eNtsa
innovation through engineering

Annual Report

2019 / 2020

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Innovation through Engineering

Our Strategic Partners

NELSON MANDELA UNIVERSITY

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

technology innovation AGENCY

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Director's Foreword

I have to be honest, if I go back to my reflections of November 2018, looking ahead towards 2020 and the associated financial planning, there was an uncomfortable apprehension within me. eNtsa, as a business unit, was focused on high-value engineering in a niche field, depending heavily on innovation of new engineering technologies and associated solutions. This narrowed our potential client base down considerably as this type of business is dependent on very high capital input with high engineering risk to success. At that point, many companies in South Africa had lost their appetite for venturing into this high-risk arena. Very few people realised that the WeldCore® technology, which is a core technology for financial sustainability in eNtsa, cost about R32 million before we started the first applications.

The eNtsa management team, with the support and "buy-in" from of all the staff unpacked the challenges for 2020 by reorganising the teams within eNtsa with the focus on increasing effectiveness at all levels of our day-to-day business. We had worked hard on obtaining a good understanding of the external and internal challenges and how to be flexible in our response to a rapidly-changing operational environment. eNtsa developed a culture to constantly look at future markets, assess changes and position ourselves to respond to opportunities in an innovative way. The 2019 question was How does eNtsa unlock "new" energy to drive eNtsa forward in the current disruptive business environment?

With a clear focus on how we wanted to do business and ensuring that we worked towards this, eNtsa turned what was perceived to be a very difficult year into a record year from a financial turnover point of view. Therefore, it is with sincere gratitude that we reflect on a successful year for eNtsa, which ended on 30 April 2020, counting our blessings, as they were abundant. The eNtsa staff really worked hard despite university and externally-based challenges, and I sincerely believe that our success was embedded in the attitude of the eNtsa staff. We have a staff complement of which by far the majority performed their day-to-day tasks as leaders with very little space for followers. We converted our dreams into goals, and as Napoleon Hill states, "A goal is a dream with a deadline".

On reading through this annual report, you will observe some remarkable success stories, all achieved by careful planning and good "old fashioned" hard work. Despite some difficult obstacles, the eNtsa staff persevered and delivered excellent work to overcome a very challenging year. I would like to thank all staff members for their share in assisting, through their actions, and writing the 2019/2020 eNtsa success story. I would like to express my thanks to the eNtsa Board, for their loyal support during the past year and guiding this very unique group to end another year on a high. We at eNtsa also greatly appreciate and thank every individual, institution and company whose paths crossed that of eNtsa in some way during the past year. We are ending the current year and starting the new financial year in a state of "lockdown", an unfamiliar territory for all of us and we can just pray for courage and wisdom from our heavenly Father to lead us through these challenging times. With HIS support, we have hope that the new financial year will be positive and exciting for everybody.

"Success is not final; failure is not fatal: it is the courage to continue that counts."
Winston Churchill

Prof. DG Hattingh, eNtsa Director, March 2020

1. eNtsa: Overview

eNtsa is acknowledged internationally as an innovation hub that supports research, design and technology assimilation for the broader manufacturing sector, with a focus on the automotive, power generation and petrochemical industries. eNtsa, a registered engagement institute of Nelson Mandela University, hosts a number of programmes and projects to advance engineering support for technology and human resource development within South Africa.

eNtsa contributes to industry with a vast range of specialised services, which are aimed to support and stimulate local innovation through supplier development initiatives. As a result, eNtsa is able to ensure that much needed engineering skills, services and training are more readily available to SMEs operating in the local manufacturing and automotive sector through our Technology Station Programme (TSP), supported by the Technology Innovation Agency (TIA).

Our Advanced Design and Modelling capabilities provide a comprehensive range of mechanical design and consulting services, which range from mechanical parts or system's design, through simulation of parts or systems by advanced finite element analysis (FEA).

Mechanical and material testing services focus on providing professional metallurgical services in the field of failure investigation and assessing process/production-related material challenges. Other services include material conformance testing with regard to material microstructure, chemical composition, environmental and mechanical properties.

Our Training Academy initiative supports efforts focused at supplier development by providing skill development interventions to our staff and students, local industry and our engineering community.

The uYilo eMobility Technology Innovation Programme is a multi-stakeholder programme hosted by eNtsa and initiated by the Technology Innovation Agency (TIA), which operates with a mandate to actively enable, facilitate and develop the electric mobility industry in South Africa. The facilities and services established within uYilo extend across a National Accredited Battery Testing Laboratory, an Electric Vehicle Systems Laboratory and a Live Testing Environment that provides a holistic enabling environment for the development of the electric mobility eco-system in South Africa.

Industrial R&D focus is currently on expanding research and technology transfer particularly in the field of Batteries, Small Sample Material Evaluation, Friction Hydro-Pillar Processing, Heat Treatment Solutions and Laser Processing (complex cutting, welding and metal deposition). The main R&D effort currently is to contribute new knowledge that will assist with managing the engineering challenges associated with safely prolonging the life of high value components, in certain instances well beyond the original design life.

eNtsa continuously strives to enhance technology innovation and to stimulate a climate of sustainable socio-economic growth in South Africa, and maintains strong relations with the Technology Innovation Agency (TIA) and the Department of Science and Innovation (DSI).

eNtsa's developmental growth since inception

2002
- **Supplier development**

2007
- Supplier development
- **Research & Development**
- **Large-scale engineering projects**

2010
- Supplier development
- Research & Development
- Large-scale engineering projects
- **Contract research**
- **Commercialisation**

2012
- Supplier development
- Research & Development
- Large-scale engineering projects
- Contract research
- Commercialisation
- **uYilo E-mobility Programme**

2015
- Supplier development
- Research & Development
- Large-scale engineering projects
- Contract research
- Commercialisation
- uYilo E-mobility Programme
- **Composite Innovation Centre**

2018
- Supplier development
- Research & Development
- Large-scale engineering projects
- Contract research
- Commercialisation
- uYilo E-mobility Programme
- Composite Innovation Centre
- **Training Academy**
- **Business Development & Client Relations**

2. About eNtsa

Our Vision

Engineering innovative solutions for a sustainable future

Our Mission

- To be a workplace of choice
- To deliver innovative engineering solutions and services
- To facilitate knowledge and skills development
- To create new business and business opportunities
- To develop a culture of innovation and entrepreneurship
- To leverage local and international partnerships for socio-economic growth
- To develop an organisation that is adaptable, sustainable and motivated

Our Slogan

"Innovation through engineering"

Our Values

Teamwork

- We are committed to common goals.
- We expect everyone to actively participate on the eNtsa team
- We openly communicate up, down and across the organisation. Communication builds trust and trust builds cohesion.
- We value the diversity of our workforce We willingly share our resources.
- Our attitude is for altitude.

Integrity

- We never compromise our principles or values.
- We act with integrity, communicate respectfully and accept responsibility.
- We require ethnical, professional behaviour by all persons associated.
- We conduct our activities in an accountable and transparent manner.

Innovation

- We nurture creativity and entrepreneurship.
- We take calculated risks to advance innovation.
- We learn from our mistakes and do not punish those who make them.
- We promote and reward ideas that advance our institutions and support sustainable development.

Excellence

- We pride ourselves in delivering work that is of the highest quality.
- We strive to exceed expectations.
- We commit to quality management and continuous improvement.
- We take the responsibility for driving tasks and actions.

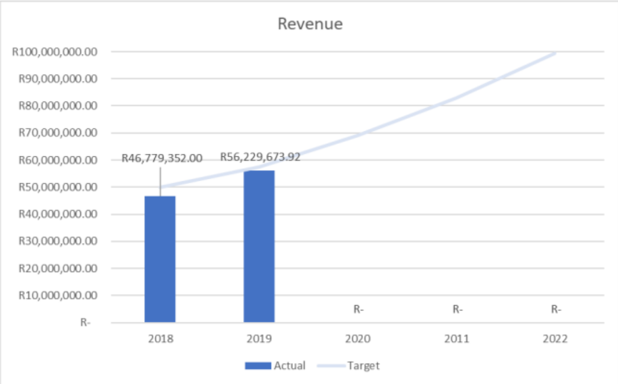
3. eNtsa Strategy

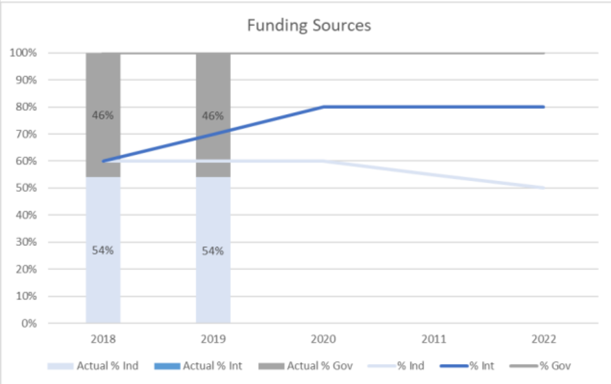
In a disruptive climate of accelerated technology and social changes, etNsa is reinventing itself to meet the challenges to benefit future stakeholders. In doing so, a high level five-year plan was developed named eNtsa's Vision 2020 that aimed to transform the technology center, operating inside an academic framework to a " World-class commercially-viable engineering orginaistation with a global footprint, while maintaining the core eNtsa DNA, innovation through engineering".

To achieve these goals, the following strategic aims have been set:

- Increase revenue by **30% year-on-year**
- **Increase HR efficiency** to increase profitability and sustainability
- Establish a **commercial arm** for eNtsa to provide new services
- Reduce government dependency by shifting client base to **local and international industry**

Progress towards the goals of Vision 2020 is being monitored on a continual basis.





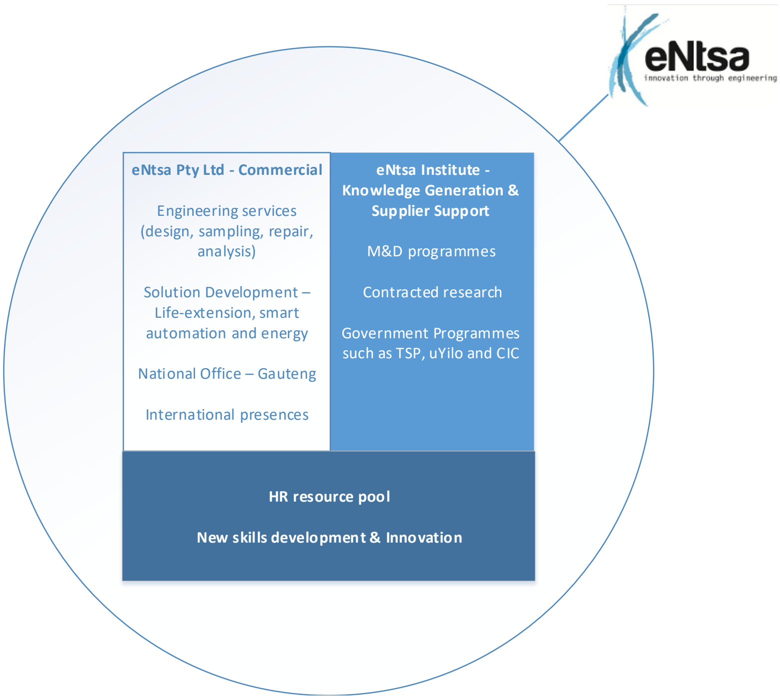
In the past year, eNtsa has made great strides towards establishing its commercial arm, which is key to unlocking the potential of Vision 2020.

The strategy for 2020 will focus on solidifying the strategic priorities identified in 2019, which are:

SO1: Less for more: Effective operations, focused on each strategic business unit in eNtsa.

SO2: Strengthen brand eNtsa: Focused on professional appearance.

SO3: Create a commercial arm



4. Our Portfolio

Development and Design Services

Mechanical Engineering Design and Analysis Services

• (CAE Services) • FEA analysis (simulation) and component design optimisation (Linear, Non-linear and Thermal analysis) • Product optimisation • Accurate CAD conversion • High-quality 2D/3D drafting and part detailing • 2D to 3D Design translation • Part design verification

Prototyping and Manufacturing

• 3D Printing • EDM Wire cutting • EDM Die erosion • 5-Axis CNC • CNC-Turning & Milling • Water-jet Cutting • Manual machining

Failure Investigation

•Failure mode analysis •Material conformity •Simulation-based analysis •Failure site analysis

3D Scanning and Optical CMM

• Portable laser scanning equipment • Scanning large components (0.3-6m) • Touch probe measurement • Scan-based design • Dimensional measurement and reporting for quality and design analysis

6-Axis Robotic Laser Cell

• Laser welding • Laser cladding • Laser profile cutting

Mechanical and Material Testing

Mechanical Testing

• Hardness • Tensile • Compression • Fatigue • Impact • Cyclic/Load component custom testing • Portable Hardness testing

Environmental Testing

• Salt spray testing • Cyclic corrosion testing • Thermal aging • Cyclic temperature/humidity exposure

Material Composition

• Spark Spectroscopy • Energy-Dispersive Spectroscopy (EDS) • Portable X-Ray Flourescence (XRF) • X-Ray Diffraction (XRD) • Carbon and Sulphur analysis

Optical Microscopy and Scanning Electron Microscopy (SEM)

• Materialography • Microstructural analysis • Weld penetration analysis • Coating thickness verification • Defect analysis • Failure surface analysis (fractography)

Small Sample Testing

• Static small punch testing • Small punch creep testing

Micro-CT Scanning

• Microtomography • 3D X-ray imaging • Non-Destructive testing (NDT) of porosity, structure, defect analysis, fibre orientation, etc.

Residual Stress Analysis

• Portable X-ray diffraction • Portable high speed incremental hole drilling

Stain and Deformation Measurement

• Portable digital image correlation (DIC) • Strain gauge measurement

Process Control and Automation

• Turnkey automation solutions • Circuit design

Battery Testing

• Lead-acid battery testing • Lithium-ion cells testing

• Other battery testing services include:

• Low current cell testing (coin and cylindrical) • Electrochemical impedance spectroscopy with model fitting capabilities (cells) • Start-stop testing of enhanced flooded batteries

Other Specialisation Areas and Services

• Customised innovative engineering solutions • Renewable 'green' energy • Joining technologies • Friction Processing (FP) • Specialised training

5. Engineering

5.1 Contract Research and Projects

By Donnie Erasmus (Deputy Director: Projects and Commercialisation)

To be a technological leader in your field requires focus and innovative solutions, these can be both daunting and costly. During the past financial year, it became evident, that to remain relevant, eNtsa had to lead areas of technology, create the space for these technologies and ensure customer uptake. This required careful planning and management of our available resources, to ensure long-term success and sustainability.

eNtsa is fortunate to have as its greatest asset, a competent, intelligent, diverse, multidisciplinary team, which mostly functions as an extended family. This coupled with great innovation, a solid, reliable and recognised network, both locally and internationally, leveraged to position ourselves as a sought-after and unique solutions provider to the Power Generation and Petro-chemical industry ensured we remain relevant.

Technologies which have been developed by eNtsa and exposed to industrial applications tend to fuel the fire of innovation. A prime example is the serration grinding technology utilised on two Kendal LP rotors in 2019 (see Figure 1).

Figure 1: Kendal LP rotor at Eskom Rotek Industries with all stages clearly visible

The serration grinding led to a requirement for development of a surface treatment process to induce desirable residual stresses on the ground surface. Whip peening, a surface modification technique was developed by eNtsa before usein conjunction with serration grinding, enabling us to offer a full surface treatment solution, from the removal of damaged material to modification of that which was remaining. Whip peening can be utilised in additional applications on rotor casings and other components, which require surface modification to resist the initiation of fatigue cracks (see Figure 2).

Figure 2: Typical whip peening tool

eNtsa is in the privileged position to count Canadian Natural Resources International (CNRI), Aberdeen, Scotland, as a client and partner in the development of friction welding solutions on oil rigs in the North Sea. Rotary friction welding is an accepted technique on certain everyday components, for example, side shafts in axles. Other sectors in industry have been slower to take up these techniques, and it is to this end that we count ourselves fortunate with CNRI.

To date, we have successfully completed two projects for CNRI and hopefully entrenched ourselves as a specialised welding solutions provider. The first project was to establish the feasibility of performing stitch welding, utilising Friction Taper Plug Welding (FTPW) to recover cracks. The challenge with FTPW has always been the ability to achieve fusion along the full length of the joint line. FTPW was successfully performed in a stitch weld scenario. Mechanical testing of the weld confirmed the feasibility of utilising this technique (see Figure 3).

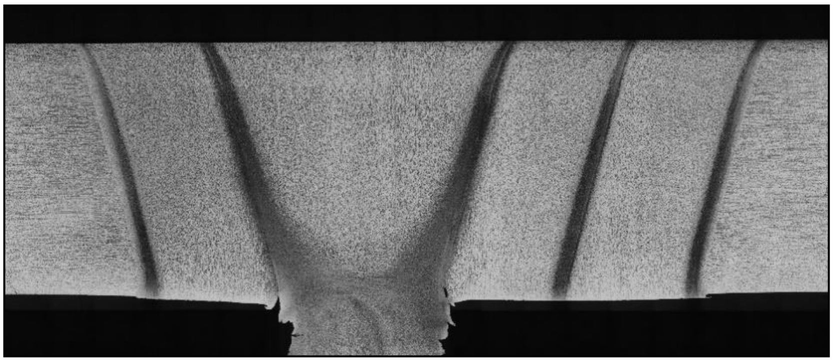


Figure 3: Stitch weld consisting of four FTPWs

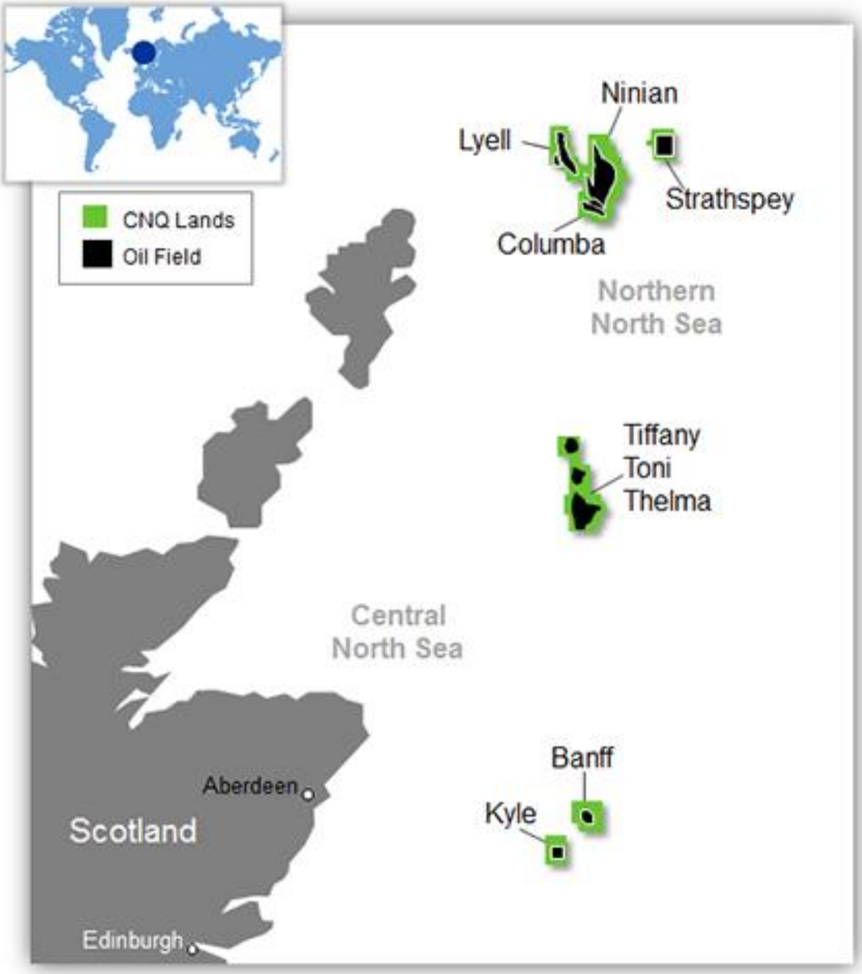


Figure 4: Ninian, Lyell and Columba fields are located in the Northern North Sea, around 386 km north-northeast of Aberdeen

There are inherent advantages in the ability to monitor critical plant parameters in real time. eNtsa identified this as an area, which could be developed into a service provided to industry. A project in this regard was completed earlier this year, and we are exploring the possibility with one of our large clients to potentially install a prototype system on their plant in 2020 for evaluation purposes.

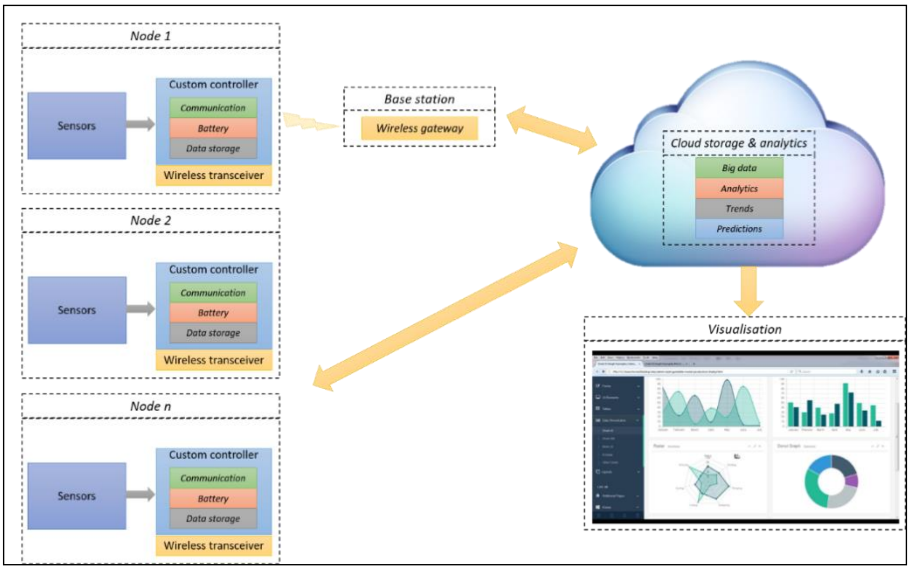


Figure 5: Online condition monitoring system overview

The welding of tubes to tube sheet in a heat exchanger cascade setup has always proven to be challenging owing to heat input and distribution during the welding process and proximity to each other, with a detrimental effect on the longevity of these joints. Industry is continuously seeking new and innovative means to improve the current method. eNtsa currently has an exciting project in this regard, and potentially a launch customer for the technique. Although this has been successfully demonstrated in a laboratory environment, we need to comply with certain mechanical tests after which we will seek approval to demonstrate it as a repair technique on existing heat exchanger cascades (see Figure 6).

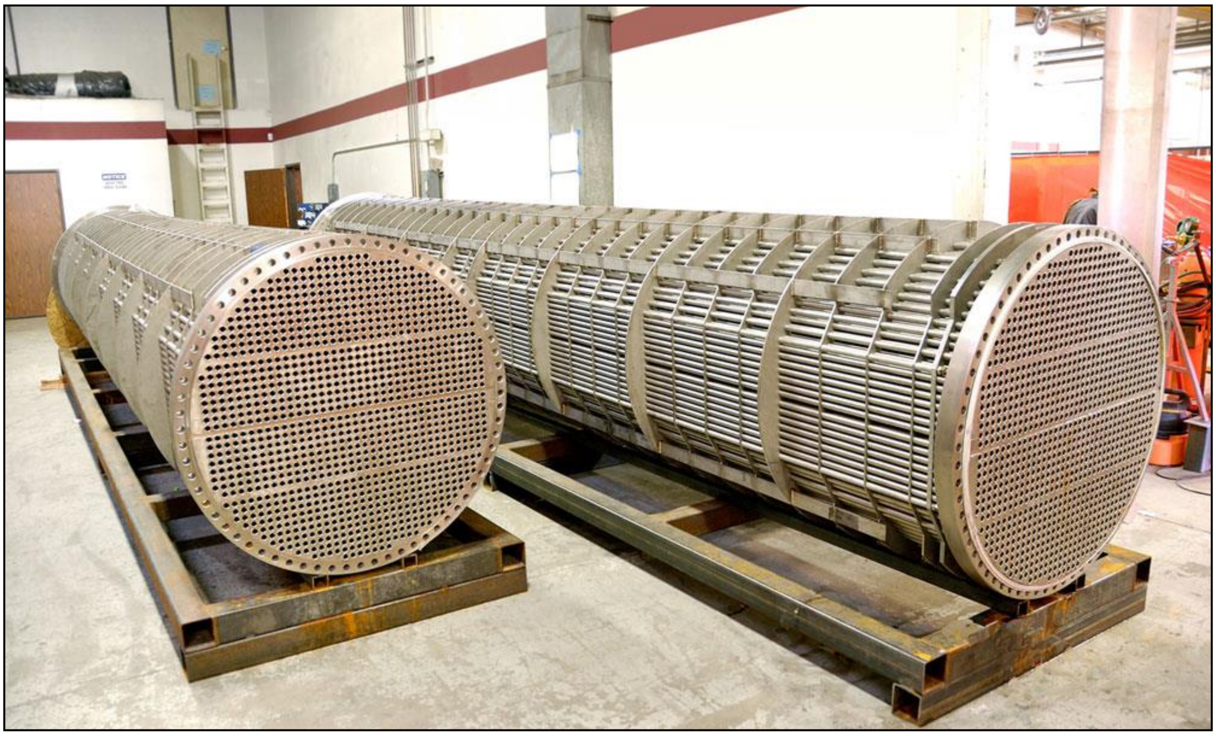


Figure 6: Typical heat exchange cascade setup(adapted from Google stock image)

Figure 7 illustrates the tube to tube weld setup in the eNtsa laboratory environment.

