Dignitaries visiting the GERC Rail Safety Outreach.

NAME	DESIGNATION	AFFILIATION
Mr Boy Johannes Nobunga	Board Chairperson	Rail Safety Regulator
Mr Mmuso Selaledi	Acting CEO	Rail Safety Regulator
Ms Madelein Williams	Media and Communications Executive	Rail Safety Regulator
Mr Loyiso Jiya	Head Of Communication	Gibela Rail Transport Consortium
Mrs Maphefo Anno-Frempong	CEO: Transport Education Training Authority	Training Authority (TETA) on one line
Mr Sabelo Mbuku	Head of Marketing & Communications	Transport Education Training Authority (TETA)
Ms Dineo Mathibedi	RSR Board member	Rail Safety Regulator
Mr Chris de Vos	RSR Board member	Rail Safety Regulator
Adv Collen Weapond	RSR Board member	Rail Safety Regulator
Dr Peaceman Sopazi	Regional Technical Manager: Eastern Region	Rail Safety Regulator

12.3 ACADEMIC ACHIEVEMENTS

Three final year students excelled to earn their GERC Final Year Projects cum laude. Anique Phillips, Enrico Lubbe and Dániel du Toit passed the scrutiny of their individual examination panels, comprising of one independent engineering examiner from industry, the examining supervisor and a moderator, both from the Department of Mechanical and Mechatronic Engineering. Whereas Anique Phillips won the award for the Best Final Year Project in Rail Engineering, Erico Lubbe was voted as Best Presenter at the GERC Seminar. Dániel du Toit was awarded the prize for the Best Final Year Project focussed on MATLAB Simulink.

Figure 45: Dániel du Toit received the award for the Best Final Year Project focussed on a MATLAB Simulink project from Prof Johann van der Spuy (Head of Department: Mechanical and Mechatronic Engineering).

12.4 ACQUISITION OF MEASUREMENT EQUIPMENT FOR GERC RESEARCH

To support the GERC vision to contribute to techniques to inform the state and behaviour of Gibela trains, the Chair has made a significant investment in versatile measurement equipment to facilitate innovative approaches for onboard and wayside measurements. HBM data acquisition devices were selected for their excellent support and existing adoption in the rail industry. This equipment allows for versatile measurement installations with data acquisition through diverse sensors. Possibilities include cameras, lasers, microphones, GPS antennas, strain gauges and accelerometers.

The equipment was specified to enable multi-channel testing on a single comprehensive project and topic or a split between various rigs. This enables dynamic deployment of the measurement hardware to cater for the dynamic needs of parallel investigations. The equipment includes:

- Three HBM Quantum MX840B data acquisition devices to record data.
- One MX1615 strain amplifier to measure with strain gauges.
- A CX22 linked to a 5G router which can be configured to allow for standalone remote testing and cloud data uploads.
- Three Micro-Epsilon lasers to measure profiles and displacements in a non-contact fashion.
- Four LVDTs to measure displacements.
- Four SLB strain sensors with custom clamp-on brackets to mount directly to the rail.
- Four Basler cameras and six different Edmond Optics lenses to capture footage of trains.
- Four PCB ICP accelerometers that can withstand measuring the harshest wheel flat.
- Low-noise co-axial cables for high quality signal transmission.
- Two robust Lenovo laptops for field testing.
- Two CatmanAP software licenses for recording multiple channels from different sensor types simultaneously.
- Four sturdy Nanuk cases to transport sensitive equipment to various test locations.
- Two 1.1kW Ratpack portable lithium power stations to facilitate field testing far away from fixed power points.
- A plethora of containers and trays to organise the equipment and maintain their condition.

The bulk of the purchase was funded by the Chair following a thorough tender process and review by an independent board. Additional funding was leveraged from the Department of Mechanical and Mechatronic Engineering to acquire the Basler camera kit and accelerometers.

Figure 46: Newly acquired equipment put to use on site.

13 THE WAY FORWARD

In closing, sincere appreciation is extended to all who have contributed to initiate the Gibela Engineering Research Chair (GERC) at Stellenbosch University. The first years of this collaboration between academia and industry have already yielded a beneficial cross-pollination of knowledge.

The establishment of the GERC emerged from a shared vision to create an advanced hub of knowledge, innovation, and practical application in railway engineering. Since its inception in 2022, the Chair has embodied the ideals of excellence, leadership, and social responsibility. This report stands as a testament to the initiation of tangible activities of researchers, students, and partners to bring this vision to life.

The impact of the GERC is detailed in student projects, Master's research, and PhD initiatives in projects with practical relevance to the rail industry, including safety improvements to technological advancements. The focus on digital twin technology and asset management for the X'Trapolis Mega passenger trains has emerged as a future research focus with the aim to pursue innovative solutions for decision support in maintenance and asset operation. This interdisciplinary pursuit enables contributions from research strengths in various engineering fields, ensuring that the research is both comprehensive and cutting-edge.

Equally important is the dedication to social responsibility. The Chair has successfully created and hosted a Rail Safety Program for schools to raise awareness about rail transport and safety. The partnerships cultivated the Railway Safety Regulator are indicative of the broader impact of the work. This opportunity is further leveraged to expose scholars to Science and Technology thereby aiming to inspire young minds to consider careers in engineering. This is an investment made in the future of the industry and the country.

Looking ahead, the GERC remains committed to its core duties: advancing high-quality research, training skilled engineers, providing academic leadership, and assisting Gibela with engineering challenges. With continued support and collaboration, the foundation built can lead to increased momentum and deliverables in the years to come.

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