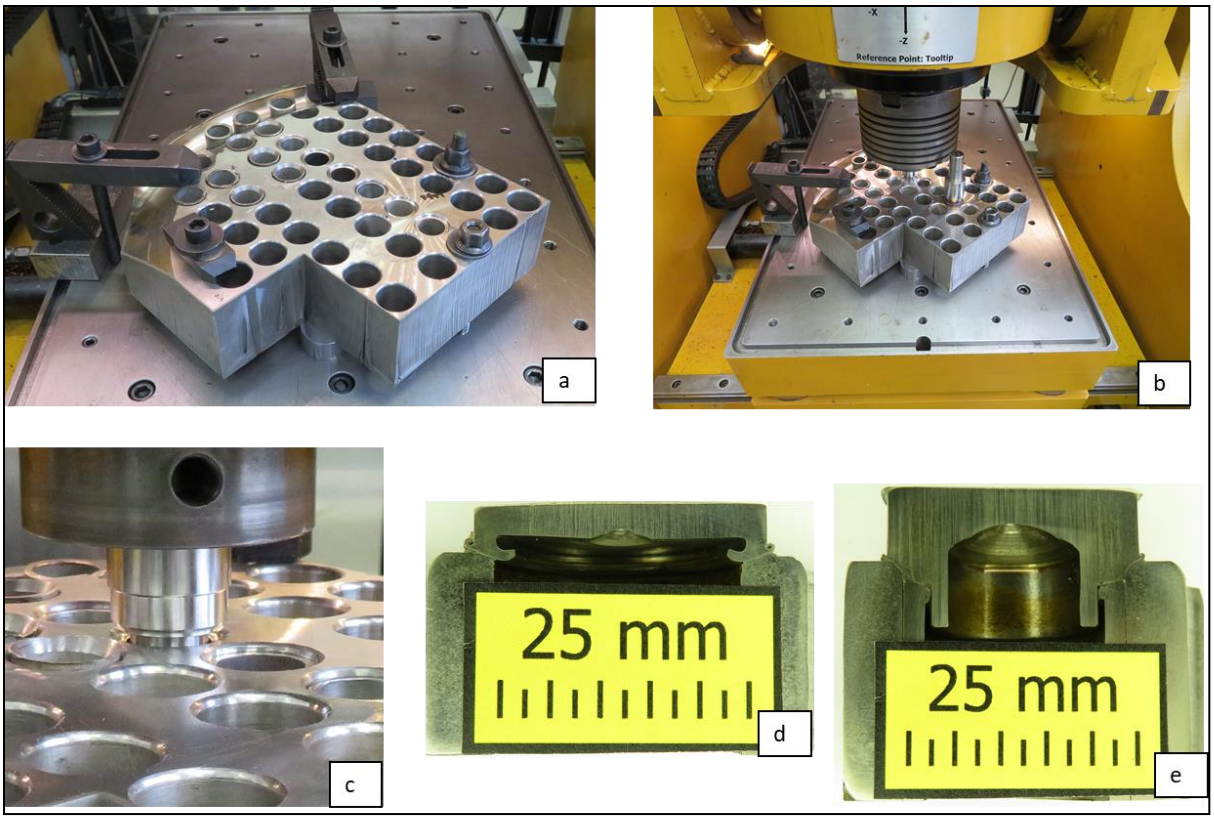


Figure 7: Tube-to-tube sheet weld setup in laboratory environment

One of the largest value projects within eNtsa, and the area we forecast as a major income source for the entity, is small sample testing. As with any new development which enjoys industry uptake, the reality is finding yourself in a constrained situation regarding space and equipment within a short timeframe. To comply with the individual project timelines, we had to invest heavily in upgrades and additional equipment to the small punch creep testing facility (see Figure 8).

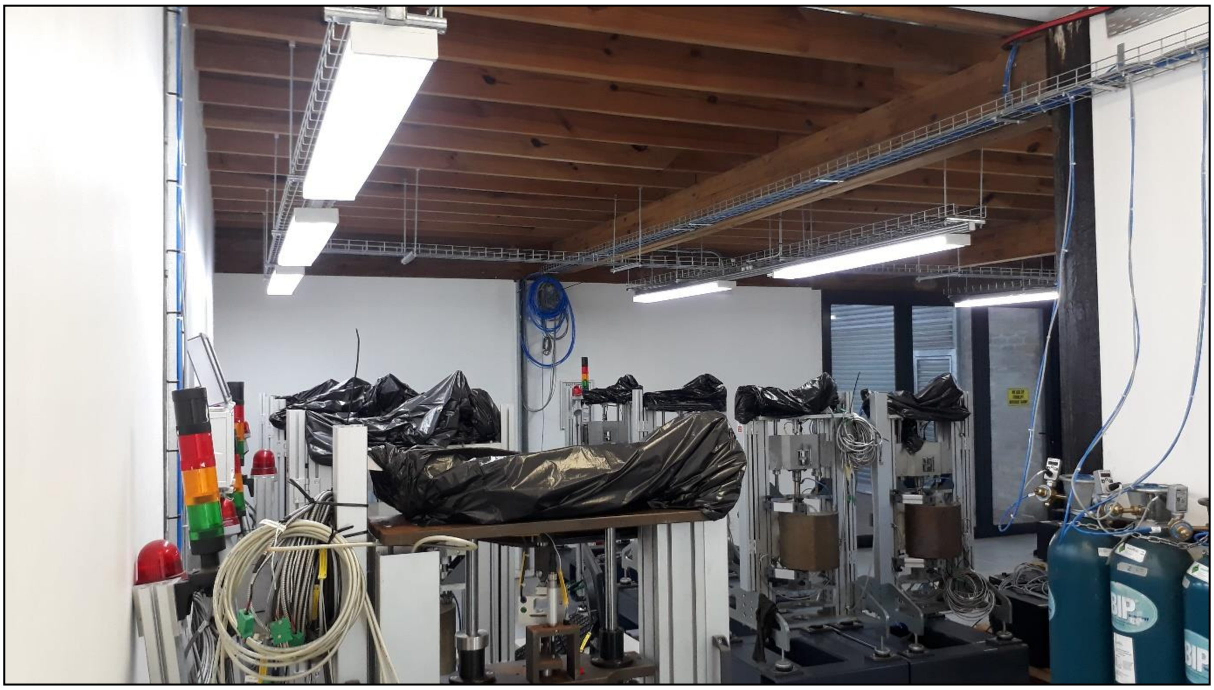


Figure 8: Small punch creep testing facility undergoing a major upgrade

The AMTC has two projects with eNtsa, one connected to the Oceans Economy and one focussed on IoT. The Oceans Economy project is the build component of a design we completed for AMTC in 2019 of a ocean glider. The IoT project involves the design and build of a multiple AGV system for use and demonstration in the Industrial Engineering laboratory (see Figures 9 and 10).

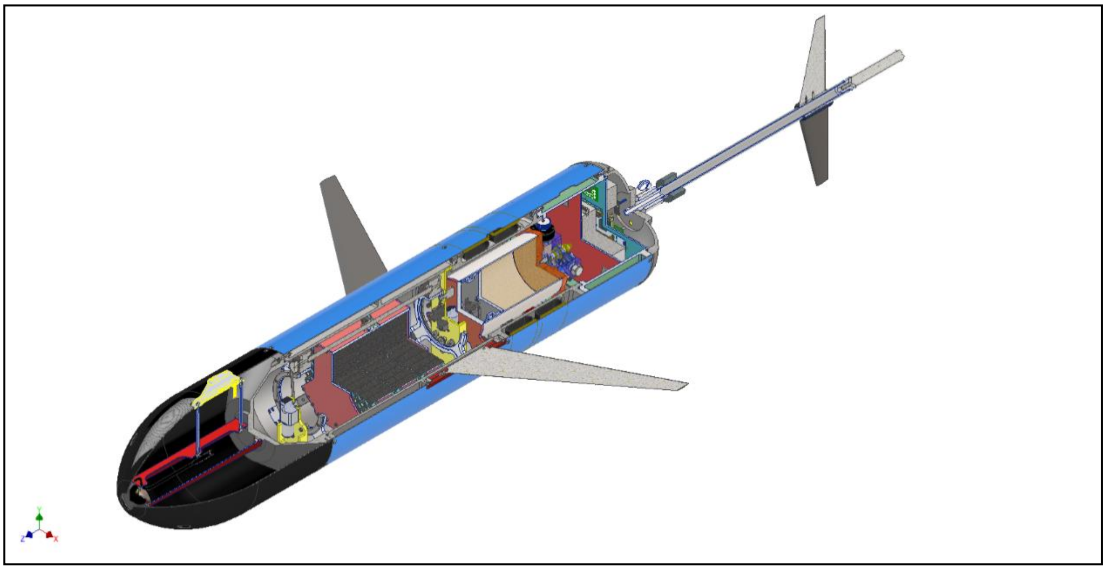


Figure 9: Designed marine systems glider, which has progressed to the build phase

Figure 10: One of the multiple AGV during the build phase

5.2 Advanced Design and Modelling

By Dr Ian Wedderburn (Deputy Director: Engineering)

The Advanced Design and Modelling group within eNtsa provides a comprehensive range of mechanical design consulting services. Capabilities range from basic mechanical and CAD design through to advanced finite element analysis (FEA), which allows the group to provide a multidisciplinary mechanical design service platform. The group makes use of a number of leading CAD platforms that allow seamless interfacing with the varying client systems. Aligned with the CAD systems, the team makes use of NX Siemens, advanced finite element analysis software, which provides linear and non-linear analytical capability.

The design group is capable of handling all phases of the mechanical design process from sketching through to detailed 3D CAD design and its associated issuing of detailed manufactured specifications and 2D CAD drawings. Other services include CAD draughting, component/design assessment, product development, re-engineering, design optimisation and 2D to 3D CAD translation. The group works closely with the automation capability within eNtsa. A vital component of any mechanical design process is component verification. The finite element analytical capability underpins the production of verified components and systems. The group has developed these services and has the capability to provide FEA services confidently to industry that cover linear static, buckling and non-linear (geometric, contact, and material non-linearity) approaches. Also included in the group's capabilities are modal, thermal and coupled thermo-structural analysis.

A few project highlights for the year were:

- **Design and build of an industry ready small punch testing unit**
- **Development of a novel surface treatment technique – Whip Peening (has now been provisionally patented)**
- **Upgraded small punch creep testing platform design**
- **Development of improved turbine serration grinding system**

A brief description of each of theseprojects is as follows.

5.2.1 Design and Build of an Industry-ready Small Punch Testing Unit (ACTS129)

Background Information

The significant advantage of Small Punch Testing (SPT) is that material properties can be derived from a very small sample of material, which would not be feasible through conventional test techniques. eNtsa had produced a research test platform that was utilised to investigate the test procedure. Through use of this platform, a number of improvements were identified that would improve the quality of the test data. This project was to develop 'industry ready' test equipment for performing SPT.

A SPT is used to determine a material's tensile properties and involves the use of a small disc of material to which an increasing load is applied via a small punch rod. The load versus displacement is recorded while the surface of the disc is visually monitored to record the initiation of a crack. Finite element modelling is then performed to reverse engineer the load versus displacement data thereby revealing the material properties.

Phase 1: Design SPT Platform with Integration of Improved Optical System for Manufacture

Once multiple engineering challenges were overcome, a final CAD design was generated as seen in Figure 11 .

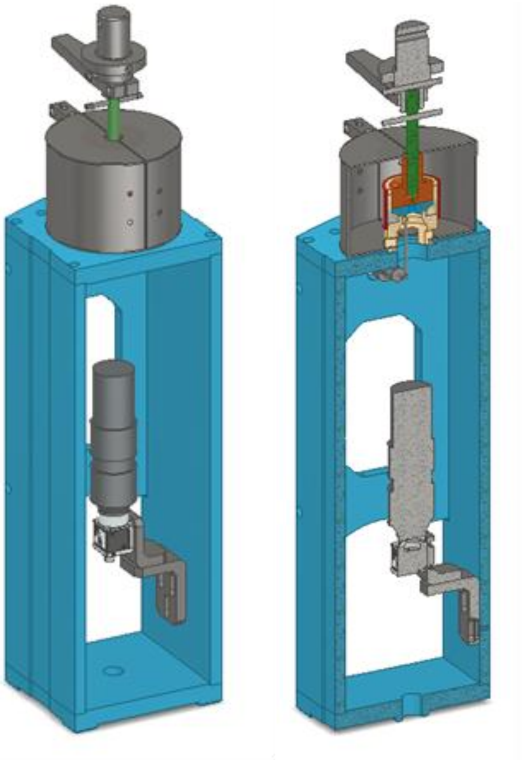


Figure 111: Full CAD models

Upon initial investigation of using Digital Image Correlation (DIC) for crack detection, it was discovered that the resolution of the existing DIC equipment was insufficient for detecting the initiation of cracks. A better route was to acquire a camera lens, which has an increase resolution, improved lighting and a DOF of at least 2 mm. After extensive research such a camera lens was located, it is a novel lens system, which only recently became commercially available.

The lens is a liquid telecentric lens with inline LED lighting. The liquid lens allows adjustment of the focal point as the lens cycles through an upper and lower limit specified by the user. This allows for a depth of field of approximately 20 mm, though for the SP test, using steel samples of 2 mm would be sufficient. Owing to the lens having an x1 magnification and the camera having a small sensor, the pixel density across the image is extremely high, meaning a crisp sharp image results. The inline lighting reduces reflections and simplifies the lighting solution (see Figure 12).

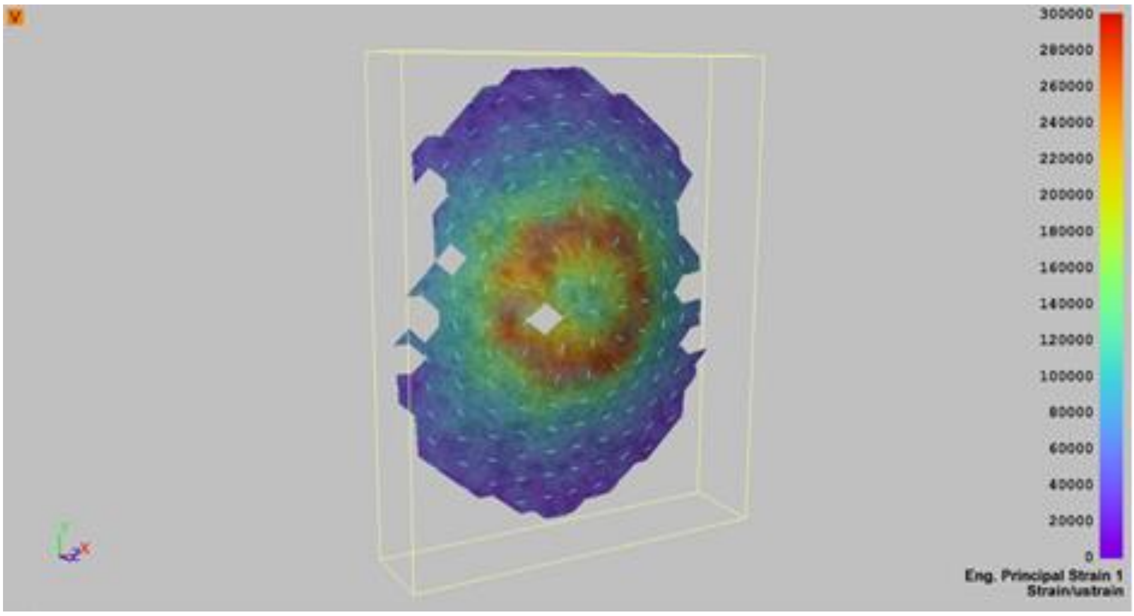


Figure 12: DIC investigation result

To ensure the platform can operate successfully at elevated temperatures, a transient temperature FEA was setup and evaluated. This was done in conjunction with the CAD design (see Figure 13).

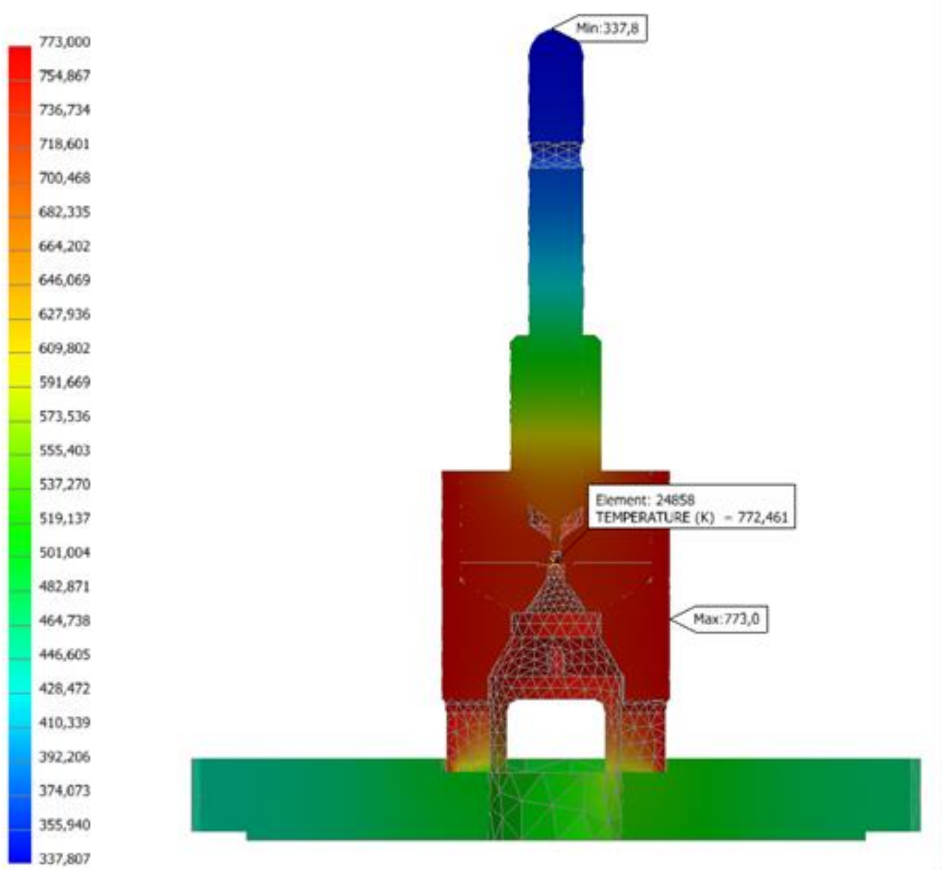


Figure 13: Transient temperature FEA solution

Phase 2: Equipment Manufacture and Assembly

Upon completing the CAD design of the equipment, the equipment was manufactured successfully. The equipment is shown in Figure 14.

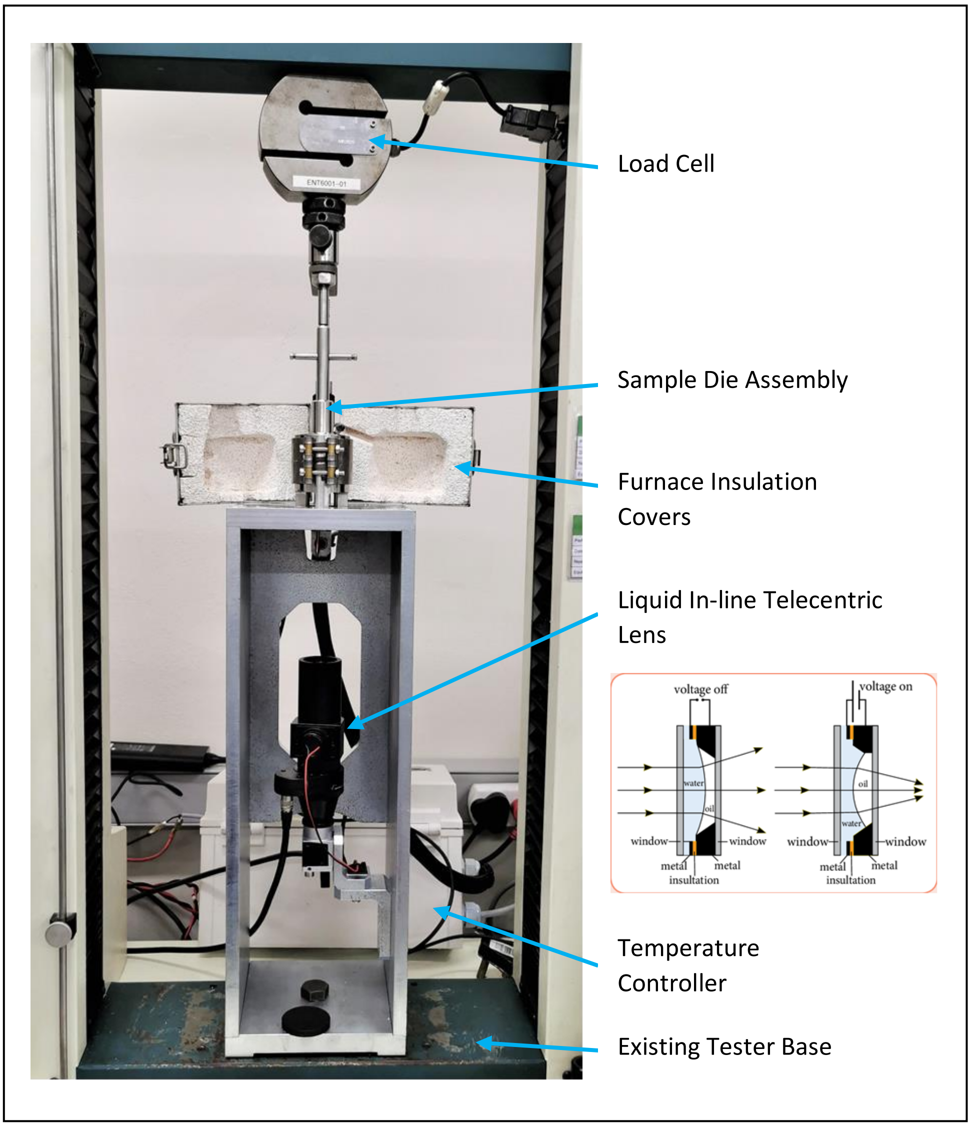


Figure 14: Assembled equipment

Phase 3: Equipment Verification and Testing

Upon completion of the equipment assembly, verification disc samples were prepared and tested. Initial tests were done at room temperature and then at an elevated temperature of approximately 500°C. The platform performed as expected and the image quality of the optical system has been significantly improved. Project specific temperatures would require further work in tuning the system's response so as to minimise overshoot and testing times. Figure 15 is the typical Force-Displacement Plot of a room temperature and elevated temperature test, which is retrieved after testing a sample.

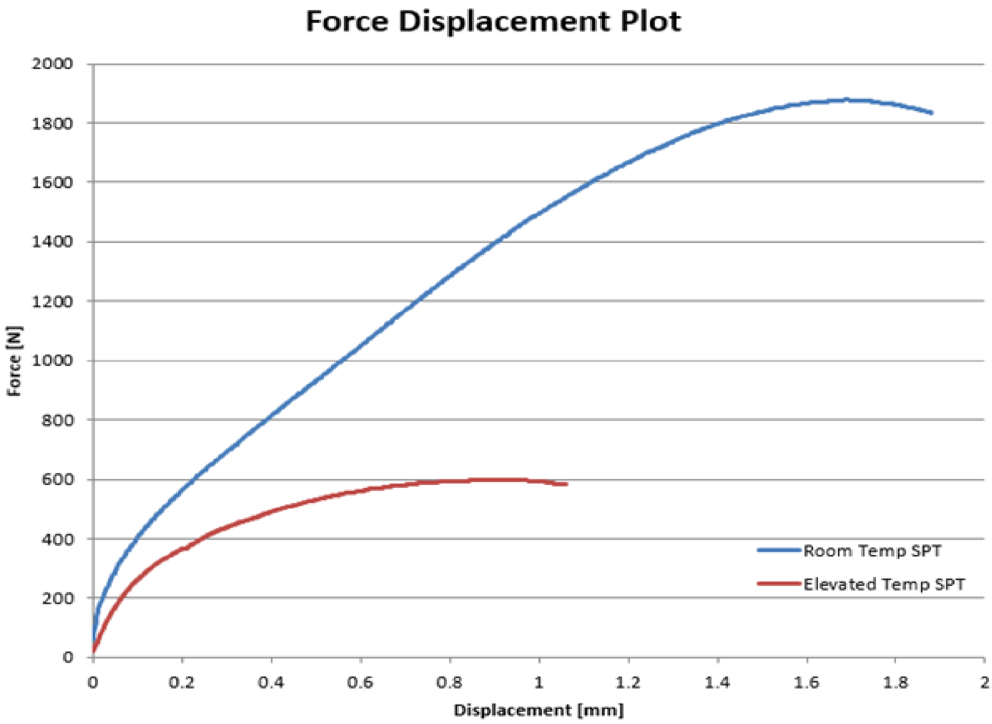


Figure 15: Force-Displacement Plot

Figure 16 is a side-to-side comparison of the image quality before and after the equipment upgrade. Though not particularly visible in the document format, the old system imaging has an approximate resolution of 800 x 800 pixels and the new a resolution of approximately 3000 x 4000 pixels, which is a significant improvement that will yield more accurate test results.

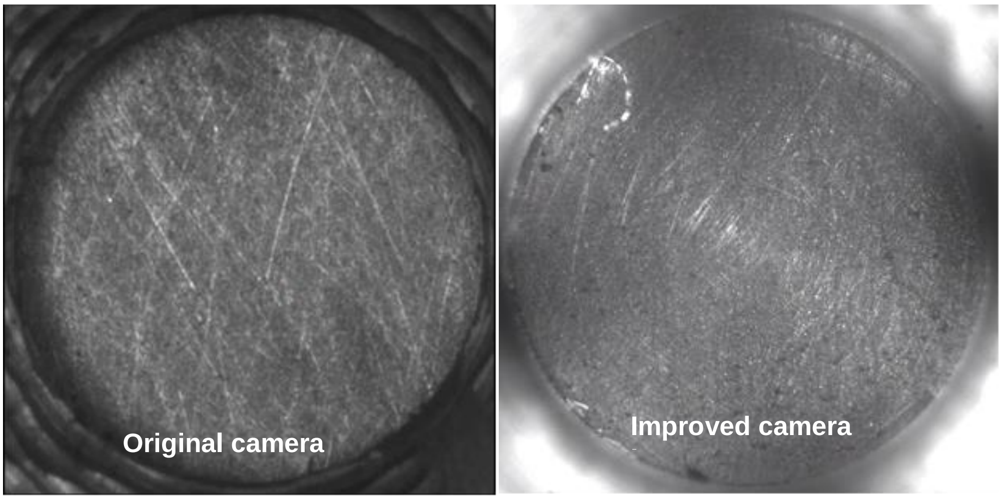


Figure 16: Imaging quality comparison

5.2.2 Development of a Novel Surface Treatment Technique – Whip Peening

Background

This project arose as a requirement linked to our Steam Turbine Rotor Serration Grinding system. Grinding of the blade attachment serration of a power generation steam turbine rotor was successfully implemented in 2019 on two ESKOM LP turbine rotors to remove surface cracks. To further improve the serration refurbishment process, an enquiry was received as to whether there was any existing surface treatment process that could be applied to enhance the crack initiation resistance of the surface through introduction of a compression residual stress at the surface. Owing to the geometry of the serrations, which results in limited access, none of the existing surface treatment processes, such as shot peening, could easily be applied. As a result, this primary achievement aimed to develop a means of performing a peening process on regions where preventative or repair serration grinding has been performed.

Feasibility Analysis

The major challenges associated with the aim of this project involved the component geometry and the manner in which the peening was to be administered. The tight confines of the serration grooves, shown in the Figure 17 illustrate the challenging accessibility and, therefore, a more novel approach was required.

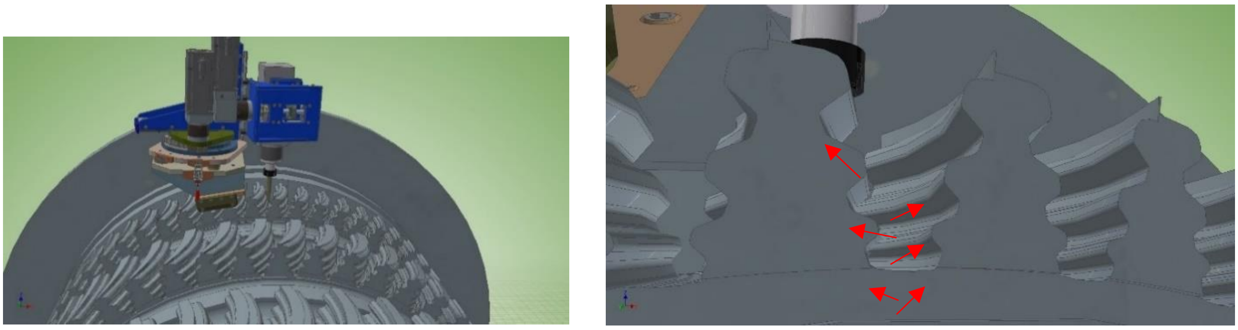


Figure 17: Turbine geometry (red arrows indicate serration positions)

A matrix of the peening approaches against various scoping criteria was prepared, and the results are tabulated in Table 1.

Table 1: Existing peening process evaluation

Type of peening	Likelihood of accessing the geometry	Ease of operation	Cleanliness requirements	Consistency and repeatability	Cost
Shot peening	***	**	*	****	**
Ultrasonic peening	*	****	*****	****	**
Laser shock peening	*	*	**	*****	*
Flapper peening	****	*****	*****	***	*****
Novel approach	*****	*****	*****	***	****

Whip Peening – Innovative Concept

The whip peening innovation was first conceived as a theoretical solution having specific ties to the unique peening requirements associated with steeple groove surface treatment. It would also be feasible to be implemented with the existing equipment developed by eNtsa to perform the serration grinding procedure.

This innovation involves a series of small high-strength tungsten beads, which are spun at a determined peripheral velocity to obtain a desired kinetic energy. The beads are constrained in a spherical dimension about the rotational center by means of a strong, but flexible link (wire, thread or line) allowing partial degrees of freedom to the rotating beads. The beads travel in a planar circular motion owing to the centrifugal reaction force of bead mass and centripetal acceleration creating a whipping action. When the whipping beads are brought into contact with a target surface, the kinetic energy of the beads is transferred to the local contact area resulting in a peening action. With accurate position control, machine parameters such as peening intensity and indentation spacing can be repeatedly achieved regardless of the whip radius.

Prototype

The development of a prototype whip peening tool went through various conceptual iterations and, after suitable testing, a final tool was designed and fabricated as shown in Figure 18.

Figure 18: Whip peening tool design (left) and manufactured prototypes (right)

Results of Trials

The experimental testing performed provided extremely positive results indicating that the process is effective at inducing a residual stress state in a confined space. Figure 19 illustrates two graphs which show test results for the untreated and treated surface, as well as images of the treated surface.

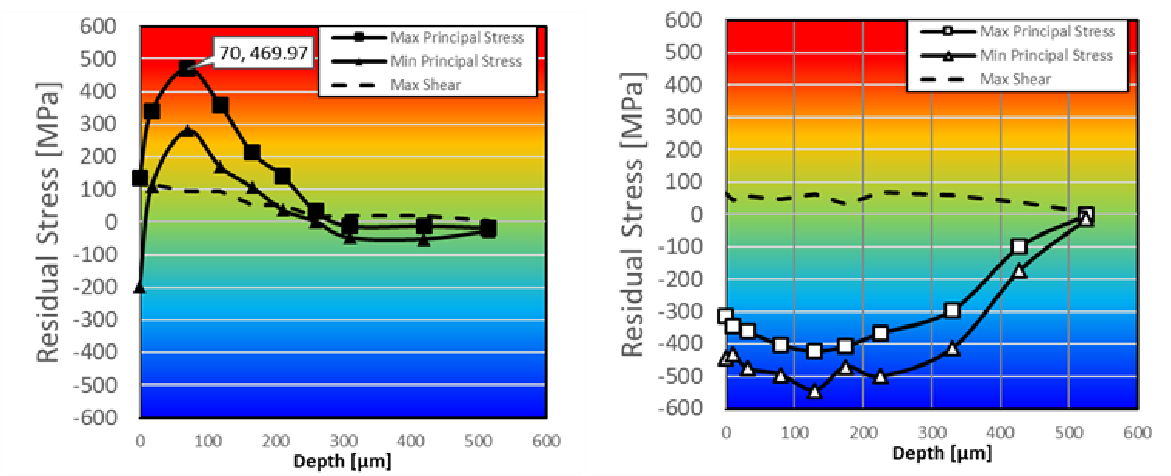


Figure 19: Initial residual stress vs. depth after grinding (Left), Residual stress vs depth after whip peening (right)

From Figure 19, it can be seen that the principal stress values have been reduced from a peak value of 475MPa at 70µm depth to compressive value of -300MPa throughout the first 300µm from the surface (see Figure 20).

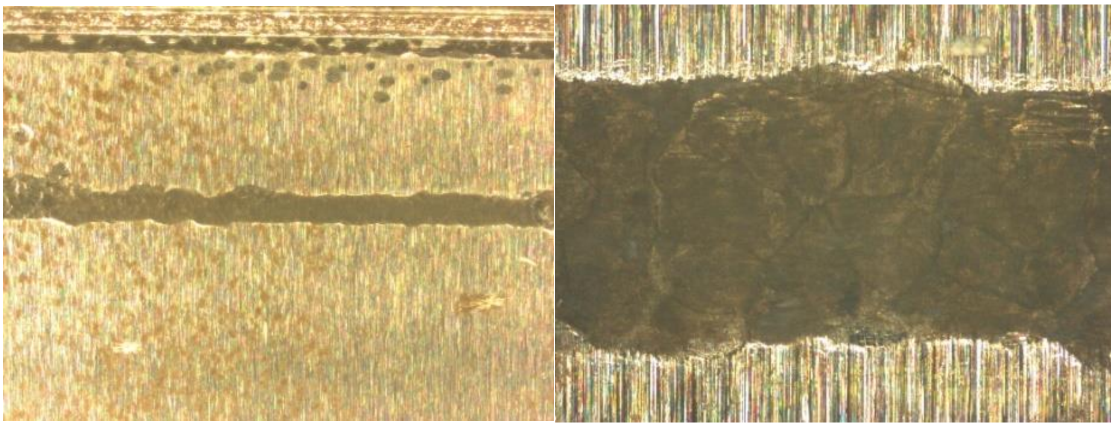


Figure 20: Surface condition after treatment, low magnification (left), high magnification (right)

Industry Technology Demonstration and Review

The process and technology was successfully demonstrated to Eskom on 3 December 2019. Eskom have taken samples for independent testing in order to evaluate the process and have stated that their test measurement concur and that they are satisfied with the process for future implementation on turbine rotor serrations.

5.2.3 Upgraded Small Punch Creep Testing Platform Design

Background

The small punch creep test platform used by eNtsa were originally designed in 2015. They had undergone some minor alterations during the initial test trials to improve operation but remained essentially the same as the prototype unit. eNtsa has a fleet of 11 platforms but with increased test demand, new platforms were identified as being required. It was decided that before building additional units a full design review should be conducted of the platforms as a few operational issues had been identified. With input from our own operational experience and important collaboration with Juhani Rantala, from VVT in Finland, a number of upgrades to the existing platforms were identified.

Design Review

The design review identified a number of changes that could be considered for the SPCT platform. A decision was taken to ensure that any changes implemented should not result in a platform that is vastly different to the existing units. Importantly, the changes should also be implementable to the existing units (see Figure 21).

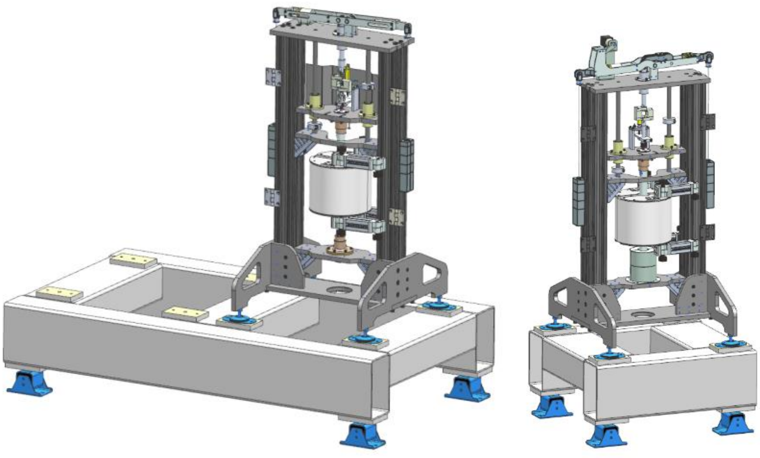


Figure 21: Original SPCT platform (left) and upgraded SPCT platform design (right)

Figure 21 shows the original SPCT platform build (left) versus the re-designed platform (right). As can be seen, the re-design does not vary considerably from the original. All changes that have been implemented can be applied to the existing units. Importantly, the test strategy, or how the tests are performed, has remained unchanged. This will ensure relevance of any new test data versus existing test data.

Improvements have primarily been made to four main systems of the platform, namely:

- Load application system
- Punch' or load column system
- Shielding gas system
- Mounting base

The load application system, as shown in Figure 22, underwent a complete re-design. An automated load application system was added to ensure a consistent and standardised loading strategy can be implemented. The adjustability of load setting was improved and a swing-over lever system was included to allow the removal of the load from the punch column.

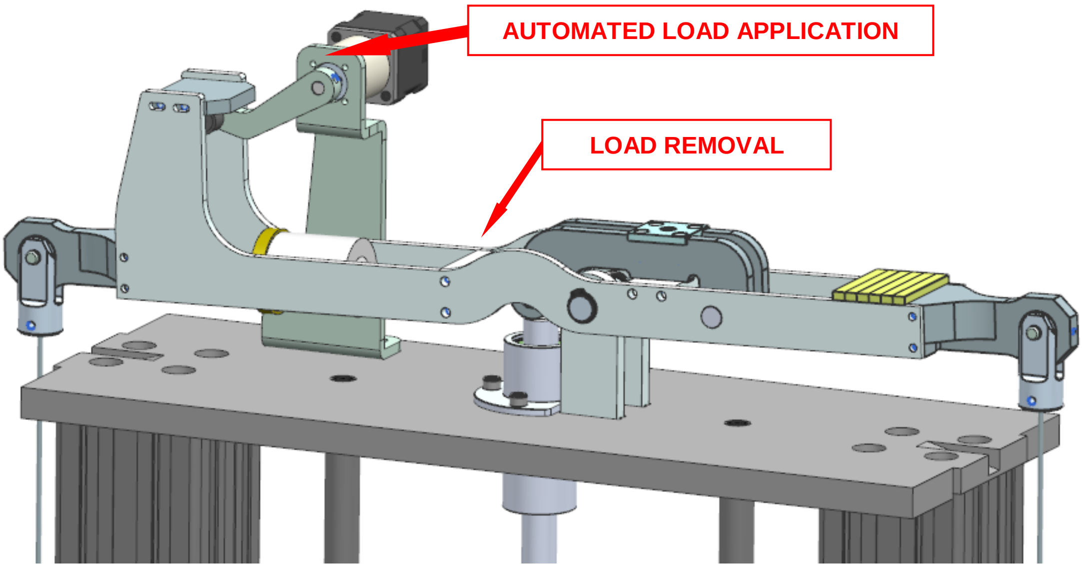


Figure 22: Re-designed load application lever system

Changes were made to the load column to assist in alleviating possible misalignment of the punch rod, which was identified as problematic. The punch column was split between the upper-end load measurement area and the lower punch rod area, which will remove the transfer of any side load to the punch rod that effects consistent axial load application.

Changes were then applied to the column design and the furnace assembly to assist in ensuring that the shielding gas reaches the test specimen to limit any oxidation that could occur. This oxidation effects the test result, so is critical to accurate test data being generated.

Finally, the design of the mounting base was changed to accommodate only a single SPCT platform per base, versus the original two platforms per base. During a SPCT test, the platform was extremely sensitive to any bumps or vibration, which meant that you could not work on a non-running unit if its adjacent unit was running a test. This lead to a loss in test operation time, which can now be avoided.

5.2.4 Development of Improved Turbine Serration Grinding System

eNtsa has developed and implemented a customised solution for refurbishment of Steam Turbine Rotors used in the power generation industry. The system allows for the removal of surface cracks at the blade mounting serrations of fir-tree type blade attachments. The system was successful in applying the preventative maintenance procedure to two of Eskom’s turbine rotors at a substantially reduced cost versus an international intervention.

Figure 23 shows the system as it was utilised. Individual bases for each blade row were required and were mounted to the rotor. These bases required moving from one blade steeple to the next. This system worked adequately, however, the move was a time-consuming procedure and was achieved with considerable effort by the operator. For this reason, an improved system of mounting and manipulating the equipment was required. This would ease the use of the equipment for the operator and also reduce the time required to complete the procedure.

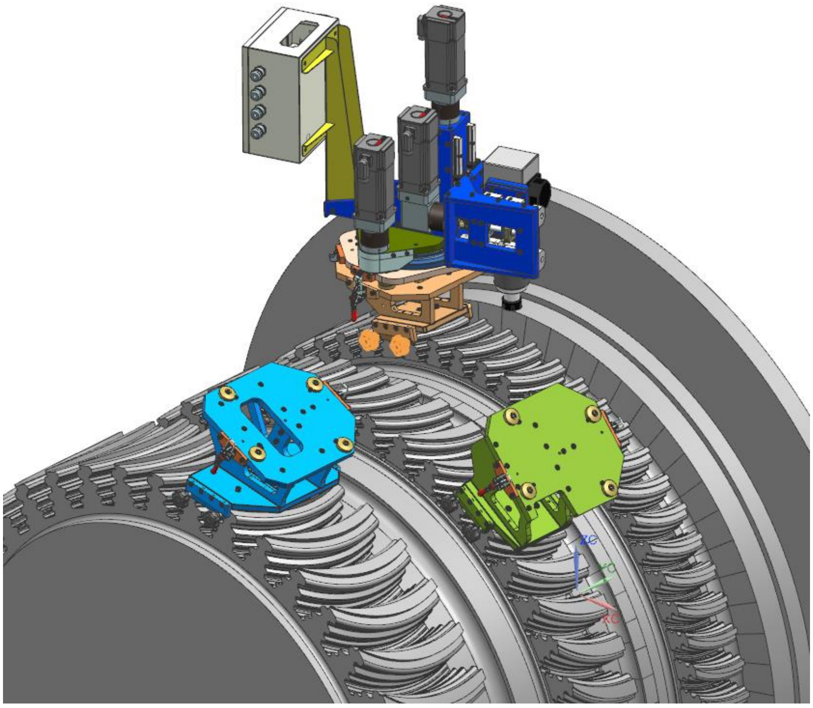


Figure 23: Initial equipment setup using mounting bases

Figure 24 shows the system that was designed and manufactured to make the serration grinding operation more efficient both in duration and from an ease of operation point of view. The system has been called the ‘Crawler System’, as the mounting of the grinding equipment is now to a trolley arrangement that ‘crawls’ around the rotor. The crawler is positioned and attached by means of a chain system, which it also uses to drive itself around the rotor. The grinding equipment is only re-positioned when moving from one blade row to the next, so instead of requiring 308 re-mountings per rotor, there will now only be six mountings required. A re-mounting typically took on average ten minutes to complete. The time required for positioning has, therefore, been drastically reduced from over 50 hours for a rotor to approximately an hour.

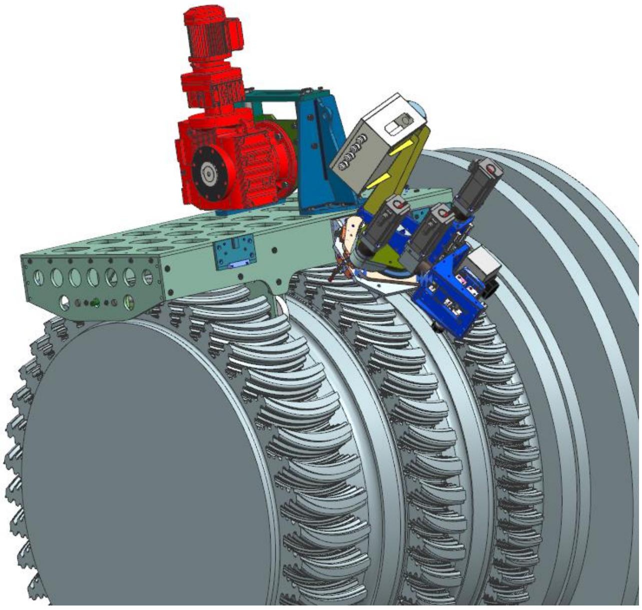


Figure 24: New 'Crawler' system for equipment setup

5.3 Small Punch Testing Facility

By Mr Louis von Wielligh (Deputy Director: Group Specialist)

The Small Punch Testing facility provides our two main clients, Sasol and Eskom, with creep rupture and materials characterisation data. This assists engineers to analyse the material state of their pipeline components as well as to make critical decisions regarding the frequency of monitoring required and the prioritisation of component replacement within their pipe systems.

It was an extremely busy year for the Small Punch Testing Facility. Mr Dreyer Bernard handed over the lab, testing and materials characterisation responsibilities to Mr Louis von Wielligh. The extensive training and handover exercise was concluded in April 2019. In May 2019, Eskom started with regular load shedding, which required eNtsa to install a generator and replace all existing UPS batteries to ensure uninterrupted testing. Throughout the year, minor modifications were made to our test procedures, the lab and existing platforms. This included, for example, sealing of the roof to prevent dust ingress and the integration of a cost effective automated loading system to improve the stability and repeatability of sample loading. Previously, samples had been manually loaded.

During September 2019, the facility and its procedures was audited by Mr Juhani Rantala from VVT in Finland. Mr Rantala is an expert in small sample testing and was involved in the development of the original CEN workshop agreement for Small Punch Creep Testing and current development of a European Standard for Small Sample Static and Creep testing. Mrs Leanne Matthysen, who represented Sasol, was present to witness the process. No major findings were made but areas of improvement were highlighted and discussed as well as possible collaborations. The exchange of information and ideas during this process and afterwards highlights the need for involvement on an international level (see Figure 25).

Figure 25: eNtsa team with Mr Juhani Ranthala from VVT in Finland (seated, third from the right in the front row) and Mrs Leanne Matthysen (seated, fourth from the right in the front row)

In terms of testing, fifty-two core samples were submitted for testing and analysis to the Small Punch Testing Facility. Sasol submitted forty-seven core samples. Thirty-eight of these cores were removed on site by eNtsa during the 2018 Sasol shutdown using the WeldCore® sampling and repair procedure, while nine cores were removed from Sasol spool pieces received by eNtsa. Eskom submitted five core samples. These core samples were removed by eNtsa from various pipe sections that were submitted for analysis.

In the later part of the year, an extensive overhaul of the facility and building of seven additional test platforms were approved. This would bring the facility in line with the requirements of an international creep facility and improve the overall project turnaround time. Key facility changes included the installation of an environmental conditioning system, the addition of a dedicated gas storage facility with a revised gas supply system and the separation of platforms. The additional platforms would be built, based on a revised design, to improve the ease of calibration and improve load stability during a test. Of the seven platforms, six would be installed in the facility, while the seventh would be shipped to VVT in Finland. The installation of the platforms was scheduled to be completed by the end of March 2020. Facility changes would be implemented throughout 2020.

5.4 Technology Station Programme

By Mr Julien De Klerk (Manager: Technology Station and Automation)

5.4.1 Overview

The main focus of the Supplier Development and Technology Station Programme (TSP), within eNtsa, is to support and stimulate the local manufacturing and engineering industries to improve the competitiveness of local manufacturers, which will enable industry to exploit and develop new markets.
With the support of the Technology Innovation Agency (TIA) and the Department of Science and Technology (DST), eNtsa is able to make much needed engineering skills, high-tech services, and training more readily available to Small and Medium Enterprises (SMEs) operating in the local manufacturing sector.

We believe that growing the *advanced manufacturing* economy in South Africa holds the key to sustainable job creation, international competitiveness, economic growth and improved quality of life for South Africans (see Figure 26).

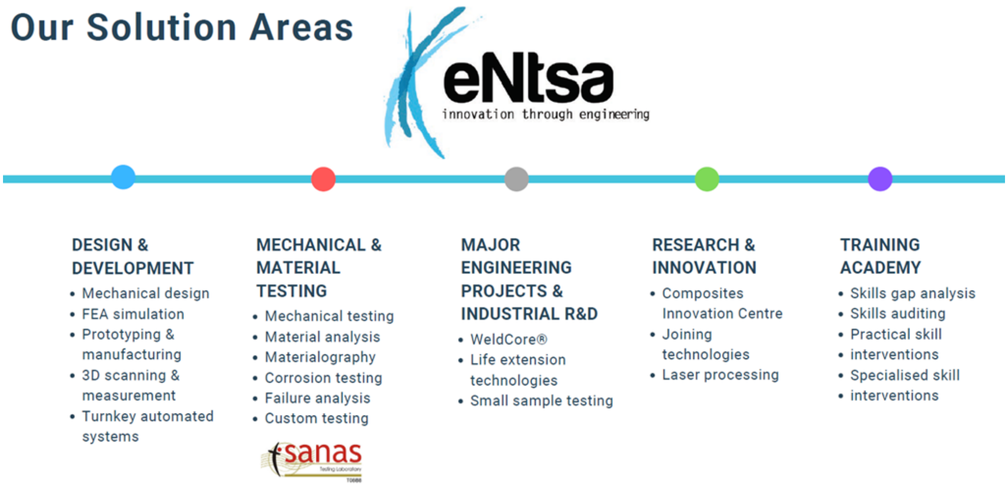


Figure 26: eNtsa Solution Areas

5.4.2 Sustainability of the eNtsa Technology Station Programme

The Technology Station programme receives grant funding from the Technology Innovation Agency (TIA) as an initiative of the South African Department of Science and Innovation (DSI). This grant funding allows SMMEs to access engineering skills and technologies to improve their products and processes, unlock new local and international markets or employ new technological improvements.

As eNtsa supports many SMME members of Global Value Chains, it has been a priority to ensure that services are also offered to the Tier 1 and OEM members of those value chains. This approach ensures that eNtsa TSP services are recognised by all companies as meeting international standard, and eNtsa is able to improve is financial sustainability by unlocking additional industry income through services to large companies.

Figure 27 ilustrates three figures which show the historical funding of the programme, as well as industry income. This shows that in recent years, a strategic approach to securing additional financial income has been adopted. This approach aims to diversify the group's income, and thus improve financial sustainability and improve services to all clients through improved HR resources and facilities.

Figure 27: TSP Funding and industry income per financial year

Note: These figures exclude equipment funding received.

5.4.3 Status of the Industry which eNtsa Technology Station Supports

When established in 2002, eNtsa (initially, the Automotive Component Technology Station, ACTS) was primarily focused on supporting the automotive components manufacturing industry in the Nelson Mandela Bay area. Over the years, as the expertise of the group expanded, the project scope broadened and became more reflective of the wider engineering and manufacturing sector.

Positioned in the Eastern Cape, eNtsa is ideally-situated in an area which is in need of economic growth. Though the automotive industry is no longer the sole focus of the group, according to the Eastern Cape Development Corporation (ECDC), the Eastern Cape hosts five of the major OEMs operating in South Africa, along with more than 100 major component manufacturers. As a result, the Eastern Cape manufactures 51% of South Africa's vehicle exports. As over 40 000 formal sector jobs exist within Eastern Cape OEMs and over 1500 supplier companies (ECDC, 2015) provide employment. This highlights the need for assistance businesses within this sector and why this remains a significant focus area of eNtsa in supporting and driving the advanced manufacturing sector. Nationally, the automotive sector employs 113 532 people across the assembly and component sectors (DTI, 2018).

On the outskirts of Port Elizabeth, the Coega IDZ, in close proximity to the new Ngqura deep-water harbour, is showing promising industrial growth. The Coega IDZ focuses on development in the metals, textiles, automotive, chemicals and energy sectors and is developing an automotive production cluster linked to the industry already established in the Eastern Cape (ECDC, 2016). This Industrial Development Zone provides a new and exciting opportunity for expansion of the local manufacturing industry.

5.4.4 Review of FY2018/19 Industry Sectors assisted by eNtsa Technology Station

Figure 28 is a review of the industry sectors assisted in the FY2019/20 period.

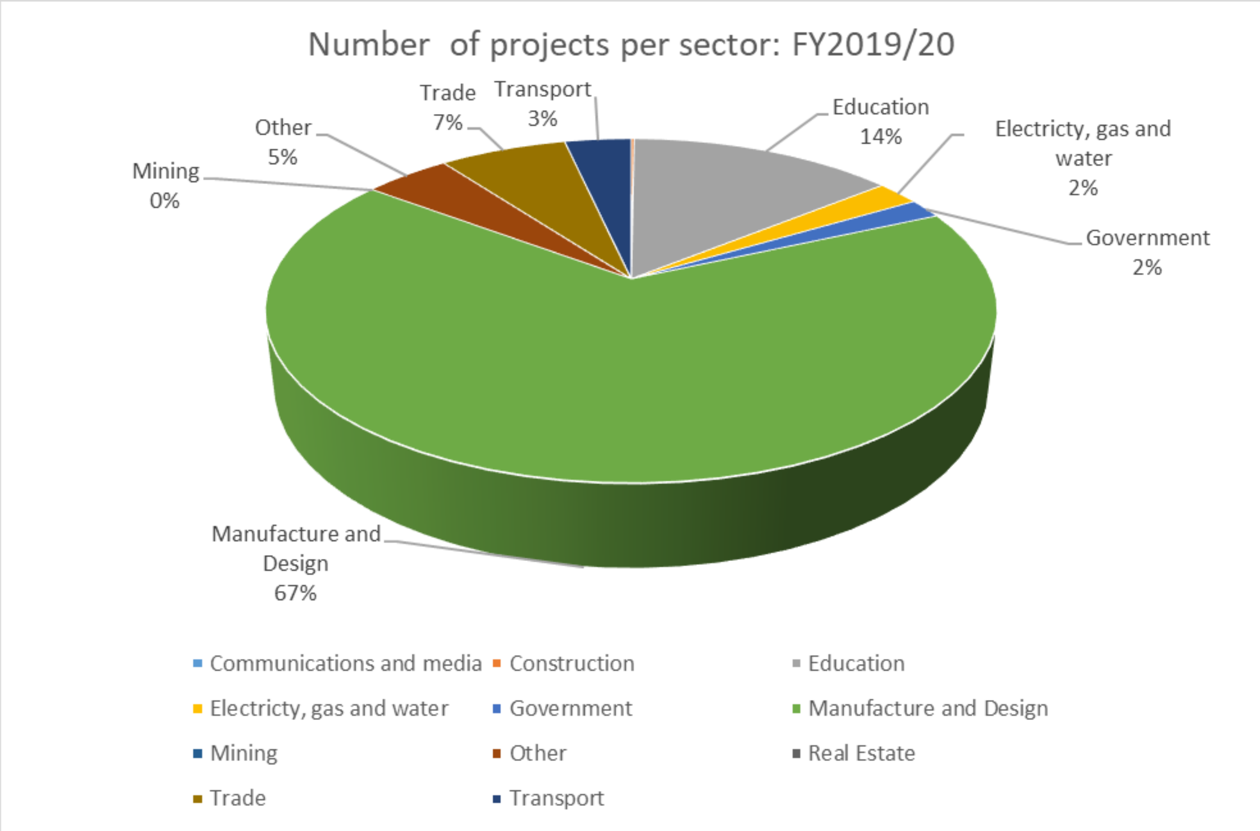


Figure 28: Number of projects per industry sector

This chart indicates the wide range of sectors in which eNtsa operates, but highlights that the majority of projects performed assist the local manufacturing and design sector (67%). This is in line with the aim to strengthen the local manufacturing sector via the supplier development programme at eNtsa.

As 67% of all TS projects are performed for the manufacturing and design sector, these can be further broken up into the relevant subsectors (see Figure 29).

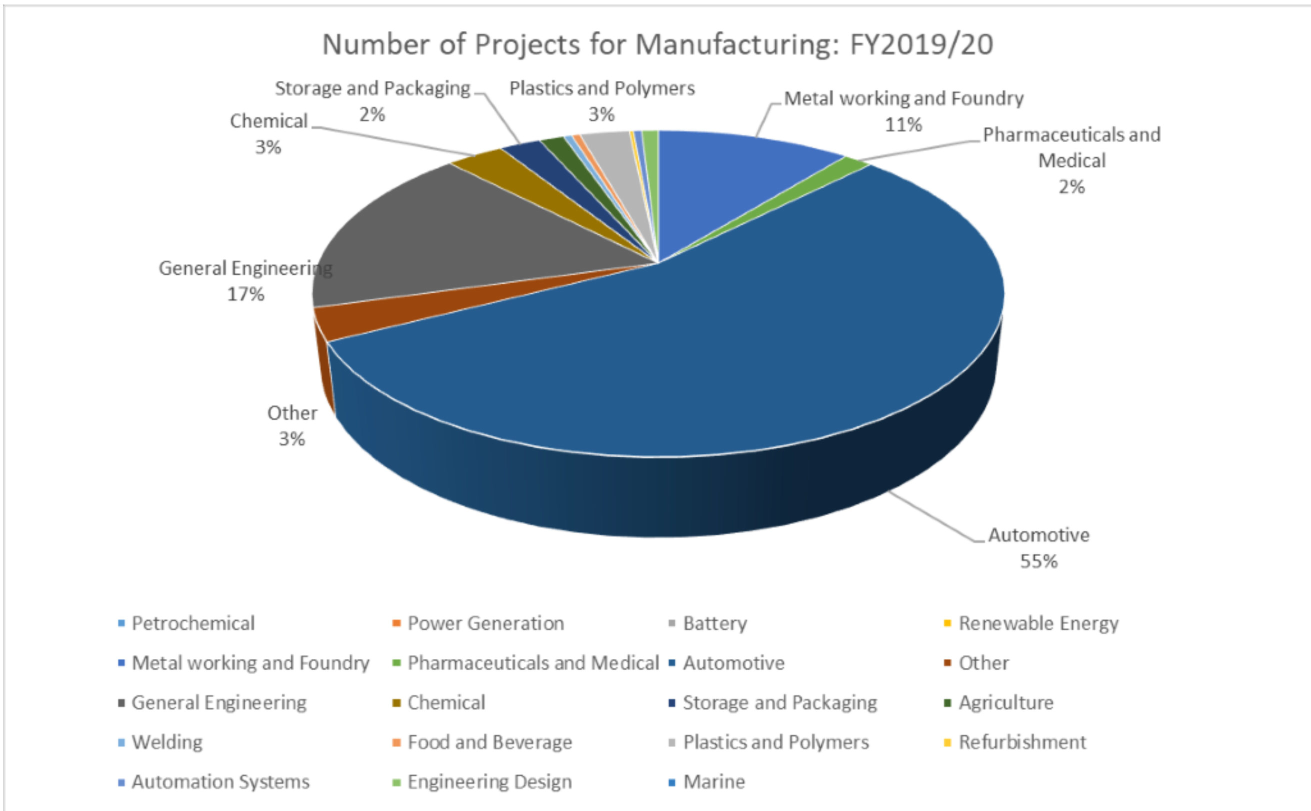


Figure 29: Number of projects per manufacturing sector

Based on these figures, 55% of manufacturing (or 37% of all projects) are directly servicing the automotive manufacturing sector. General engineering and metal working contributed 17% and 11%, respectively. The remaining 17% of is made up of a wide variety of manufacturing industries, showing the broad impact of the Technology Station Programme.

The automotive sector remains a key manufacturing sector for South Africa, contributing 8% of the nation's GDP. The automotive industry also directly stimulates many other manufacturing sectors, as reflected in the clients assisted in 2019/2020. Many of the general engineering, metalworking, chemical and welding industries in South Africa, and especially the Eastern Cape, feed into the automotive supply chain and are thus directly linked. This means that up to 56% of all projects may be related to the automotive sector. This highlights the spread of manufacturing industries to which eNtsa adds value but also reinforces the need to continue a strong focus on assisting the automotive sector and members within the value chain.

5.4.5 Automotive Sector Drivers

The automotive sector in South Africa continues to drive industrial development, contributing 7.5% to the GDP. As the various industries in South Africa begin drafting and adopting sectoral master plans, the automotive sector leads, which is the South African Automotive Masterplan 2035 (SAAM 2035). This master plan focuses on achieving a set of objectives by 2035, including 1% of global vehicle production, 60% local content, 100% employment growth and industry transformation (NAACAM, 2020).

The plan outlines six 'pillars' which denote the key areas where activities are requires to achieve the set targets. These pillars of focus influence the entire sector ecosystem, providing a common framework for OEMs, Tier 1 manufacturers, SMEs and supporting entities to adopt and work towards.

Sectoral master plans allow eNtsa to align to the identified industry targets and support the activities identied in the six pillars of SAAM 2035. Figure 30 outlines the six pillars of the master plan 2035 (NAACAM, 2020).

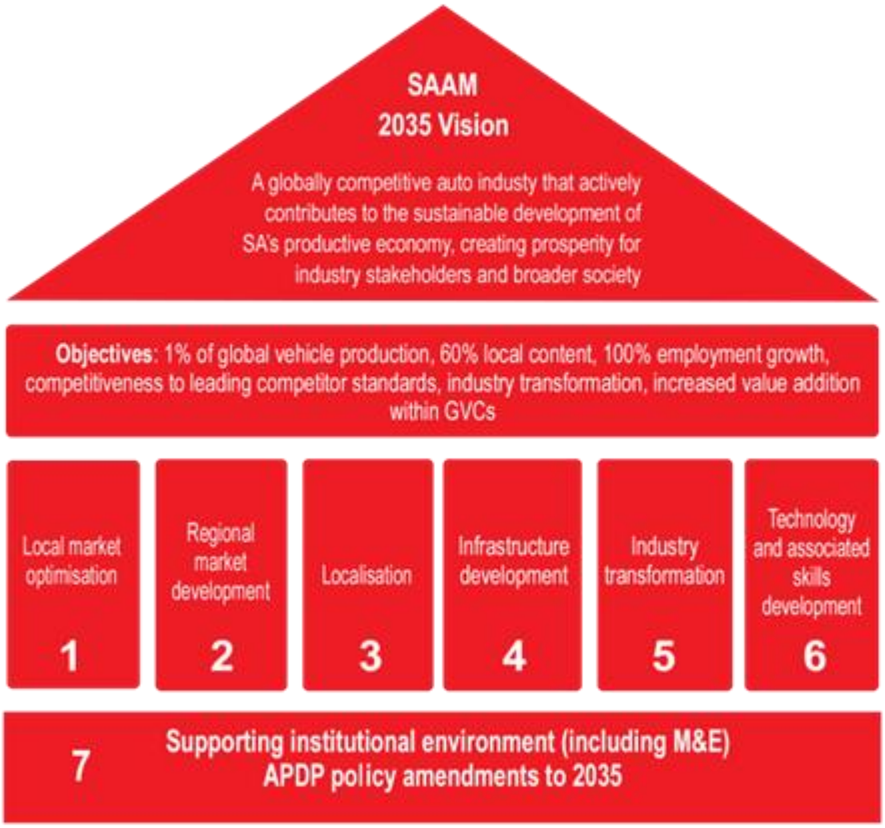


Figure 30: SAAM 2035 Masterplan Six Pillars

5.4.6 ISO17025:2017 SANAS Accreditation of Testing Laboratory to support Global Supply Chains

eNtsa has successfully implemented an ISO17025:2017 quality management system to ensure that support to industry meets global standards to enable our local manufacturers to deliver products which meet international standards and expectations. The aim of operating an accredited testing facility is to enable more local manufacturers to unlock potential localisation and export opportunities. Many of these supply opportunities require rigorous testing to ensure quality standards are adhered to. This is especially needed to align with the automotive industries Master Plan 2035 (SAAM 2035), which sets a target of 60% localisation in the South African automotive industry by the year 2035.

eNtsa is proud to report that ISO17025:2017 SANAS accreditation was granted on 16 September 2019, and subsequently audited and extended for 18 months in February 2020. This is external auditing and accreditation viewed as an important confirmation of the quality of work completed at eNtsa for our R&D and testing partners. eNtsa's management extends its thanks to TIA and DSI for the support in enabling this accreditation.

5.4.7 Assistance to Industry through the Technology Station Programme at eNtsa

The programme aims to support industry in two main areas, namely, ***Technical Support*** and ***Knowledge Transfer***. The following sections provide some of the statistics pertaining to the assistance provided to SMEs during 2019/20.

5.4.7.1 Technical Support

In FY2019/20, the eNtsa Technology Station Programme has completed 500 industry assistance projects for local companies. This industry assistance covers a wide spectrum of testing, design, product/process development, technology demonstrations and manufacturing assistance.

During this period, SMEs were supported through 1**92** engineering projects assisting a total of different **121** SMMEs. The FY2019/20 totals for SMMEs assisted were **121**, with the annual target being **125.** This equated to **97%** of the annual technical assistance target.

In the same period, **308** projects were completed for **59** different large companies, with an average of **25** large companies assisted each quarter.

Figure 31 shows the graphic representations of the projects completed and companies assisted.

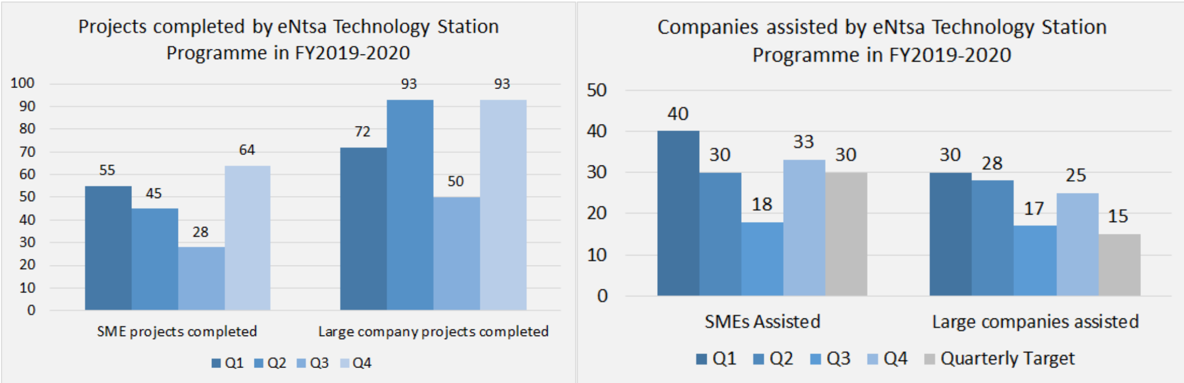


Figure 31: Projects completed in FY2019/20 (Left) and number of clients assisted in FY2019/20 (right)

Figure 32 shows the distribution of activities completed within the eNtsa Technology Station amongst different technical areas. This graph highlights a fundamental difference between activities in these different fields. Test and analytical work reflect a significantly higher volume of work compared to all other areas, but this does not mean that the majority of work performed is in this area. Rather this indicates the necessity for access to frequent analytical services to support industry's efforts to optimise, qualify, monitor and understand their manufacturing processes.

If one reflects on the value of completed projects, it is clear that this high volume does not relate to the greatest value activities. Rather, categories, such as '*Product and Process Development*', '*Applied Engineering Design and Development*' and '*Research and Development*', have lower volume of activities but represent the greatest value activities and greatest amount of time spent by staff. Figure 31 provides an overview of the quarterly trends, and relative volumes, but it also indicates that there exists a demand across the categories of activities provided by eNtsa.

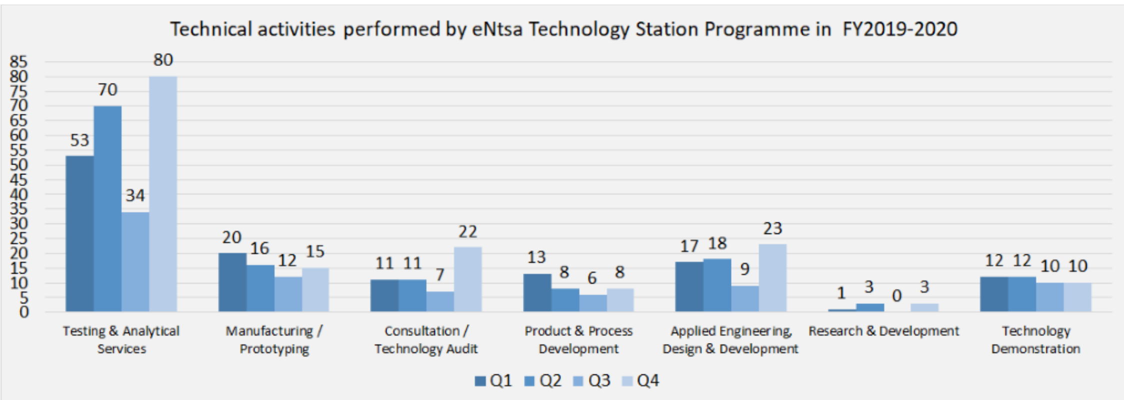


Figure 32: Technical activities performed by station

When evaluating the impact of projects for companies, it is not always clear what the full benefit is down the line. However, in some cases eNtsa is able to record impact in certain categories to track the areas where we were able to benefit our clients. Project captured as facilitating export readiness enabled the production of components or products destined for export markets. It was recorded that **75** of the projects completed in FY2019/20 had a direct impact on export readiness.

The areas of impact for the TSP projects completed in FY2019/20 can be seen in Figure 33.

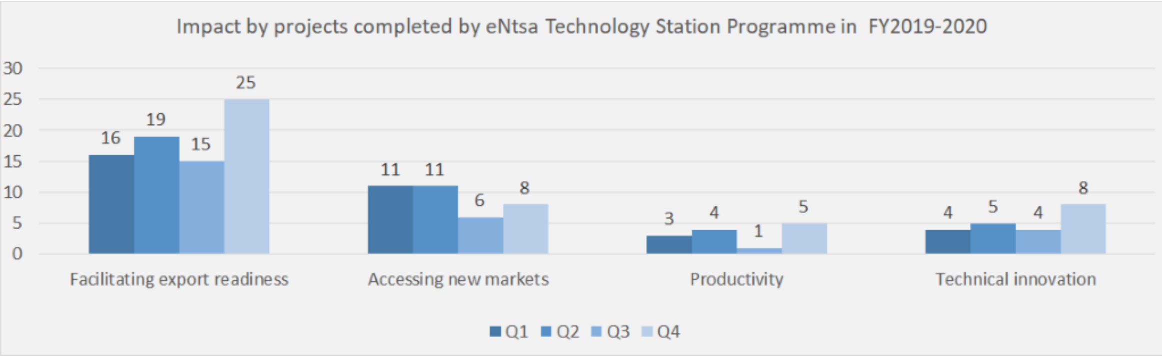


Figure 33: Project impact evaluation

5.4.8 Highlighted SME Projects

The following section contains information on some highlighted SME projects or notable interventions.

5.4.8.1 Engineering Support Unlocks R2m Green Energy Contracts for Student Start-up: OKARA Energy

Client: OKARA Energy [SME]

Assistance offered by eNtsa: OKARA Energy is start-up, launched in 2019 by two Nelson Mandela University engineering graduates. The pair aimed to provide engineering solutions in the renewable energy sector. OKARA Energy identified that local wind turbines required maintenance to be performed, where torque arm bearings and pins needed to be removed and replaced. Previous attempts by local and international service providers resulted in damage to the turbine. eNtsa assisted OKARA Energy with a technical evaluation of the available engineering technologies, testing of the pin material and providing a conceptual design layout for the identified diamond-wire cutter solution. OKARA Energy completed a function design, fabricated and iterated the diamond-wire cutter to be commercially operational. The result was a successfully completed contract, which led to OKARA Energy becoming the dedicated engineering service provider for a South African wind farm.

Deliverables: Technology evaluation, conceptual design, material test data and consultation.

Application Sector: Renewable Energy

Envisaged / Recorded Impact: Over R2m in contracts secured by OKARA Energy in 2019, and five jobs created.

OKARA Energy secured a R1m contract with the local windfarm for the maintenance service in 2019, and has been appointed as the dedicated service provider to the windfarm. This appointment has further created opportunities for the company, including a new R1.1m contract in 2019 to perform oil services on wind turbines using custom equipment of their own design. OKARA Energy is currently engaging with eNtsa as it explores new contracts within the renewable energy sector with an estimated value of R5m (see Figure 34)

Figure 34: Concept design (left), prototype diamond wire cutter (centre), oil service equipment on site (right)

5.4.8.2 Engineering Support Unlocks R2m Green Energy Contracts for Student Start-up: Bellingham and Smith

Client: Bellingham and Smith [SME]

Assistance offered by eNtsa: Bellingham and Smith (B&S) is a manufacturer of cricket bats based in Thornhill, Eastern Cape. They identified a need to increase the level of technology in their manufacturing process to gain the required export contracts to maintain/expand current workforce and access new markets. eNtsa developed a prototype 4-Axis CNC wood router in January 2018 (supported by DSI scale-up funding). Since then, hundreds of bats have been machined on this system, with a daily outputs for the machine currently at 30 bats and increasing.
The client has indicated a need to continue scaling-up their production capabilities with further custom machining to allow them to increase output and upskill their workforce. The aim of this project was to develop a bespoke, industrial CNC wood router with three cutting heads to increase production and reliability.

Deliverables: Bespoke 3-Axis, 3-Spindle, CNC wood router

Application Sector: Sport Equipment Manufacturing

Envisaged / Recorded Impact: Table 2 illustratesproductivity figures that depict the impact of the Technology Transfer Package.

Table 2: Productivity impact of introduced technology

Productivity impact of introduced technology			
Description	**Before eNtsa assistance**	**Using prototype platform (DSI Scale up project)**	**Using new 3 Spindle CNC wood router platform (TIA TSP Funded)**
Time to machine bat stock shape	~50min	25min	8min
Time saving	0%	50%	84%
Bat produced per day *(based on current staff of 10ppl)*	22*	35**	50***
Increase in productivity	0%	59%	127%

* Peak production with multiple hand shapers, this production quantity and quality was inconsistent
** Manual hand shaping required in parallel to CNC prototype to increase production. This created mixed consistency in results.
*** Only CNC bat shaping used, resulting in improved repeatability and reliability

In addition to improving productivity by 127%, B&S indicated that the quality of the final product had improved as bat shapes are consistent, and they had the ability to produce a wider range of shapes and sizes to supply a greater market. By increasing the overall capacity of B&S, it has the potential to create employment for the Thornhill community, improve sustainability of the company and create opportunities in export markets.

B&S has begun upskilling staff to increase output demands, and approximately 1000 bats were produced in February/March 2020. B&S is currently negotiating new local and international contracts based on this new capacity (see Figure 35).

Figure 35: System commissioned at B&S and staff trained on the operation of the system in Thornhill

Programming, Debugging and Testing completed at the Nelson Mandela University

5.4.8.3 Engineering Support for Green Energy Product Manufacturer in Dimbaza: AET Africa

Client: AET Africa [SME]

Assistance offered by eNtsa: AET AFRICA is 55 % youth and women owned, level 2 and 80% BEE Start-up Company with offices in East London and manufacturing plant in Dimbaza, Eastern Cape. The company produces a green energy product called the 'Hotspot'. This product is retrofitted to an existing geyser to reduce energy usage by 27% and improve heating time. eNtsa was approached to collaborate on this project by the Centre for Rubber Science and Technology (CRST) at the Nelson Mandela University. The CRST was completing a DSI funded project to assist the company with their polymer product and process issues. It was noted that a portion of the scrap issues were related to mechanical/electrical issues in the production facility.

eNtsa completed a site investigation in Dimbaza, Eastern Cape (near King Williams Town and East London), identified a number of initial issues to complete as part of a technology transfer package. These included thermal modelling and design of a suitable heat diffuser to reduce low and high temperature zones in the preheat and gelling ovens. A solution was also provided to eliminate bubbles forming in the product tank. A prototype was produced for testing the use of quick couplers on the mandrel suspension frame to reduce cycle time and accidental damage. These solutions have been installed in Dimbaza, and eNtsa continues to assist AET Africa.

Deliverables: 2x Heat diffusers to reduce defects, motor to eliminate cavitation, quick coupler frame

Application Sector: Green Energy Product Manufacturing

Envisaged / Recorded Impact: Reduce scrap, improve productivity, retain employment of residents

5.4.9 Knowledge Transfer

During the FY2019/20 period, a total to **161** clients were assisted with training and knowledge transfer activities, with the annual target being **100.** This equated to **161%** of the annual target.

The distribution of these activities across the quarters are illustrated in Figures 36.1 and 36.2.

Figure 36.1: Clients assisted with SLPs and knowledge transfer activities

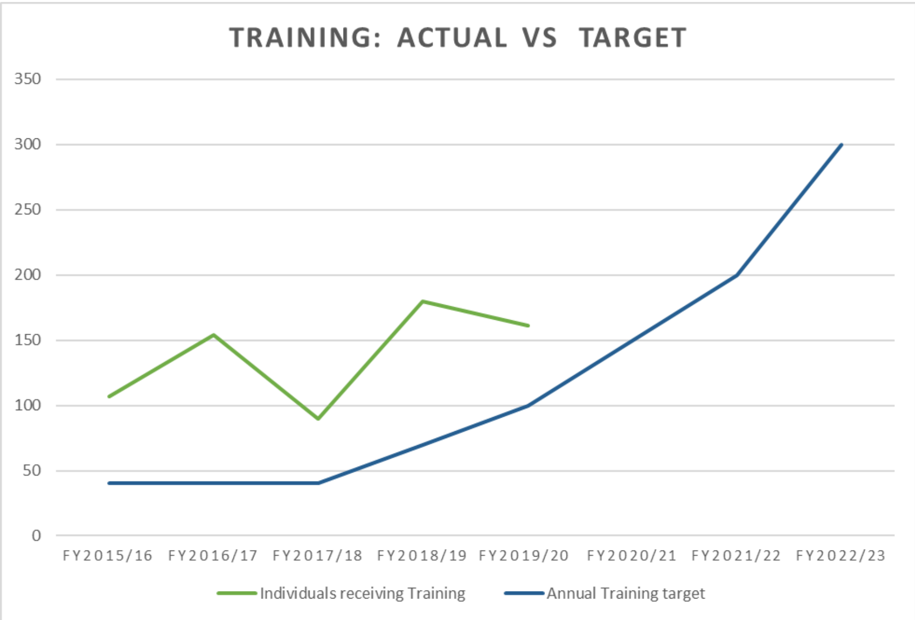


Figure 36.2: Training figures showing three year projected target increases

These training values fall in line with eNtsa Technology Station training three-year plan to increase annual targets to 300 by FY2022/23 in a sustainable organic growth.

For more on interventions that took place in the FY see section 6.3 (Training Academy interventions).

5.4.10 African Advance Manufacturing and Composites Show 2019

As part of the Knowledge Transfer and Technology Demonstration activities, eNtsa participated at the African Advanced Manufacturing and Composites Show 2019. This event highlighted advanced technologies and workshops focusing on the new manufacturing developments. eNtsa hosted an exhibition stand with examples of advanced optical technologies for rapid design and evaluation, which are accessible via the DSI/TIA TSP programme. Hubert van der Merwe also presented a technology talk on Digital Image Correlation and its uses. TSP technologies were demonstrated to SMEs, scholars, public and corporates (see Figure 37).

Figure 37: Collection of images from the Advanced Manufacturing and Composite Show 2019

5.4.11 RAPDASA Additive Manufacturing Industry Open Day

In July 2019, eNtsa took part in the RAPDASA Additive Manufacturing Industry Open day hosted at the Nelson Mandela University in collaboration with the South African Institute for Mechanical Engineers (SAiMechE) and RAPDASA. The event hosted national role players in the additive manufacturing space and created a platform for industry to experience advances in technologies. eNtsa demonstrated 3D printing, Laser Metal deposition and 3D scanning technologies to industry and student participants (see Figure 38).

Figure 38: Collection of images from the RAPDASA Additive Manufacturing Industry Open Day

5.4.12 Thought Leadership – South African Automotive Benchmarking Club (SAABC)

eNtsa was invited to present a thought leadership talk to members of the South African Automotive Benchmarking Club (SAABC). The talk was presented at a thought leadership and study tour event hosted in Port Elizabeth at the CRH Africa plant. The eNtsa Tech Station Manager presented to industry on the benefits of collaborating with technology partners in efforts to achieve the localisation targets set out in the automotive sector's master plan. Examples of success with eNtsa partnerships with industry were discussed (see Figure 39).

Figure 39: Collection of Thought Leadership event with the South Africa Automotive Benchmarking Club (SAABC)

5.4.13 UNIDO Seminar: Green Economy, Job Creation, Sustainable development and Economic Growth

The United Nations Industrial Development Organisation (UNIDO), in partnership with the South Africa Association of Energy Economics and Nelson Mandela University, in October 2019, hosted a seminar on careers and skills development in sustainable energy with emphasis on energy management in the green economy.

This seminar invited students from all faculties within Nelson Mandela University to take part in the discussion of a green economy. Representatives from UNIDO, namely, Ashanti Mogosetsi and Petronella de Wet presented on the following topics, “Sustainable Transport and Energy for a Green Economy” and "UNIDO, energy, gender and you!”.

The seminar also included a panel discussion with the topic, “Can the adoption of a green economy really create jobs and lead to sustainable development and economic growth [in South Africa]?” eNtsa’s Technology Station Manager, Mr Julien de Klerk and uYilo’s Programme Manager Ms Edem Foli were invited members of this panel discussion (see Figure 40)..

Figure 40: Collection of images from the UNIDO Seminar on Green Economy, Job Creation, Sustainable Development and Economic Growth

5.4.14 Work Integrated Learning and Graduates in Training

In addition to formal knowledge transfer training activities, eNtsa also hosts a number of Work Integrate Learning (WIL) programmes with post-graduate students as interns and Graduates in Training (GIT). This programme allows young engineering professionals to gain hands-on experience and develop a broader understanding of engineering work requirements, skills and tools. Through this programme, the Technology Station aims to positively impact youth employment.

Table 3 and Figure 41 illustrates some information on the interns hosted within the programme in FY2019/20.

Table 3: Interns

		Gender	**Race**	**Studies**		**Period of Intern**	
ID No.	**Names & Surname**	**M/F**	**Bl/wh/ clr/Ind**	**Qualification level**	**Registered for post grad**	**Commencement date**	**End date**
9804176010086	Phelelani Baca	M	BL	ND Mechanical Engineering	P1/P2	01-Mar-18	31-Dec-20
9806201114080	Aphiwe Josayi	F	BL	ND Mechanical Engineering	P1/P2	01-Mar -18	31-Dec-20
9503210750083	Nozipho SIbambo	F	BL	BTech Metallurgy	Completed BTech	01-Jan-20	31-Dec-20
9706181300081	Karabo Nkhwashu	F	BL	ND Metallurgy	BTech	01-Mar-19	1-Apr-20
9208195905088	Nkululeko Badule	M	BL	ND Mechanical Engineering	P1/P2	01-Feb-19	31-Dec-19
9604195488085	Musengeli Ndalamo	M	BL	ND Mechanical Engineering	P1/P2	01-Feb-19	31-Dec-20
9812145146089	Keegan Kroutz	M	CLR	ND Electrical Engineering	P1/P2	01-Jan-2020	31-Dec-20

Figure 41: eNtsa Interns

5.5 Controls and Automation Group

By Mr Akshay Lakhani (Group Specialist: Automation and Controls)

Controls and Automation

The 2019-2020 year for the Controls and Automation group was a year when previously-developed technology was put into practice. This included the Steeple Groove Serration grinder and WeldCore™ site applications, where members of the Controls and Automation group played a critical role.

Funding was secured for the Online Condition Monitoring project, and as a need, a software programmer was added to the team. Four test nodes were developed with different communication methods and ability to measure temperature, strain and vibration. This was developed with the petro-chemical industry in mind, but could be used in other industrial applications. The captured data was sent to a cloud platform for storage and visualisation (see Figure 42).

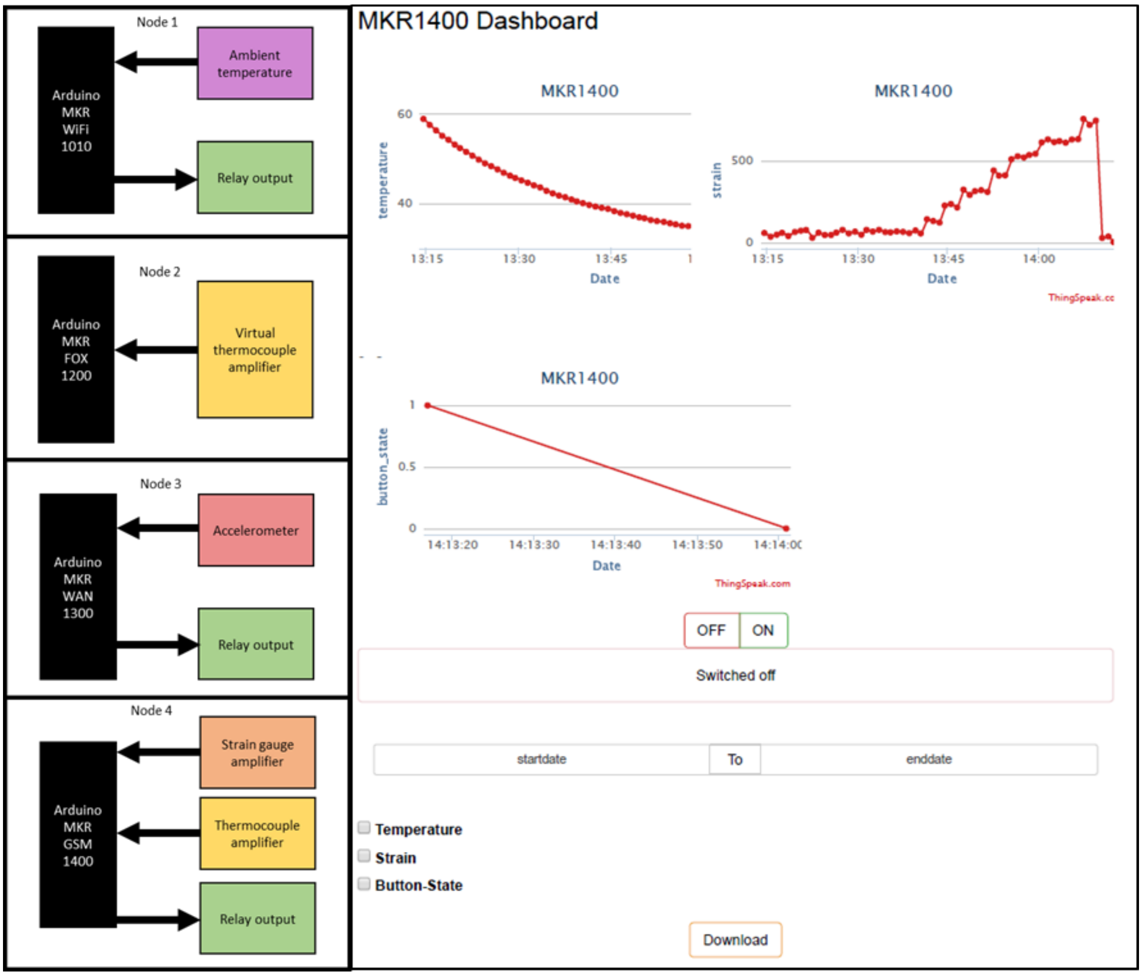


Figure 42: Online Condition Monitoring – Cloud platform for storage and visualisation

Continuing with the theme of Industry 4.0, the group secured a project funded by MerSETA to design and build three state of the art AGVs (Autonomous Guided Vehicles). The design and manufacture of the first AGV was completed and used high-end industrial PLC and motors/drives. It also used the latest indoor GPS system for navigation together with its mecanum wheels to achieve orientation independent motion (see Figure 43).

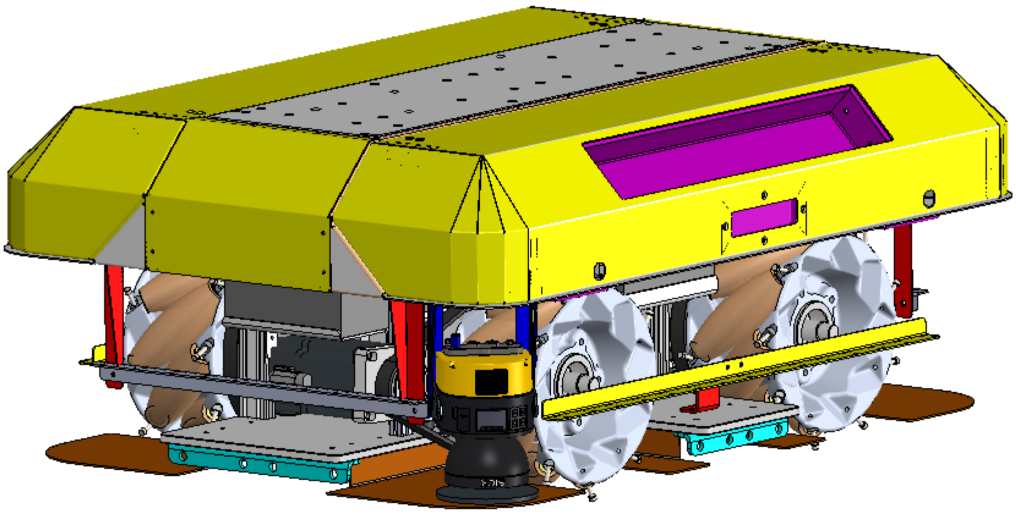


Figure 43: Autonomous Guided Vehicle

Following the success of the original CNC wood router for cutting cricket bats, we design and manufactured a 3-spindle 3-axis CNC wood router using Industrial control systems. The system was able to cut three bats at a time with a better surface finish and less time than the original machine (see Figure 44).

Figure 44: CNC wood router designed for local client

With the establishment of the MRU (Marine Robotics Unit) and the marine glider design in 2018-2019, engineer Kyle Donaldson from the group was given an opportunity to assist with marine glider setup and deployments in the Pemba channel, Zanzibar, and in Port Alfred. He was part of the team from NOC in Southampton conducting research in that area (see Figure 45)

Figure 45: Marine Glider

5.6 Composites Innovation Centre

By Mr Andrew Young (Director Engineering)

5.6.1 Overview

This project aims to enhance the composites engineering footprint through a programme with activities that will create knowledgeable, experienced engineers with a composites engineering capability. This footprint and resource capacity generated from efforts within the composities engineering sphere can assist in research and development, focusing on high-end surface finishes required in industry for export quality products.

This project will see the **Collaborative Fibre Composites Programme (CFCP)** II project funding utilise the Composites Innovation Centre (CIC) infrastructure and equipment provided through the high-end infrastructure funding.

Based on the report of the outcomes of the CFCP II Workshop held in Port Elizabeth on 4 July 2018, it was agreed that a project should be supported for developing the skills and techniques for manufacturing of, '*Class A Composite Panels – Panels without Rework or Finishing.'* This project would assist in identifying composites engineering short-comings in existing composite design, material and manufacturing technologies.

Through this project, eNtsa at Nelson Mandela University plans to use and develop local composites engineering technology and ensure that the Composites Innovation Centre is equipped with the competencies and equipment to provide the industry with accurate interpretation and design assistance.

Individual activities have been identified to address the scope of work required to complete this project.

5.6.2 Background and Motivation

The CPCF project aims to initiate development within composites engineering, to bring the high-end composites infrastructure alive, and lay the foundation for additional investment and resource development in the CIC.

Composites engineering plays a key role in boat building, port infrastructure, renewable energy, and aviation, with opportunities being explored in automotive markets. Industry stands to benefit from this strategy with the human capital development required throughout the value chain in this composites project.

The composites research projects are in line with the Nelson Mandela University strategy and the current composite related activities in Port Elizabeth and the Eastern Cape.

5.6.3 Project Objectives for 2019

The project objectives are highlighted in Table 4. The 'project' is designed as a tool to develop the required human capital expertise required for the establishment of a Composites Innovation Centre (CIC).

Table 4: CIC 2019 objectives

Activity	Description	Outcomes
Objective 1 – Initiate material development	**Project Description** – Audit of several manufacturers and material suppliers, test mechanical properties of the products. Evaluate the need for evaluation for smoke and toxicity. **Skills developed** – Mechanical testing of composite components	Database of mechanical properties of the materials used as well as the product's design requirements.
Objective 2 – Evaluate the manufacturing processes	**Project Description** – Create composite panels initially using glass as a mould substrate (Defects will be a result of the material and process). Test with different mould substrates. **Skills developed** – Mechanical testing of composite materials and familiarisation with processes and manufacturing techniques	A database/matrix of mechanical properties of the materials from different suppliers using different manufacturing processes, fibres, resins and mould substrates. Defect count using X-ray tomography
Objective 3 – Simulate and predict the performance of composite materials	Simulate and predict the performance of composite materials and the manufacturing processes using Finite Element Analysis (FEA) **Project Description** – Use the materials database to create a FEM model and predict the performance of composite flat samples and their manufacturing process using the software. **Skills developed** – Simulation using Siemens NX FEA software	FEM model that can accurately predict the mechanical performance of the composite materials, considering the applied load and fibre direction
Objective 4 – Design and simulation	Design and simulation of an automotive component, for example, bonnet of car (hood), external door panel, rear spoiler, etc. **Project Description** – Use FEM model to design and predict the performance of an automotive component where a 'Class A' panel would be relevant **Skills developed** – Simulation using Siemens NX FEA software	CAD design of an automotive bonnet with the corresponding FEA simulating the predicted structural performance of the component
Objective 5 – Build the tooling required for manufacturing the automotive part	**Project Description** – Use the information generated from the composite material database to manufacture a tool for the making a usable product with a Class A panel. **Skills developed** – Mould manufacture using CNC technologies	A tool capable of producing a **Class A panel**

Objective 6 – Build and test parts with a Class A panel	**Project Description** – Build and test the part against the predicted FEA performance and X-ray tomography **Skills developed** – Test and measurement. Defect analysis using X-ray tomography	**Component** with 'Class A' panel.

5.6.4 High-level Impact

The high-level impact for the project is shown in Table 5. Table 5 indicates the development of the human capital expertise, as well as the industrial collaborations established for completing the project within the Composites Innovation Centre (CIC).

Table 5: CIC high-level impact

Impact	Number	Description
Students	4	Four interns will be appointed to work on the project
Technical Papers	2	A journal paper will be prepared for each of the projects completed
Technology Transfer	4	The technologies utilised for this project include: • Mechanical Testing, (Tensile, Charpy) • Finite Element Analysis (Siemens NX for predicting material behaviour) • X-Ray Tomography (Defect analysis) • CMM machining of moulds • Digital Image correlation (DIC) (Displacement of a loaded part)
Technology Demonstrators	2	Using the database, a model will be created for the manufacture of a Class A panel in the specific industry sector. The model will include the mechanical properties as well as the expected defect counts expected for the manufacturing technique selected. An engine hood (bonnet) is to be manufactured as an automotive component demonstrator. This will require the design, manufacture and building of moulds for demonstration, experimentation and training (a 'Class A' panel is required for the hood).
Industrial Partners	5	Industrial partners identified include: • Custom Works • Hitech Automotive • Welfit Oddy • Amficraft • Cape Composites
Material Suppliers	5	Suppliers of raw materials considered for this project include: • Bodotex Composites • Aerontec • AMT Composites • NCS resins • Scott Bader

5.6.5 Project Progress

5.6.5.1 Work Planned for the Reporting Period (1 April 2019 – 30 June 2019)

Work planned for this period includes the activities highlighted under the 'Objectives' and audit of several manufacturers and material suppliers, test mechanical properties of the products.

Skills developed – Mechanical testing of composite components addressing the issues raised during the Initiation Meeting by assessing the testing requirements and creating a composite testing methodology. Additionally, the project was more clearly-defined with the required resource allocation and the roles of the industrial partners explored.

The work planned for the reporting period includes:

- Developing the required test standards
- Training the human capital (Interns) to perform the variety of tests indicated
- Expanding the material property database

5.6.5.2 Work Planned for the Reporting Period (1 July 2019 – 30 August 2019)

Work planned for this period includes the activities highlighted under the 'Objectives' in Section 1.4, that is expanding the material property database and identifying a potential product for prototyping. This phase of work includes:

- Audit of several manufacturers and material suppliers
- Manufacture 'in-house' panels using various resin systems and fabrics
- Test 'in-house' panels and compare to predicted results
- Determine the viability of X-ray tomography as a tool in assessing composite panels

Skills developed

- Techniques for wet layup and using different resins and fibres
- Mechanical testing of composite components tensile, flexure, impact
- X-ray tomography, utilisation of the equipment
- Autoclave, simple post cure methods

Work Completed

5.6.5.3 Work Completed for the Reporting Period (Initiation – 31 March 2019)

Establish a project management structure within the Nelson Mandela University for the management of the project activities, these would include manufacture, test/measure and simulation.

The project has been subdivided into four separate 'Work Packages'.

The work packages include:

- **Audit:** Test and measurement of products requiring the use of 'Class A'
- **Specification and Database:** Create a material specifications database that meet the composite requirements evaluated in Phase 1 and update the FEM prediction model for the materials evaluated
- **Design and Manufacture:** Design the component as well as the tooling for the component selected
- **Test and Measurement:** Evaluate the manufactured panel against the predicted performance of both the FEM and materials database

Audit

Project collaborators were identified, these aimed to assess the performance of their product with the goal of improvement. These companies included: Custom Works, Hitech Automotive, Welfit Oddy, Amficraft and Cape Composites.

Test specifications were identified to assist in establishing the mechanical performance of the supplied panels. The test specifications include:

- Tensile Strength: ASTM D3039
- Flexure: ASTM D790
- Impact Strength: ASTM D6110

5.6.5.4 Work Completed for the Reporting Period (1 April 2019 – 30 June 2019)

The project collaborators were slow in providing the required composite samples necessary for the audit phase, which had the consequence of delaying the mechanical tests planned.

Skills developed

The appointed interns were trained to use the Hotwire-Foam cutter (equipment supplied through the high-end infrastructure funding). Additionally, the interns were trained to perform the required Tensile, Impact and Flexure tests (see Figure 46).

Figure 46: Interns, Kulani Mabunda, Aphiwe Josayi and Nandim Ndlangwe, performing mechanical tests on composite coupons

Material has been provided by two of the identified project collaborators with the additional suppliers promising delivery. The following results being recorded for the mechanical tests performed (see Figure 47).

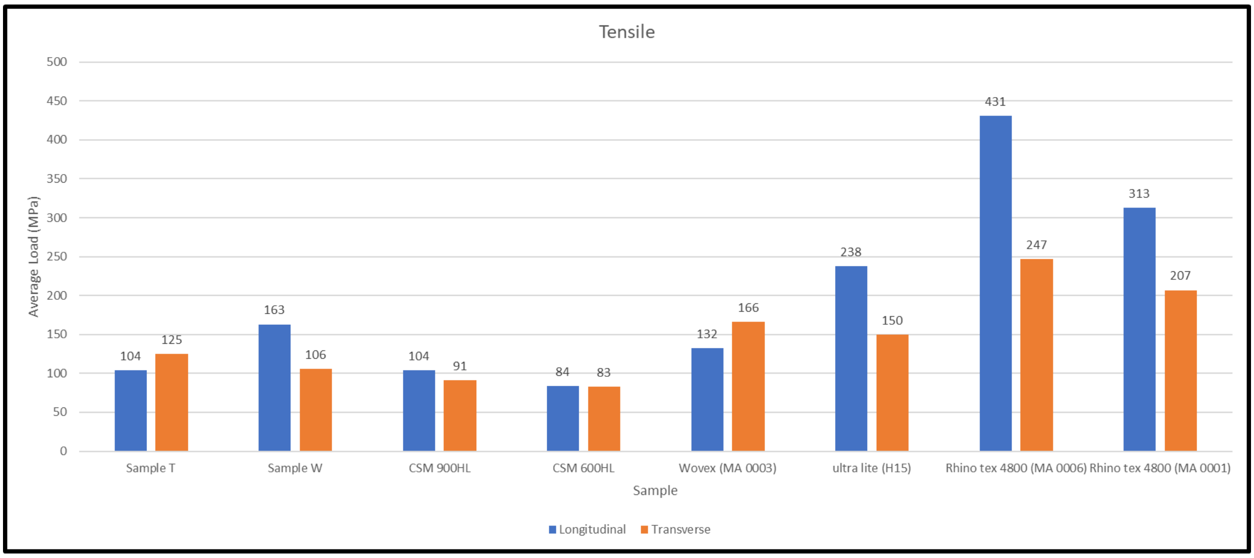


Figure 47: Tensile performance of supplied panels

The tensile test has been performed according to the specification ASTM D3039, which comprises of five specimens being tested in each of the principle stress directions, namely,   the tensile tests per supplied coupon.

80 tensile tests have been performed to date as part of this project. The variance between the measured maximum stress of longitudinal direction versus the transverse direction is evidence of the asymmetrical layup used in manufacturing the composite panel (see Figure 48).

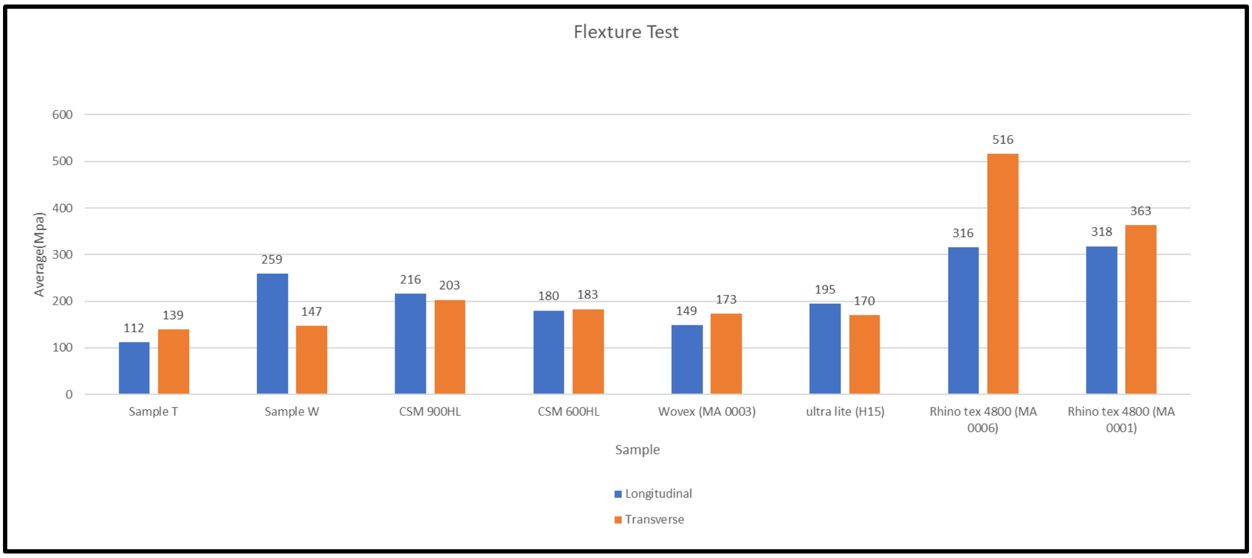


Figure 48: Flexural strength of supplied panels

The flexure test has been performed according to the specification ASTM D790, which also comprises of five specimens being tested in each of the principle stress directions, namely, ten tests per supplied coupon. Eighty flexure tests have been performed thus far for this project. Flexure can indicate the tensile strength behaviour of a sample, however, the difference between the flexural strength and tensile strength can show the contribution of the gel coat to the structural performance (see Figure 49).

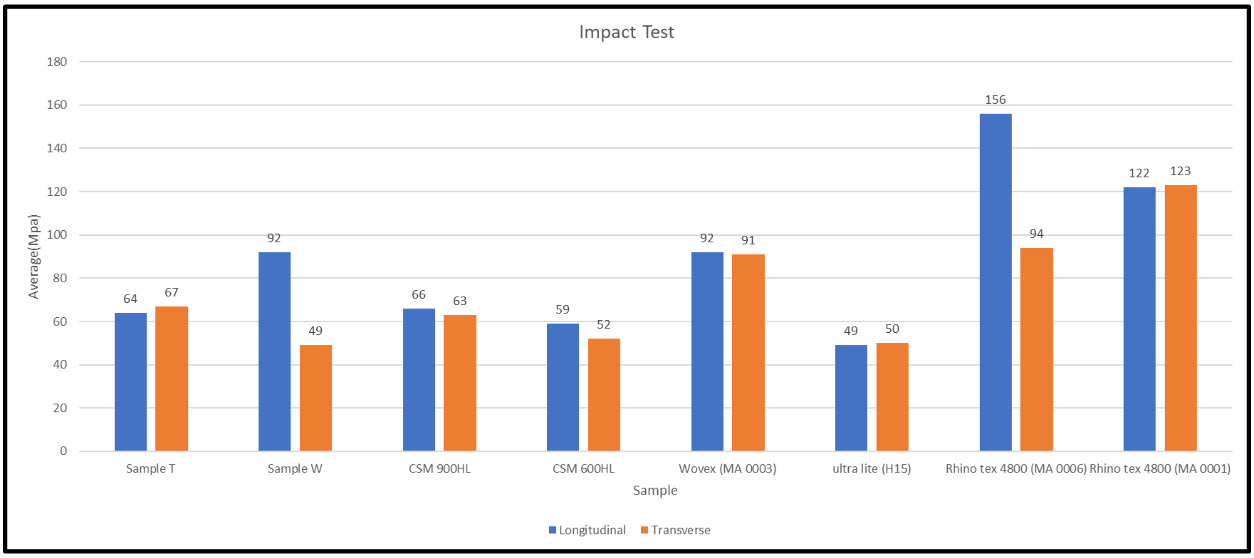


Figure 49: Impact strength of supplied panels

The impact strength test has been performed according to the specification ISO179, which comprises of ten specimens being tested in each of the principle stress directions, namely, 20 impact tests per supplied coupon. One hundred and sixty flexure tests have been performed for this project. The impact strength is considered the ability material to absorb energy. The various fibre directions will have differing abilities to absorb energy (see Figure 50).

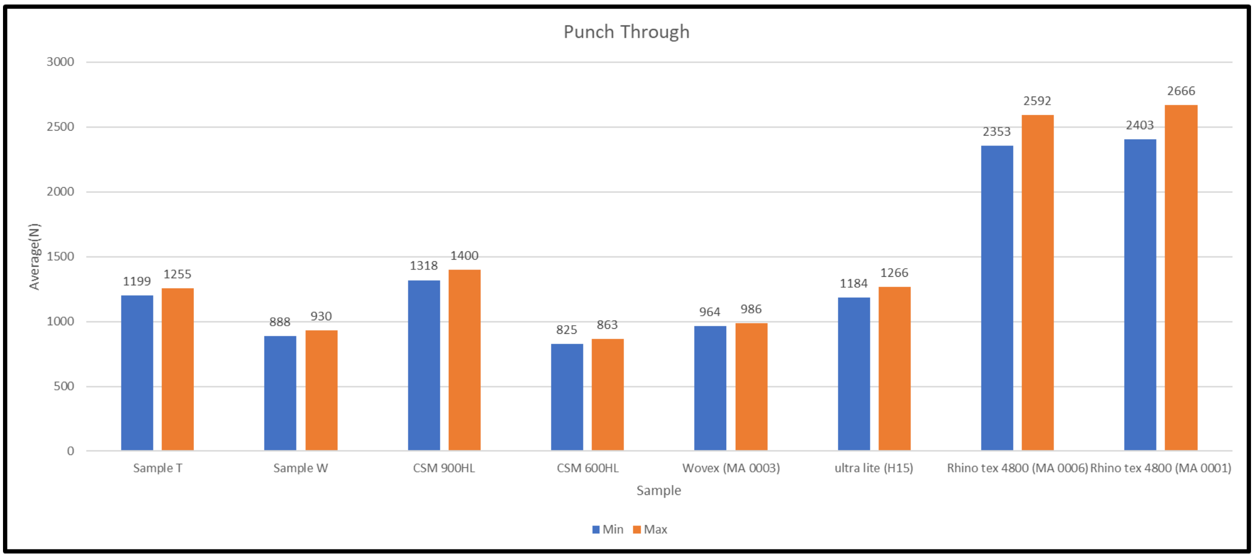


Figure 50: Punch through test of supplied panels (in-house test)

The punch through test is a ‘in-house’ test method, used to determine the ability of the supplied material to resist damage. A sample is place on a test platform with a 20mm spherical load being applied. The total defection versus the applied load indicates the ability of the laminate to resist damage.

Included in this phase of testing is an evaluation of the tomography using the micro-CT scanner,with various images being generated. The µCT image will show the fibre type, fibre orientation, density (layering) as well as the thickness of the gel coat used.

The CT scanner detects X-rays through a part, and the part is progressively rotated at known increments; then the images are collated, and a CAD model of the laminate is generated. The CAD model can provide information including defect analysis (see Figures 51 and 52).

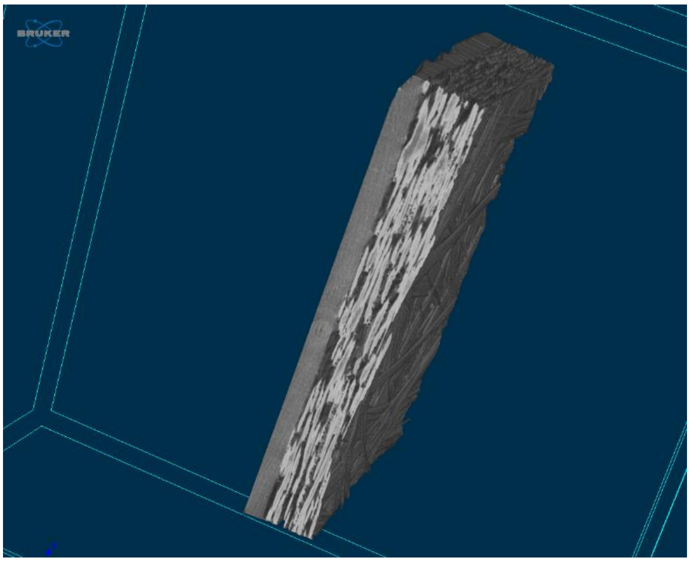


Figure 51: X-ray tomography showing the composite ‘chop-strand’
[Note: the thick gel coat layer.This sample will show poor tensile strength performance due to the poor fibre density.]

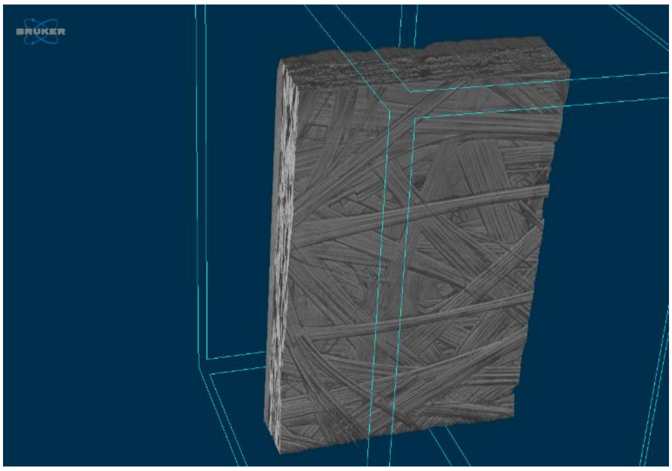


Figure 52: X-ray tomography showing the composite 'chop-strand'

5.6.5.5 Work Completed for the Reporting Period (1 July 2019 – 30 August 2019)

The test and audit phase of the project received the required attention with the project project collaborators supplying the agreed products.

The interns were trained to work according to the required test specifications, including ASTM D3039 for Tensile Strength, ASTM D790 for Flexure and ASTM D6110 for Impact Strength.

Additionally, a collaborative project has been established with Aerosud and the Fraunhofer (Institute for Manufacturing) using the Digital Image Correlation (DIC) for defect analysis on aerostructures.

Skills developed

The appointed interns have been trained to perform the required Tensile, Impact and Flexure tests according to the specifications:

- ASTM D3039 (Tensile Strength)
- ASTM D790 (Flexure)
- ASTM D6110 (Impact Strength)

Furthermore, a CIC intern has received training using the X-ray tomography equipment and is now capable of supporting composite testing, battery testing and friction welding research projects (see Figures 53 and 54).

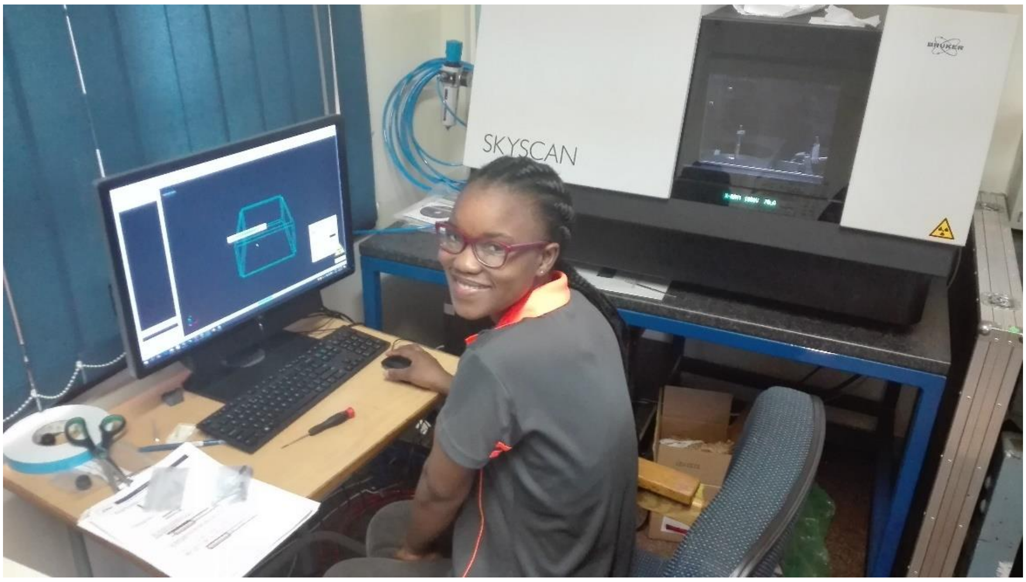


Figure 53: Intern, Aphiwe Josayi, performing an X-ray tomography evaluation of a part

Figure 54: Intern, Ivan Madihlaba assisting with tensile testing

CIC Interns have used 'Wet-Layup' techniques for the manufacture of test samples with Figure 55 illustrating the performance of the evaluated panels.

The benefit of the carbon fibres was evident in the tensile test, while the impact strength test showed the advantage of utilising the aramid fibres.

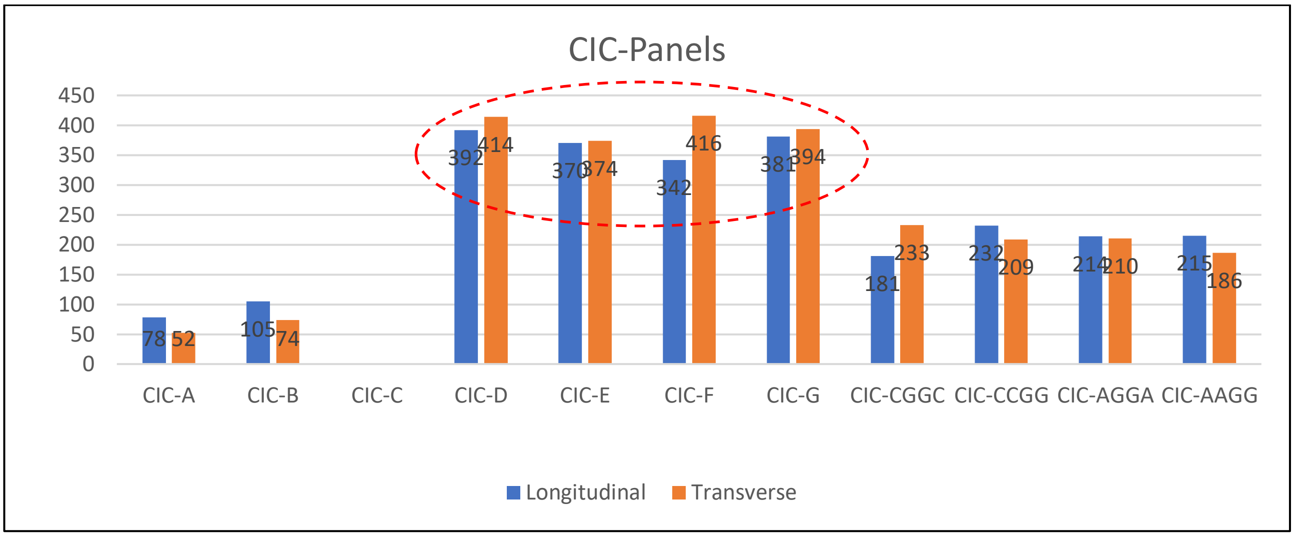


Figure 55: Tensile performance of panels produced at the CIC [Carbon fibre panels highlighted]

All tests performed according to the specification ASTM D3039 (five specimens being tested in each of the principle stress directions) (see Figure 56).

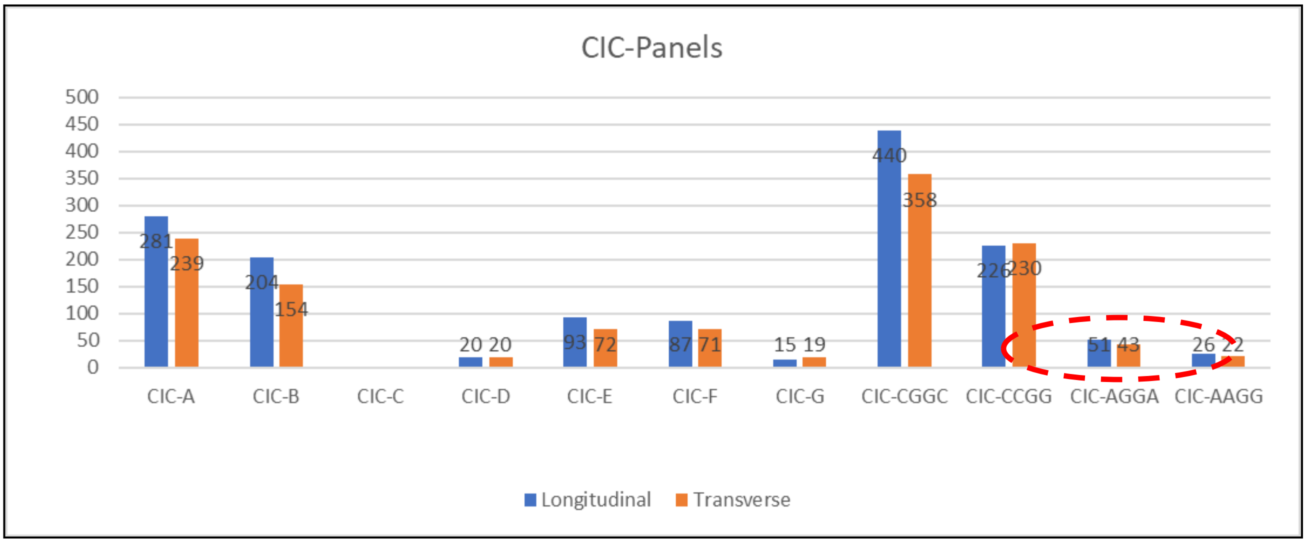


Figure 56: Flexural strength of supplied panels [Poor shear strength of aramid panels highlighted]

The flexure test was performed according to the specification ASTM D790 (see Figure 57).

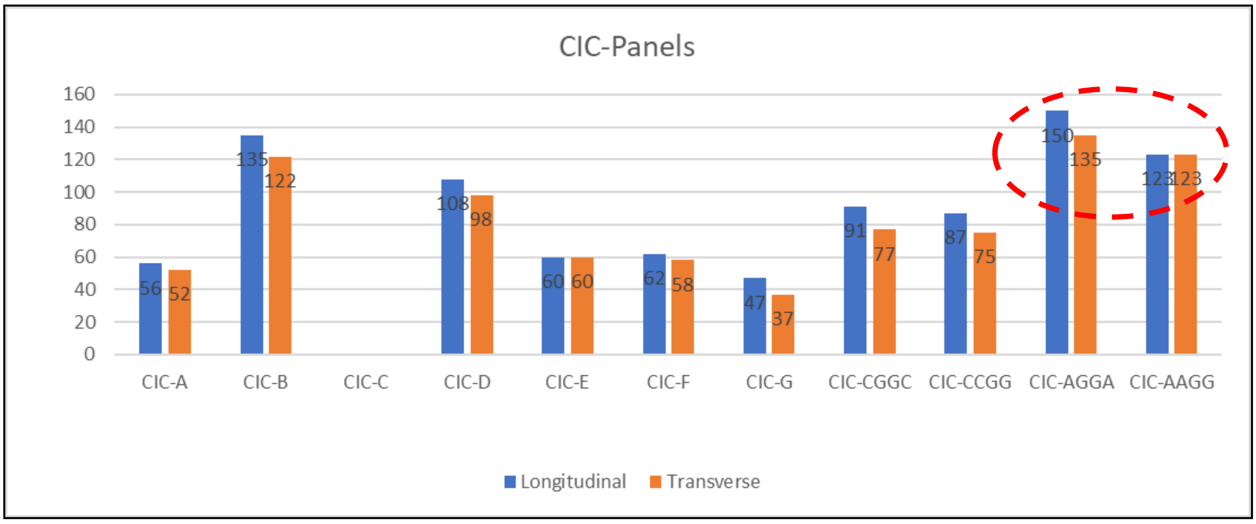


Figure 57: Impact strength of supplied panels
[Impact resistance of aramid highlighted]

The impact strength test was performed according to the specification ISO179 (see Figure 58).

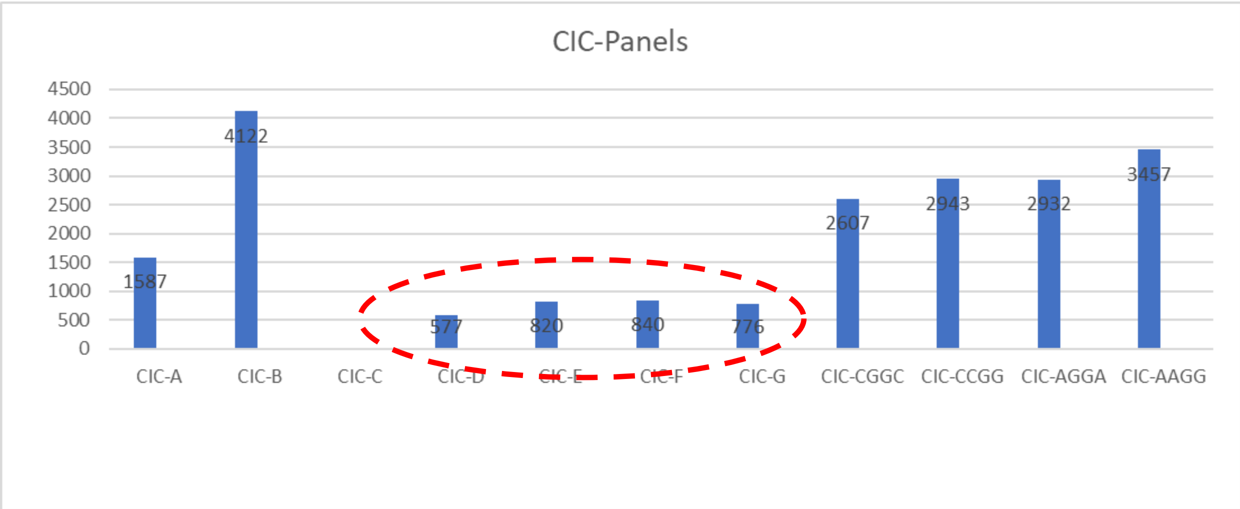


Figure 58: Punch through test of supplied panels (in-house test)
[Poor punch through performance of thin carbon panels]

The punch through test is a ‘in-house’ test method, used to determine the ability of the supplied material to resist damage (see Figures 59, 60 and 61).

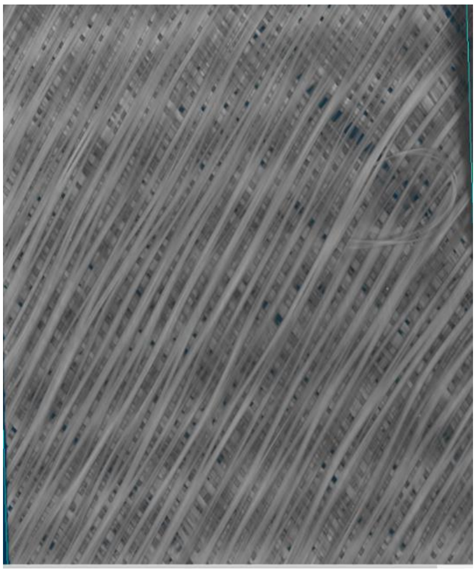


Figure 59: X-ray tomography showing two layer of 410g/m^2 composite glass fibre [Wet hand layup]

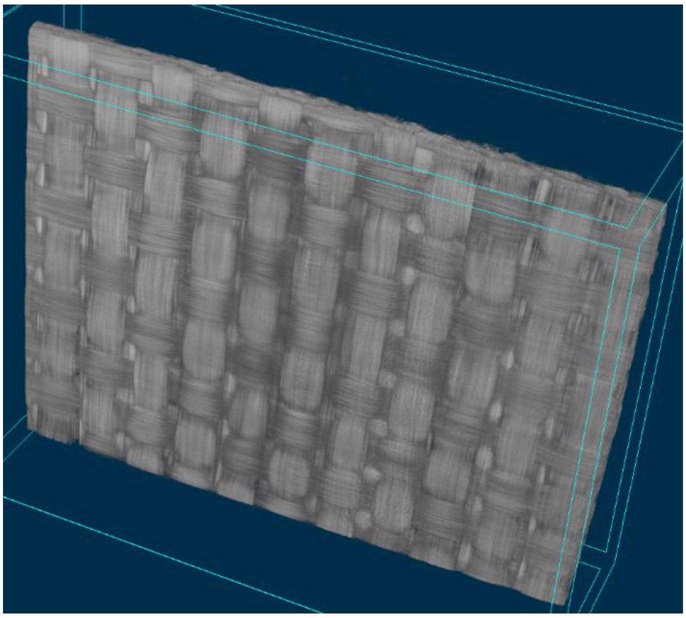


Figure 60: X-ray tomography showing customer supplied 'RhinoTex 2400'
[Note: Fibre density]
[Note: Thick gel coat layer. This sample will show poor tensile strength performance due to the poor fibre density.]

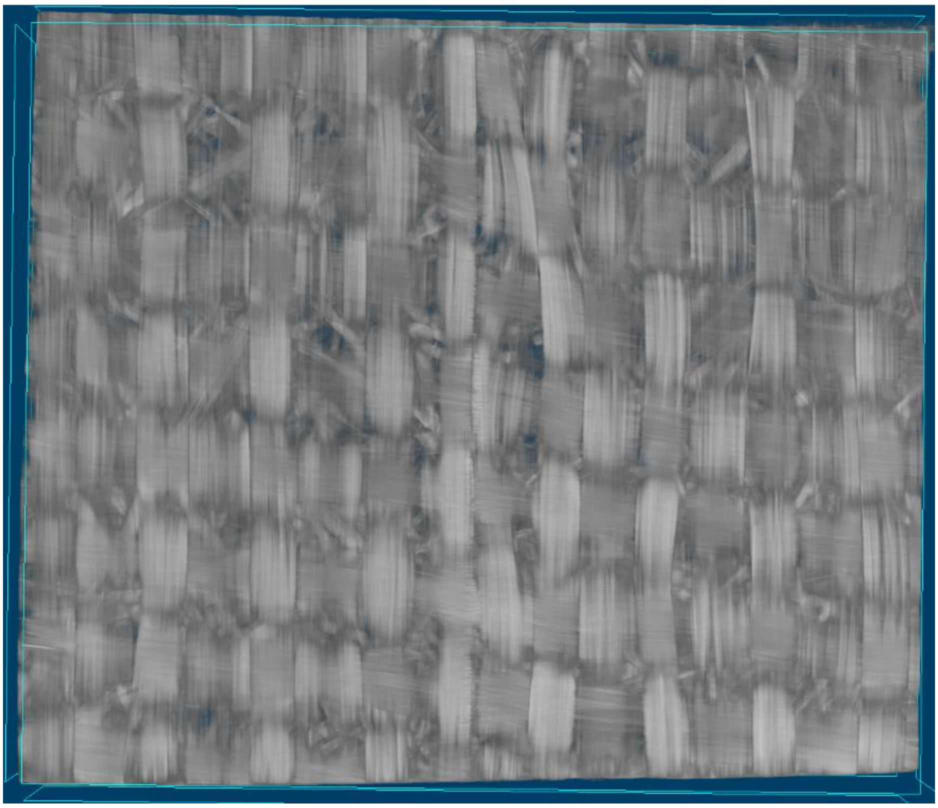


Figure 61: X-ray tomography showing the composite layering, woven fibre on 'chop strand' [Note: High-fibre density]

5.6.5.6 Work completed for the reporting period (1 September 2019 – 1 December 2019)

In collaboration with the project partners a component deemed both necessary and challenging has been selected for design as an A Class Panel. The component being the hood of a Classic Ford Mustang (1967).

The test panel was laser scanned using a Creaform Metrascan. The data was initially saved as .stl data and after some manipulation saved as to a more usable .stp format. Mould designs have been created from the manipulated scan data (see Figures 62 to 68).

Figure 62: Laser scanning equipment

Figure 63: Hood from Ford Mustang (1967)
[Note: Large surface 'A-Class' area and turbocharger intake – Requires tooling Insert]

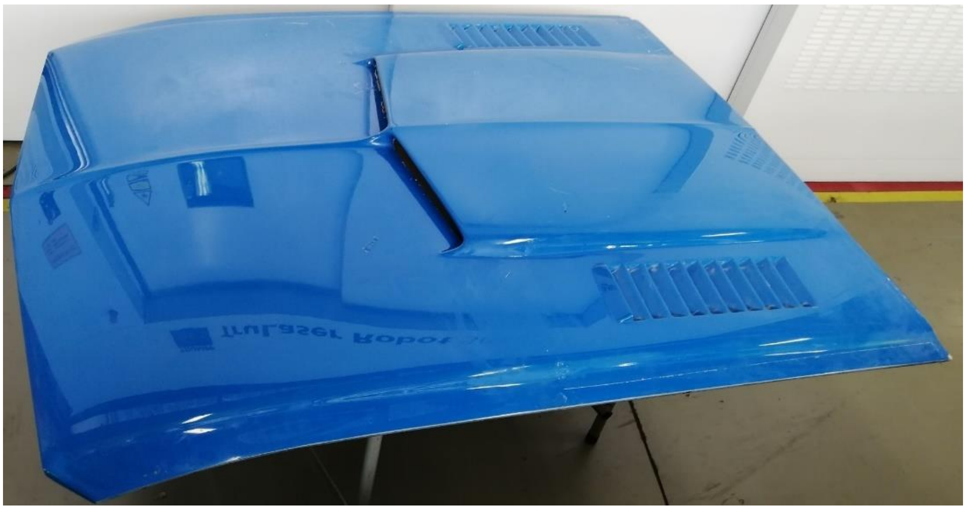


Figure 64: Hood from Ford Mustang (1967)
[Note: Large surface 'A-Class' area and turbo charger intake. Cooling louvers requires draft to the right while turbocharger intake required draft to the left]

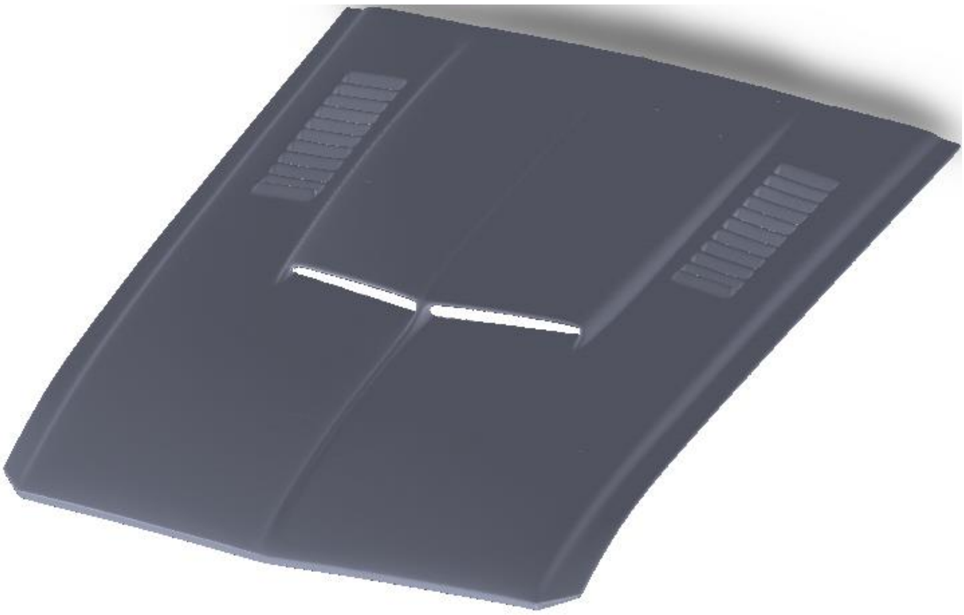


Figure 65: CAD model generated from Creaform laser scanner - ‘A-Class’ panel from Ford Mustang (1967) [Note: Large surface area and turbo charger intake – Insert required]

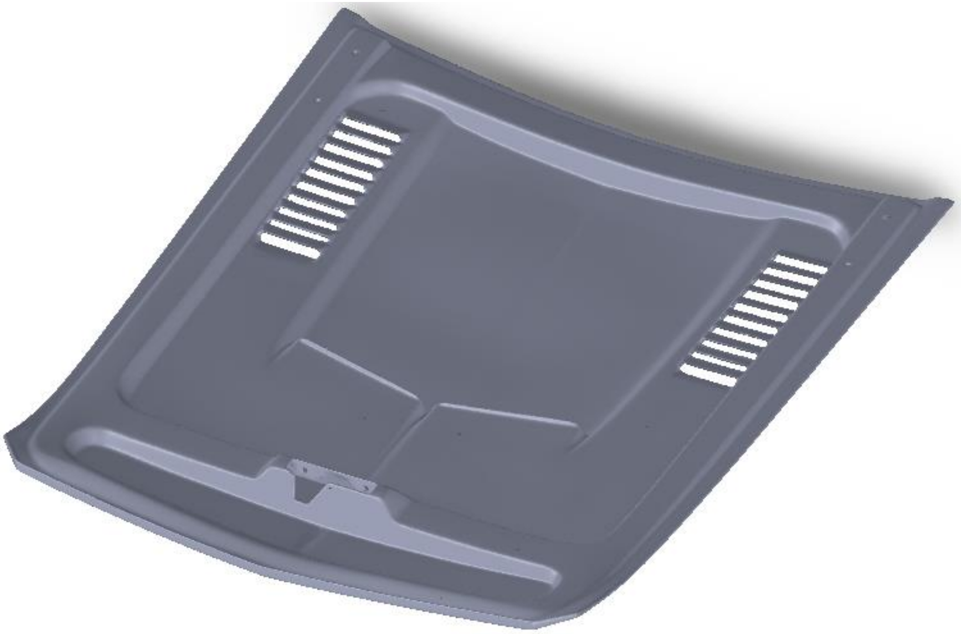


Figure 66: CAD model generated from Creaform laser scanner B-Surface of Ford Mustang Hood [Note:The cooling louvers requiring insert in mould]

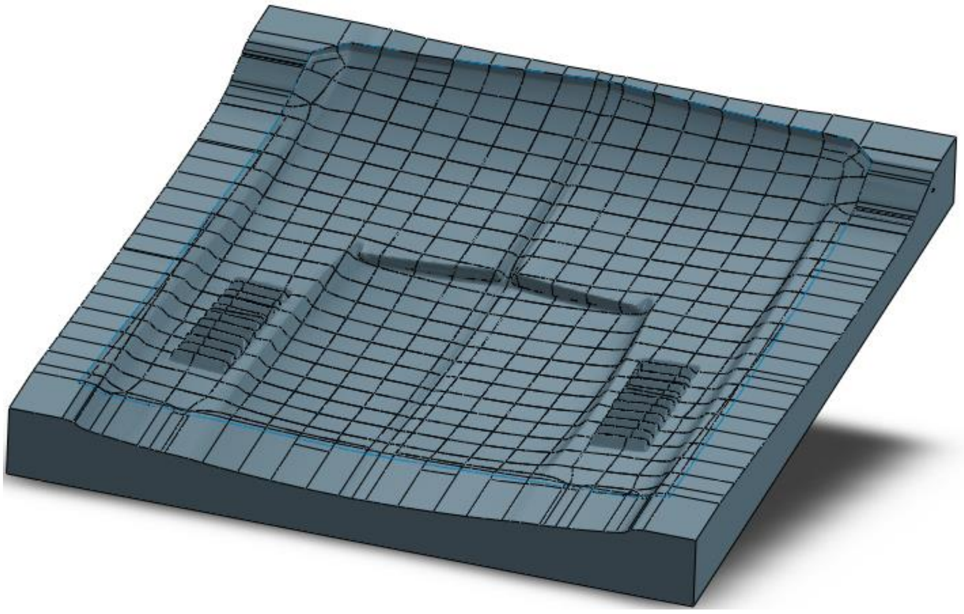


Figure 67: Mould design for hood showing louvers and negative turbocharger surface incorporated [Note: Edge flange modelled for vacuum sealing]

Figure 68: Prototype core cut using Hot-Wire foam cutter

The interns have been assisting with the measurement and modelling as well developing the skills required for operating the CNC Hot-Wire foam cutter. They have assisted with various prototypes which include the manufacture of a large stand-up paddle board, a potential export product for a local manufacturer.

5.6.5.7 Work Completed for the Reporting Period (1 December 2019 – 11 March 2020)

During this reporting period the CAD data for the Mustang hood has received necessary refinement (see Figures 69 and 70).

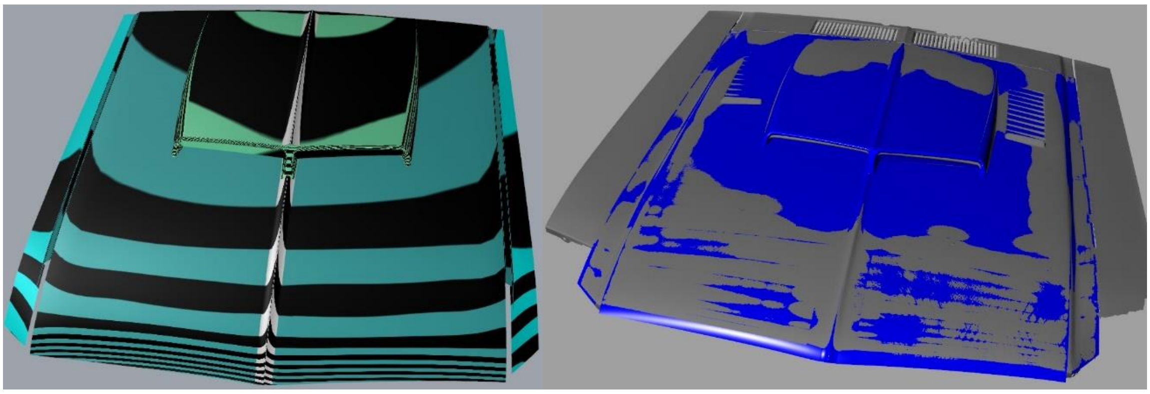


Figure 69: Cad refinement of the hood data; Zebra lighting for accentuating possible defects in body lines/curves. Blue body overlay showing scan data imperfection measured from supplied part

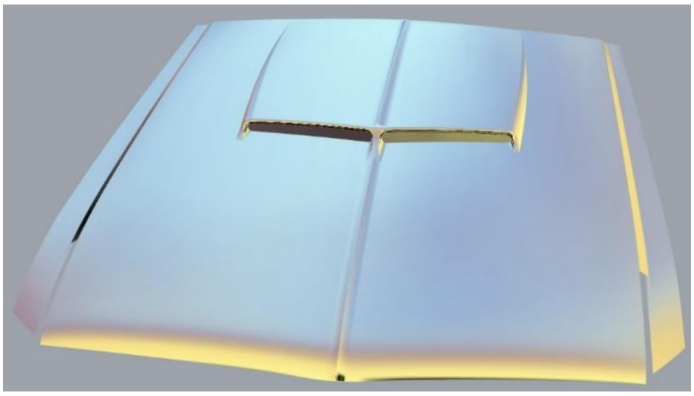


Figure 70: CAD rendering of the scanned body panel

The collaborative opportunities between eNtsa (Nelson Mandela University), Aerosud and the Fraunhofer Institute for manufacturing have been explored, this culminating in a project to develop repair technologies/techniques for the repair of carbon fibre aero-structures.

Additionally, the CIC Intern assisted with the development of a new ‘sporting goods’ fishing platform. Required complex 3D cutting techniques (see Figures 71 to 73).

Figure 71: Prototype development of a fishing platform [Stand-up paddle board]

Figure 72: Prototype tank evaluation of manufacturing technique via vacuum infusion [Model tank container for shipping chemicals]

Figure 73: Vacuum infusion setup

6. Training Academy

By Ms Nadine J Goliath (Training Academy Manager)

eNtsa has identified industrial training and skills development as an additional opportunity to expand and broaden the customer base giving rise to the opportunity of launching an eNtsa Training Academy. This eNtsa's ambition is aligned with the University's Vision and Mission, aiming towards providing an environment generating cutting-edge knowledge and providing a platform for diverse educational opportunities to constructively contribute to a sustainable future, globally.

6.1 Objectives

- To **continuously improve internal skillset and knowledge** to provide innovative services to our clients and strategic partners
- To **assist industry with skill upliftment interventions to bridge skill shortfall** and move towards business operation best practices
- To **create a platform for local and international collaboration** aimed to encourage internationalisation of local markets
- To **encourage an environment of learning, teaching and engagement for the community** aimed at contributing towards effort of sustainability.

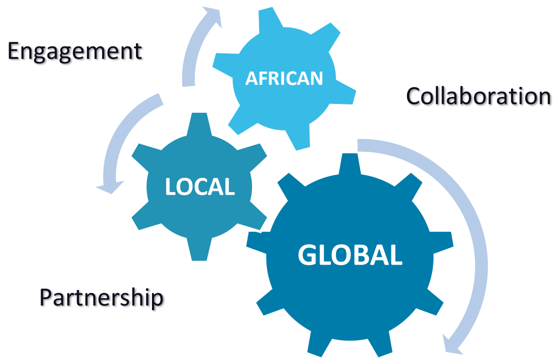
6.2 Training Intervention Categories

eNtsa Training Academy aims to support by providing various types of services (administrative or technical). To organise interventions within the Academy, the following categories have been identified:

- **Internal training and engagement:** aimed at developing internal skill set or knowledge of internal university staff, interns and postgraduate researchers.

- **Industry-focussed training and engagement**: aimed at industry members to develop necessary skills or knowledge to improve organisation operation or operational knowledge according to best available practices.

- **Community-focused training and engagement**: aimed at supporting knowledge sharing, knowledge advancement and skill development between various members with in society in effort to promote collaboration and engagement.



6.3 Training Academy Activities 2019/20

6.3.1 eNtsa Training Academy activities hosted in collaboration with TSP

Table 6 illustrates the various knowledge transfer activities that were completed in FY2019/20.

Table 6: Summary of eNtsa hosted training in collaboration with eNtsa TSP initiative

	Training / Knowledge transfer description	Venue	Presented by	No. of attendees
1	**Introduction to Metallurgy:** Purpose of training: Introduce trainees to the basics of metallurgy Target audience: Individuals working with selling, ordering or designing with metals.	Nelson Mandela University	Dr Annelize Botes (CSIR/NMU)	14
2	**Introduction to Metallurgy:** Purpose of training: Introduce trainees to the basics of metallurgy Target audience: Presented to staff at First National Batteries on request, to broaden understanding of metals	First National Batteries (East London)	Dr Annelize Botes (CSIR/NMU)	7
3	**Continuous Quality Improvement Training:** Purpose of training: Introduce trainees to the basics of metallurgy Target audience: Presented to staff at Borbet South Africa based on skills analysis and evaluation of European standards	Borbet South Africa	eNtsa Training Academy and Top QM Systems	19
4	**Learning and Presentation fundamentals** Purpose of training: Introduce trainees to best practices when presenting technical training and preparing presentations for clients Target audience: Presented to staff at DamoChem a black-owned SME in the chemical industry	Nelson Mandela University	Nadine Goliath (eNtsa)	2
5	**Basics of Safety System Integration and Design Training** Purpose of training: Introduce trainees to the basics and importance of safety in automation system design Target audience: Presented to senior engineering students from Mechatronics and Mechanical engineering	Nelson Mandela University	eNtsa Training Academy, Vernon Nortje and Craig Cuff (Prime Automation)	57
6	**Professional Metallographer** Purpose of training: Training providing insight into the materialographic preparation process Target audience: Laboratory and quality technicians/engineers	Nelson Mandela University	eNtsa Training Academy and Advanced Laboratory Solutions (ALS) and Streurs	10
7	**Introduction to 3D printing** Purpose of training: Introduction to 3D printing technology, allowing participants to experience a practical, hands-on training workshop. Each participant received a mini 3D printer, which they worked on for the duration of training and kept to promote self-learning. Target audience: 3D printing enthusiasts and participants interested in 3D printing technology for professional or personal use	Nelson Mandela University	Dr Sean Poole (eNtsa, NMU)	15
8	**Geometric Dimensioning and Tolerancing (GD&T)** Purpose of training: Introduce trainees to the correct application and interpretation of international ISO/ASME GD&T principles. Particularly hosted to fill the gap in the global supply chain and support localisation/export where local manufacturing staff cannot correctly interpret OEM drawings and manufacturing specifications. Target audience:	Nelson Mandela University	eNtsa Training Academyand Technia	27

	This course is suited for all paricipantsinvolved in design and manufacturing processes, from design engineers through to manufacturing engineers, technicians and inspectors of all abilities.			
10	**Motion Master Class** <u>Purpose of training:</u> The intention of the course is to present introduction-level information, tips and rule-of-thumb guidelines for a wide range of motion control concepts, providing a simplified overview. <u>Target audience:</u> Target audience is PLC programmers and machine builders, and any participant wanting to learn about how motion control systems work.	Nelson Mandela University	Etienne Phillps (eNtsa/Beckhoff, UK)	10
			Total	**161**

Figures 74 to 77 illustrate the photographs of training activity groups from Table 6.

Figure 74: Introduction to Metallurgy: Motion Master Class

Figure 75: Basics of Safety System Integration and Design Training

Figure 76: Introduction to 3D printing Training

Figure 77: Geometric Dimensioning and Tolerancing (GD&T) Training

6.3.2 Eskom EPPEI Engineering Practitioner Training Programme (EPTP)

The skills capacity gap within the power generation industry, more specifically within Eskom, Eskom Power Plant Engineering Institute (EPPEI) and eNtsa was addressed, through the Nelson Mandela University. An agreement was put in place to create a platform and establish the necessary infrastructure required to bridge this skills gap within the South African and, more generally, the Southern Africa power generation industry. EPPEI was established in 2012 to increase skills capacity of engineers in Eskom.

Part of EPPEI's drive includes the Operators, Maintenance and Engineering Practitioners initiative which aims to create the opportunity for plant personnel to advance their knowledge, leading to an increase in their technical competence, allowing for more efficient operation and maintenance of Power Plants. Furthermore, this will create the opportunity for all plant personnel to advance their knowledge, leading to an increase in their technical competence, allowing for more efficient operation and maintenance of Power Plants

The objectives of the Engineering Practitioner Training Programme (EPTP) are as follows:

- To provide the opportunity to engineering practitioners to gain a thorough understanding of their job activities including engineering fundamentals and practical plant operation and maintenance requirements
- To provide engineering practitioners with an accredited certification of professionalism in their job profile

The EPTP has a two phase approach. Phase I focusses on delivery of short courses and Phase II aims to establish a formal nationally-accredited qualification with the assistance of HEIs allowing Eskom staff to obtain a formal qualification, while working, by attending accredited modules offered via the Engineering Practitioner Training courses. Phase I utilises a set out building blocks method to ensure that the necessary resources are engaged and the necessary milestones are reached to achieve effective execution of the project.

Table 8 illustrates the number of people trained within Eskom on the various course available for delivery, which resulted in **795** candidates receiving training within this project.

Table 8: Number of candidates trained per training course as presented within the EPTP initiative

EPTP Course Schedule from April 2019 - March 2020						
No.	**Course name**	**Start date**	**End Date**	**Number of attendees**	**Month of the year**	**Total for the month**
1	Valve Principles and Terminology	13 May 2019	16 May 2019	43	**May-19**	**52**
2	Tech Fire Systems and Life Safety	22 May 2019	22 May 2019	9		
3	Introduction to Reliability Engineering	18 June 2019	19 June 2019	10	**Jun-19**	**23**
4	Boiler Essentials Mass Energy Balance	25 June 2019	27 June 2019	13		
5	Risk Based Inspection Awareness Training	10 July 2019	10 July 2019	12	**Jul-19**	**38**
6	Risk Based Inspection Process Training	11 July 2019	11 July 2019	16		
7	Degradation Mechanism and the required Inspection Training	17 July 2019	17 July 2019	10		
8	Piping, Flanges and Pressure Vessels - Part 1	06 August 2019	07 August 2019	23	**Aug-19**	**54**
9	Tech Fire Systems and Life Safety	07 August 2019	07 August 2019	15		
10	Piping, Flanges and Pressure Vessels - Part 2	13 August 2019	14 August 2019	23		
11	Degradation Mechanism and the required Inspection Training	20 August 2019	20 August 2019	16		
12	Boiler Essentials - Mass Energy Balance	10 September 2019	12 September 2019	9	**Sep-19**	**19**
13	Risk Based Inspection Process Training	27 September 2019	27 September 2019	10		
14	Introduction to Reliability Engineering	16 October 2019	17 October 2019	22	**Oct-19**	**28**
15	Tech Fire Systems and Life Safety	30 October 2019	30 October 2019	6		
16	Risk Based Inspection Process Training	06 November 2019	06 November 2019	7	**Nov-19**	**43**
17	Risk Based Inspection AwarenessTraining	11 November 2019	11 November 2019	8		
18	Tech Fire Systems and Life Safety	13 November 2019	13 November 2019	18		
19	Risk Based Inspection Process Training	22 November 2019	22 November 2019	10		
20	Risk Based Inspection Process Training	28 January 2020	28 January 2020	9	**Jan-20**	**9**
21	Risk Based Inspection AwarenessTraining	11 February 2020	11 February 2020	13	**Feb-20**	**13**
22	Risk Based Inspection Process Training	16 March 2020	16 March 2020	10	**Mar-20**	**10**
Grand total for period: 1 April 2020 - 31 March 2020					**289**	

Engagement is underway for the continuation of this project in the new financial year. The involvement of Universities of Technologies (UoTs), research facilities within HEIs and experts (within industry and a consultancy capacity) is a core focus to further develop efforts to ensure content technically relevant and applicable to Eskom.

7. uYilo eMobility Technology Innovation Programme (EMTIP)

By Mr Hiten Parmar (uYilo Director / Business Development Manager) and Edem Foli (Programme Manager)

Initiated by the Technology Innovation Agency, the uYilo eMobility Programme (uYilo) has been hosted within eNtsa, at Nelson Mandela University, for the past seven years. uYilo is a multi-stakeholder collaborative programme focussed on enabling, facilitating and mobilising electric mobility (eMobility) along its associated sectors in South Africa. The programme's activities extend across government lobbying, industry cohesion, enterprise development, thought leadership and skills development. uYilo is profiled as a Strategic Initiative within the national Department of Transport's Green Transport Strategy (2018-2050) to which Strategic Pillar 8 promotes electric and hybrid-electric vehicles.

uYilo has since established a foundation of specialised expertise and key infrastructure towards accelerating the growth of eMobility in South Africa. The programme's facilities consist of a National Accredited Battery Testing Laboratory, Materials Characterisation Laboratory, Vehicles Systems Laboratory for component level support and a Smart Grid EcoSystem that provides a live testing environment for universal interoperability.

These facilities and services supporting enterprise development as well as the annual uYilo Kick Start Fund support technology advancements through funding local innovation value chain development of eMobility products and services. The initiative seeks greater alignment with the Department of Trade and Industry's 2035 South African Automotive Masterplan, which aims to achieve 60% localisation. A total of 30 Kick Start Fund project proposals were received for the FY 2019/20 funding call, of which three applications received funding. The approved projects were an electric vehicle, which focused on vehicle telematics prototype by Lattech Systems, a feasibility study for the production of high purity manganese sulphate by the Manganese Metal Company and a detailed feasibility study for electric bus operations in South Africa by Golden Arrow Bus Services.

In the FY2019/20, uYilo continued to serve on a number of national initiatives that enabled the uptake of eMobility in South Africa. As a member of the Department of Energy's South African Smart Grid Initiative (SASGI), uYilo provided input into relevant policies, legislation and the national direction for eMobility technologies into smart grids. The programme continued support to the National Association of Automobile Manufacturers of South Africa (NAAMSA) for electric vehicle technology. uYilo was included within subject matter experts to the Manufacturing and Engineering Related Services SETA (merSETA) coordination of the Hybrid and Electric Vehicles Transportation Electrician qualification for South Africa. uYilo also participated as a working group member of the Department of Science and Innovation's Energy Storage Research, Development and Innovation (RDI) Consortium, which aims to develop value-added battery components based on the beneficiation of local mineral resources, to position South Africa to become part of the global value chain for energy storage and electric vehicle applications.

uYilo has continued to play an integral role in enabling the uptake of eMobility in South Africa while leveraging on international exposure (see Figure 78).

Figure 78: A Department of Science Innovation (DSI) delegation led by the Director General, Dr Phil Mjwara, and the Minister of Higher Education, Science and Innovation, Dr Blade Nzimande, visited uYilo's facilities on 16 August 2019

7.1 Vehicle Systems and Smart Grid EcoSystem

By Mr Hiten Parmar (uYilo Director) and Edem Foli (Programme Manager)

The Vehicle Systems facility provides mobility platform development and integration of all products across the e-Mobility spectrum from a variety of global suppliers to accelerate the deployment of electric vehicle technologies in South Africa. To establish a benchmark and helps set future technological goals, new technologies are evaluated and integrated from the component level to the vehicle system level for optimal performance and application. uYilo provides support for electric mobility platforms while evaluating current and future technologies for electric vehicle components to aid in the implementation of advanced technologies to expand market applications. The facility additionally provides skills development along the associated high voltage systems within electric vehicles.

The Smart Grid EcoSystem facility provides a live testing environment to facilitate universal connectivity between electric vehicles and supporting smart grid infrastructure. It supports demonstration and analysis of electric vehicles, and development of infrastructure technologies to aid in the advancement of technologies to expand their commercial applications. The infrastructure consists of various electric vehicle ecosystem elements such as electric vehicles, a mix of AC charge points, DC fast chargers and Vehicle-to-Grid system capabilities. Renewable energy is incorporated to supply the charger network and is dynamically controlled through a supervisory Energy Management System for individual charger energy profiling. Energy storage is achieved through repurposed electric vehicle battery packs serving as ‘second life’ application under stationary storage. The smart grid network management system is aligned to global protocols to support future innovative developments. The facility allows incubation and demonstration activities that will provide critical data to the development and commercialisation of next-generation vehicles and supportive smart grid infrastructure (see Figure 79).

Figue 79: uYilo’s Smart Grid EcoSystem provided the interoperability of various manufacturers’ equipment while expanding the scope for new technology development

In FY 2019/20, uYilo’s Smart Grid EcoSystem provided the interoperability of various manufacturers’ equipment while expanding the scope for new technology development. The project’s activities extended across renewable energy generation, second-life electric vehicle batteries integration as stationary storage, vehicle-to-grid (V2G) of ancillary grid services from electric vehicles, and an autonomous energy management system providing resilient charging infrastructure for electric vehicles aligned to the IEC 61850 smart grid protocol. The activities also reinforced uYilo’s partnerships and engagements with Nissan (South Africa and Japan global headquarters), BMW South Africa, Mercedes Benz South Africa, Eskom and NUVVE Technology (USA).

7.2 Battery and Storage Systems

By Dr Nico Rust (Group Specialist: Energy Storage Systems), Dr Xandri van Niekerk (Group Specialist: Materials) and Prof. Ernst Ferg (Research Advisor).

The uYilo battery-accredited testing laboratory supports the local R&D and manufacturing entities by providing accurate and reproducible testing services relevant to the evaluation of new energy storage solutions whilst also providing validation of existing battery technologies. The accreditation of the uYilo testing laboratory that is already into its fifth year, is in line with the South African National Accreditation System (SANAS) laboratory requirements, which is recognised internationally under the ISO standards system. In 2019, the laboratory updated its quality system from the ISO17025 (2005) to ISO17025 (2017), which places more emphasis on the statistical measurement of uncertainty, risk management and impartiality of analysis done.

The laboratory also has the accreditation to test lithium-ion cells for stationary applications according to IEC62620 (Performance), and in 2019 has done a number of testing services of various Li-ion cells for local importers and suppliers. Of particular interest is the comparative performance evaluation of imported cells from a number of suppliers to ensure consistency and durability for specific applications.

The laboratory commissioned its 100V battery tester to accommodate 48V and higher battery module testing. It has the ability to use a CANBus communication protocol interface that can measure or control various battery management functions, while subjecting the battery to a pre-programmed testing sequence. Current projects included the evaluation of a 48V Li-ion module that was refurbished with 2nd life calendar-aged Li-ion pouch cells. The intended battery module will be used in an all-terrain vehicle (ATV) by the NMU campus horticultural staff. The uYilo battery testing laboratory also provided a range of other battery testing that was beyond the scope of its accreditation. These include testing for batteries used in UPS and renewable energy storage applications and automotive battery standards. The laboratory is currently the only facility in South Africa that can provide Dynamic Charge Acceptance (DCA) testing according to EN50342-6 specifications for starter batteries used in micro-hybrid vehicle applications. This is a lengthy and relatively complicated test method that required specialised equipment. The tester allows for the evaluation of up to six batteries at a time and can take up to two to three months to complete. The service allows the local battery manufacturers to develop and improve their batteries in conjunction with automotive technology advancements.

The materials laboratory continued to provide a range of unique set of testing services to not only the local battery manufacturers, but also to other materials based industries. These include plastic material, pharmaceutical products, metal components and soil samples. The handheld XRF has been used a few times for on-site analysis at various facilities for elemental composition and/or alloy identification. The materials testing laboratory have also diversified their services by participating in a number of collaborative projects within the university. These have led to joined projects with eNtsa, the Department of Chemistry and the Department of Geosciences, which also includes more requests for analysis using a Micro-CT scanner.

In 2019, the uYilo's battery group had a number of postgraduate research projects that related to the developing battery materials for lithium-ion cells.

Charmaine Gelant, an MSc student completed her project at the end of 2019 that studied the solid state phase transitions involved in the synthesis of doped lithium titanate materials for Li-ion batteries. Aspects of the work were also written up as journal article and submitted for publication. The article is currently under review with the journal "Powder Diffraction". In collaboration with the advanced energy materials research group at Wits University, some of the synthesised battery materials from the project were sent to the synchrotron facility at Brookhaven, New York. The preliminary study is looking at understanding the materials phase transitions at the atomic scale thereby giving unique insights into the mechanism of making highly pure nano-structured materials. The results from the study would give further support to a larger in-situ temperature study of a range of similar battery materials at either the Brookhaven (NY) or Diamond (UK) synchrotron facilities later in 2020 (see Figure 80).

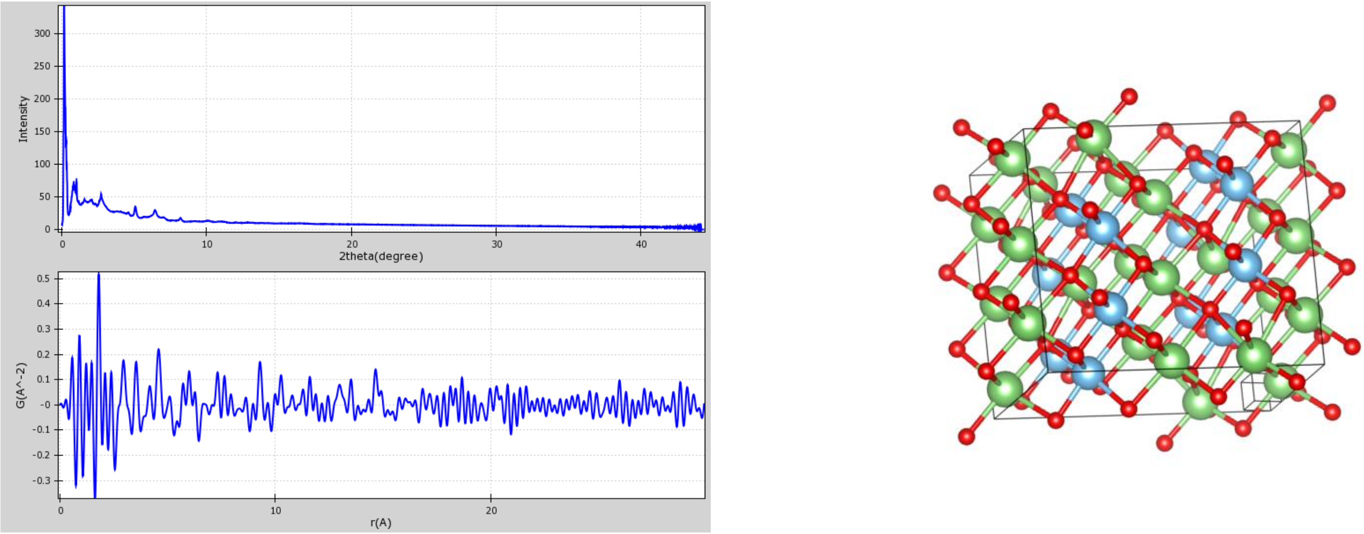


Figure 80: Dsplay of X-ray synchrotron diffraction data of both the Bragg Diffraction and xPDF (Pair Distribution Functions) of the Lithium Titanium Oxide made at 550°C. The Bragg diffraction patterns shows its composition to be predominantly amorphous (top graph) and the interatomic spacing of the phase composition (bottom graph). [Inserted Image: Crystal structure of Li_2TiO_3, one of the minor phases found in the Li-ion battery material.]

8. Research

By Prof. Danie G. Hattingh (Director) and Prof. Ernst Ferg (Research Leader Battery Storage)

eNtsa with its focus on innovation has always placed a high value on applied research with a focus on student development linked to commercial and engineering value added. Available research infrastructure at the university in general has become unreliable owing to age and historical poor maintenance, necessitating the development of a financially-supported mechanism in the form of eNtsa engineering projects. Mr Riaan Brown, Facilities Engineer who is linked to eNtsa from the Faculty side, ensured that new investments in infrastructure are carefully-managed and maintained, providing a safe, professional and productive research environment for researchers. Late in 2019, eNtsa developed a research road map for the entity, which is now being implemented. To strengthen our research endeavours, eNtsa also appointed Dr Dreyer Bernard during January 2020 as a Senior Researcher in the group to assist with planning and leading research. The main areas for applied academic research are:

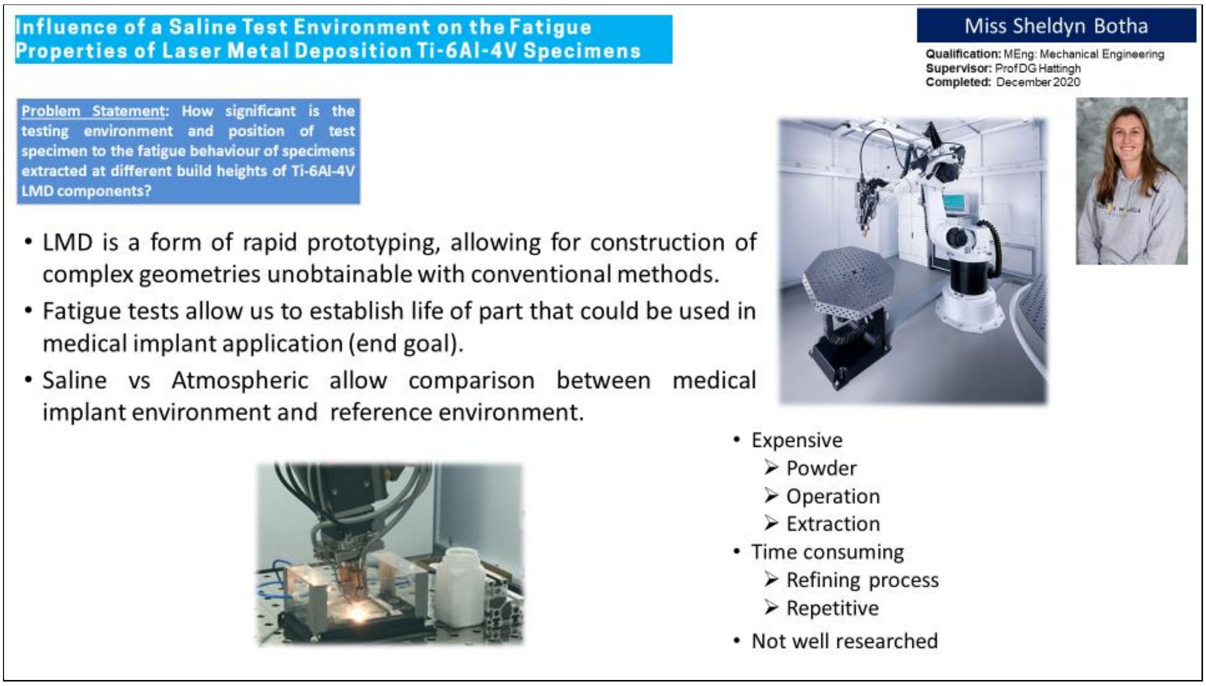
- Charging infrastructure and battery technology for e-mobility
- Laser processing with an emphasis on complex geometry laser metal deposition (LMD) components and fatigue
- Solid state joining technologies for titanium and aluminium sections and life prediction/extension models via small sample testing for high-value engineering plants.
- Localised heat treatment of thick-walled HPHT components
- Life extension of engineering structures based on Small Sample Testing Methodologies

8.1 Engineering Postgraduate Projects

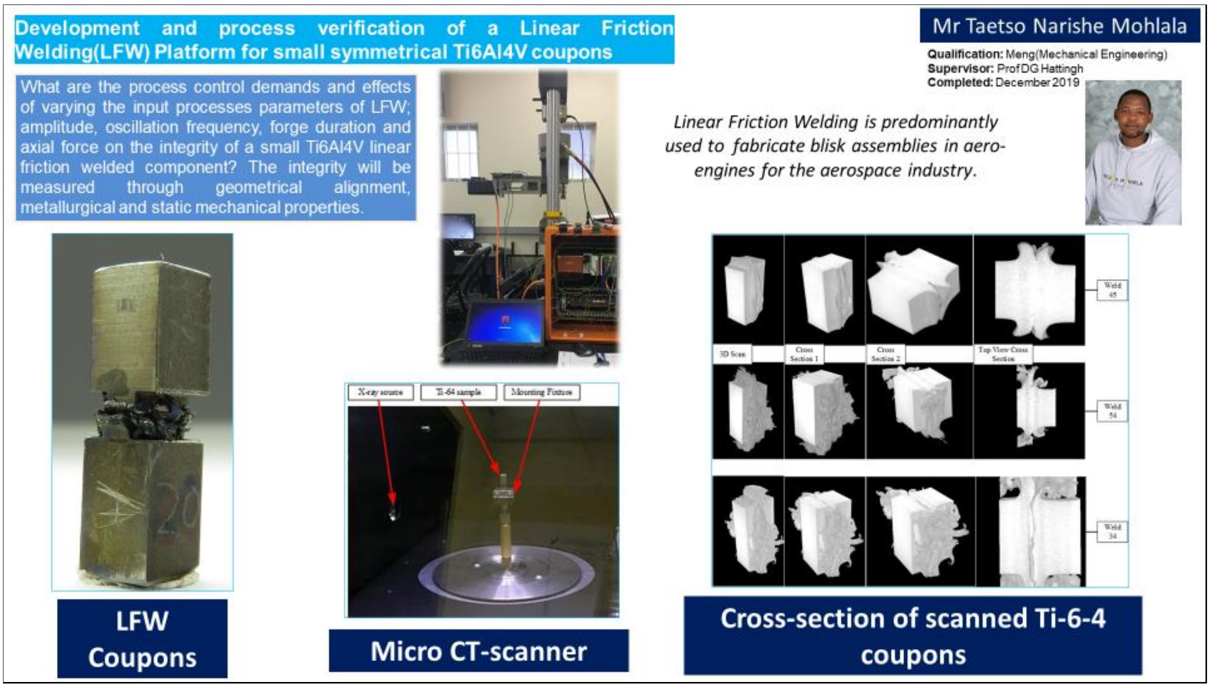
Some of the main engineering projects include:

8.1.1 Friction stir welding of thin section aluminium extrusion for marine application (Mr Prince Chakamhi – MEng Mechanical Engineering)

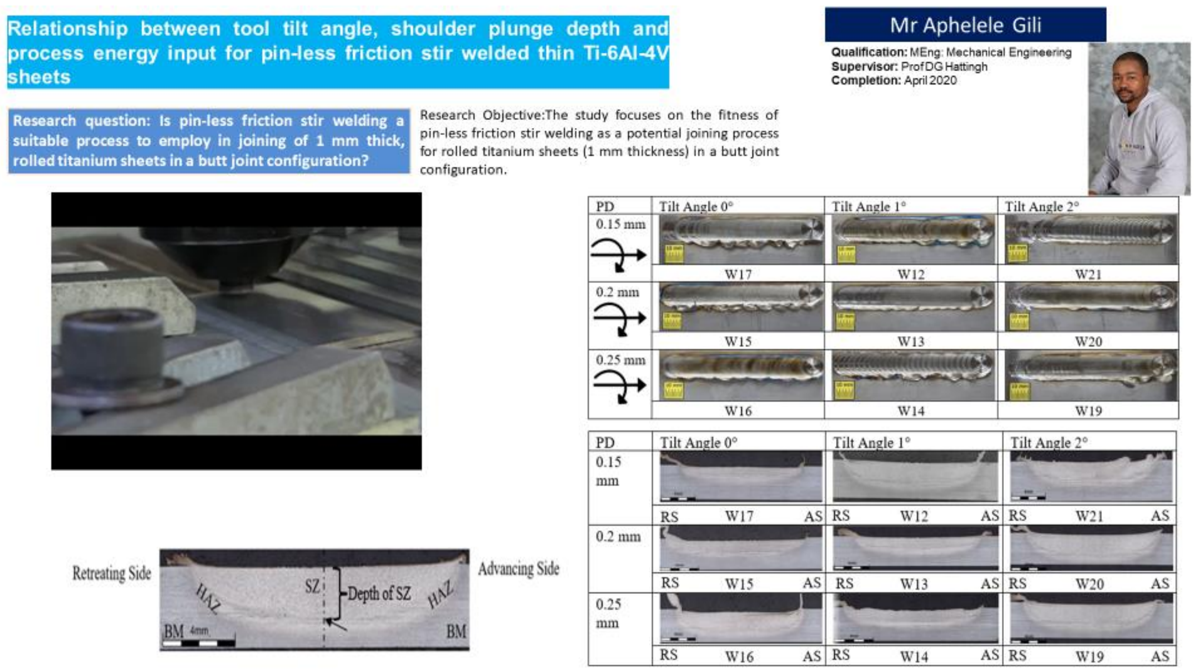
8.1.2 Influence of saline test environment on the fatigue properties of Laser Metal Deposition in Ti-Al-4V specimens (Ms Sheldyn Botha – MEng Mechanical Engineering)



8.1.3 Development and process verification of LFW Platform for small symmentrical Ti-6Al-4V coupons (Mr Taetso Narishe Mohlala – MEng Mechanical Engineering)



8.1.4 Relationship between tool bit angle shoulder pluncge depth and process energy input ofor pinless friction stir welded thin Ti-6Al-4V sheets (Mr Apelele Gili MEng Mechanical Engineering)



8.1.5 Stress corrosion susceptibility of Friction Hydro Pillar Prepared Steam Rotor Disc Blade Locating hole (Willem Pentz – PhD Mechanical Engineering)

Currently the power generation industry is struggling to keep older coal power plants running efficiently. One of the major hurdles is to keep repair and service cost low. Over time stress corrosion cracking (SCC) occurs in the locating pinholes of tier type rotors which locate the turbine blades. This is where this research aims to assist with an alternative repair technique, solid state Friction Hydro Pillar Processing (FHPP) welding, to have longer service intervals thus saving cost and time.

Four different FHPP axial forces were selected to compare their respective performance in subsequent tensile testing, impact testing and SCC testing. All the tensile samples extracted from preheated welds and post weld heat treated (PWHT) welds fracture in the parent material, which indicates good weld efficiency. The impact crack route from the weld nugget towards the parent material was identified in the energy and force graph. An example of the impact data is shown in Figure . A curve was also generated to identify which axial force promotes impact toughness.

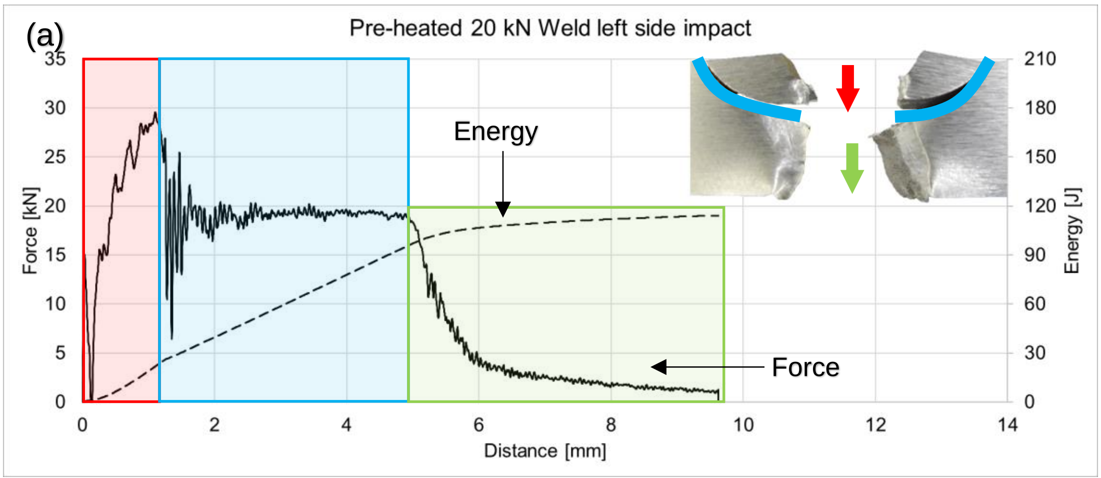


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Figure 81: Pre-heated 20 kN weld impact data

SCC occurs when a tensile stress is applied to a susceptible material when in a conducive environment for cracking. A new SCC W-shape was designed and performed well during initial testing. Both the preheated weld samples and the PWHT weld samples had improved SCC performance over their respective parent material samples as shown in 82.

A high axial force, low process energy, and high process energy rate (low process energy and low weld time) produced a weld with improved SCC resistance in the PWHT specimens as shown in Figure .

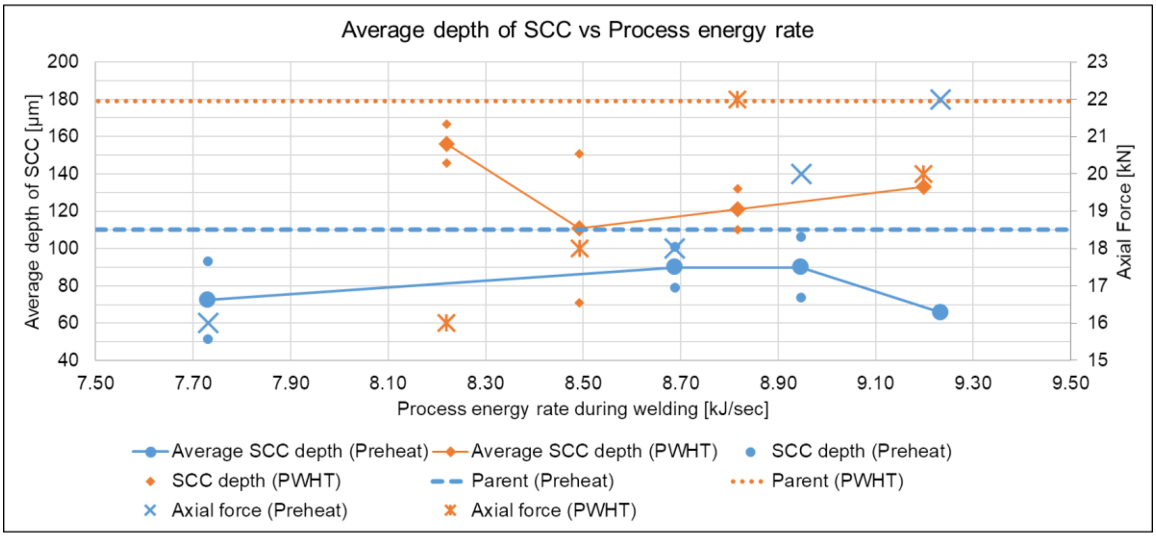
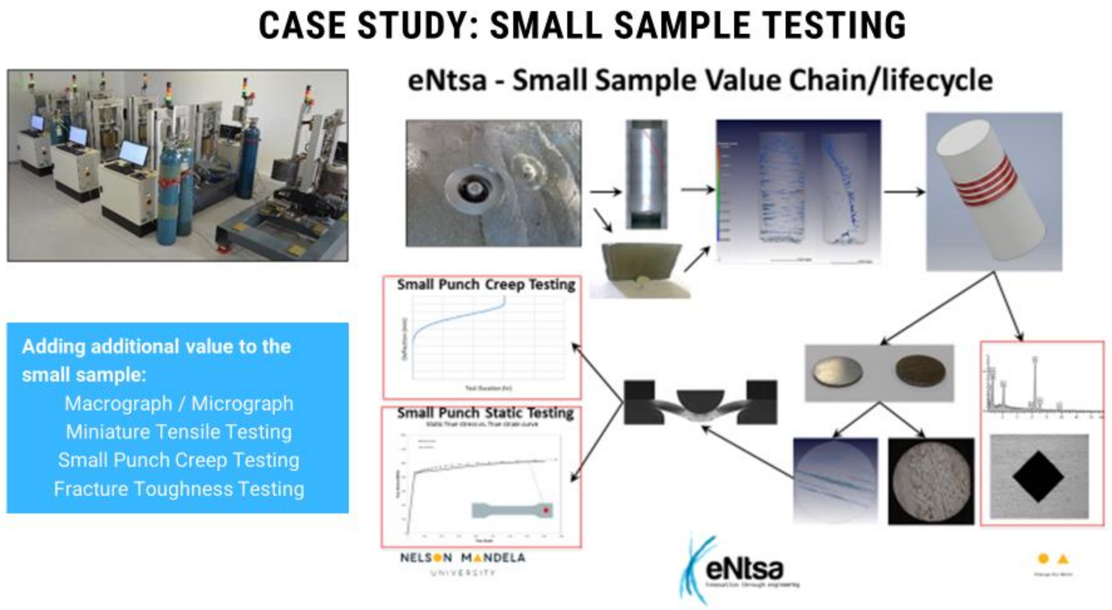


Figure 82: Average SCC crack depth against Process Energy Rate

FHPP (with PWHT) is a promising repair technique as it improved on the SCC resistance and impact toughness as well as having 100% bond efficiency.

8.1.6 Small sample testing value chain



8.2 Emobility and Energy Storage Postgraduate Projects

Masters level student, Amelie Krupp, based at the Oldenburg University that was continuing with the work on investigating the use of lithium iron phosphate based Li-ion batteries for high power grid-system applications, completed her studies in October 2019. Ms Krupp passed her dissertation examination with *cum-laude* and will be continuing with her research work in 2020 in the same field of work that will be expanding the collaboration with the uYilo research group.

In addition, the uYilo research group in collaboration with the DLR research group in Oldenburg applied to two German state-funded projects. These were the “Electrification of Urban Mobility in Sub-Sahara Africa: *Increasing the sustainability of innovative feeder services*” under the German federal government’s “Call for Resilience strengthening and structure development in African cities and metropolitan areas“. Their project leader is Dr Benedikt Hanke. The second project was submitted under the funding call of “Programme Advocating Women Scientists in STEM (PAWS)”, with a project title “Lithium-ion-battery operation and safety optimisation”. Their project leader is Frank Schuldt. We are awaiting feedback on both projects in 2020.

Another uYilo master’s student, Francis le Roux (MEng (Mechatronics)), spent six months of 2019 on a student exchange programme at Ingolstadt Hochschule Germany. She worked under Prof. Schweiger and focused on the development of protocols and testing of batteries for electric vehicles. Her project focus is on the development and use of suitable battery simulation software to use machine-learning algorithms to not only optimise the charging and discharging of high power Li-ion batteries but also to establish a predictive model to determine its state of health. Ms le Roux had the opportunity to be part of a number of learning programmes specific dealing with the engineering aspects of battery storage systems. She will be continuing with her studies in 2020 and will be an integral part of developing suitable teaching and learning programmes pertaining to battery systems for eNtsa (see Figure 83).

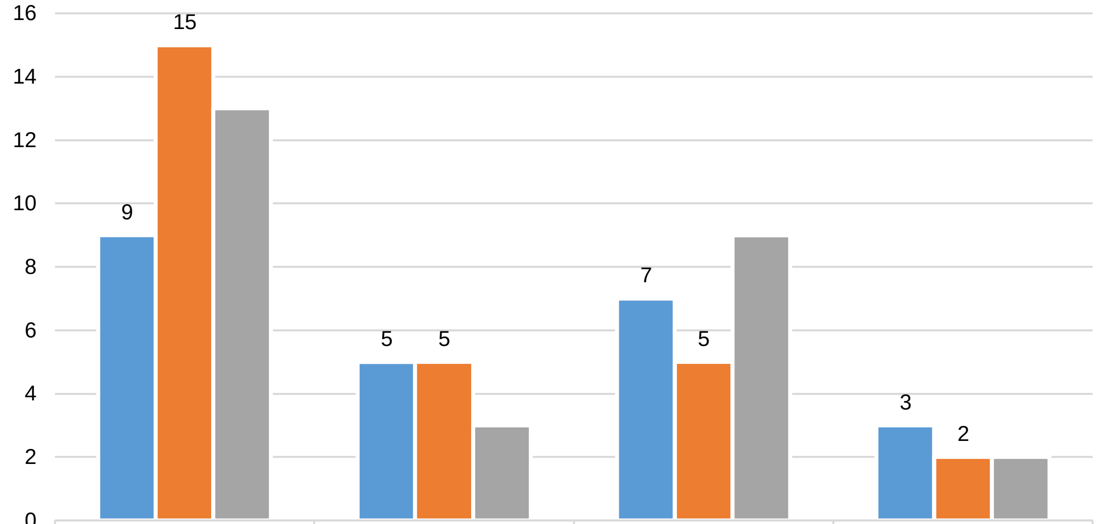
Figure 83: Francis le Roux in Germany visiting Mercedes Benz factory in Stuttgart

Ntombela Nompilo started her MSc (Chemistry) under the supervision of Dr Xandri van Niekerk. The project focused on the encapsulation of flame retardants for temperature-dependent release of flame retardants into the electrolyte of a Li-ion battery. This would be to reduce the safety hazards found in typical Li ion batteries when exposed to high temperature conditions. The work will look at developing unique chemical encapsulation techniques of various certain phosphate based chemicals that can remain stable in a battery electrolyte.

As part of Prof. Ernst Ferg's research sabbatical in 2018 at the Deutsche Luft und Raum (DLR)- Institut für Vernetzte Energiesysteme in Oldenburg Germany, the article entitled, “The challenges of a Li-ion starter lighting and ignition battery: A review from cradle to grave” was published in “The Journal of Power Sources”. In addition, aspects of work done by a previous master's student Brandon Davoren was published in the “South African Journal of Chemistry” with the title “An investigation into the corrosion rates of Inconel 600™ in different corrosive solutions”.

8.3 Research Outputs

Figure 84 illustrates the research outputs for 2017/18 to 2019/20.



	Masters students	Doctoral students	Journal articles	Conference papers
2017/2018	9	5	7	3
2018/2019	15	5	5	2
2019/2020	13	3	9	2

Figure 84: Research outputs stats (2017/18 – 2019/20)

Research associated outputs for 2019/2020 included the following:

- Masters students: **13**
- Doctoral students: **3**

- Journal articles: **9** (all from internationally recognised journals)
- Conference proceedings: **2** (one international and one local conference)

9. Operations

By Mrs Lucinda Lindsay (Deputy Director: Operations)

eNtsa's operations team is a well-integrated group of office professionals and technical support staff. This group is responsible for the operational function within eNtsa, interfacing with official university policies and procedures, which include human resource management, finance management, procurement, marketing, branding, facilities maintenance and general administrative support to the eNtsa team.

Staff within this group have a unique range of skills, which allow us to provide a customised approach to service delivery and addressing the demand for interventions within the engineering and innovation spheres.

9.1 Finance

Figures 85 and 86 illustrate eNtsa's annual turnover in millions as well as its business units' contribution to the turnover.

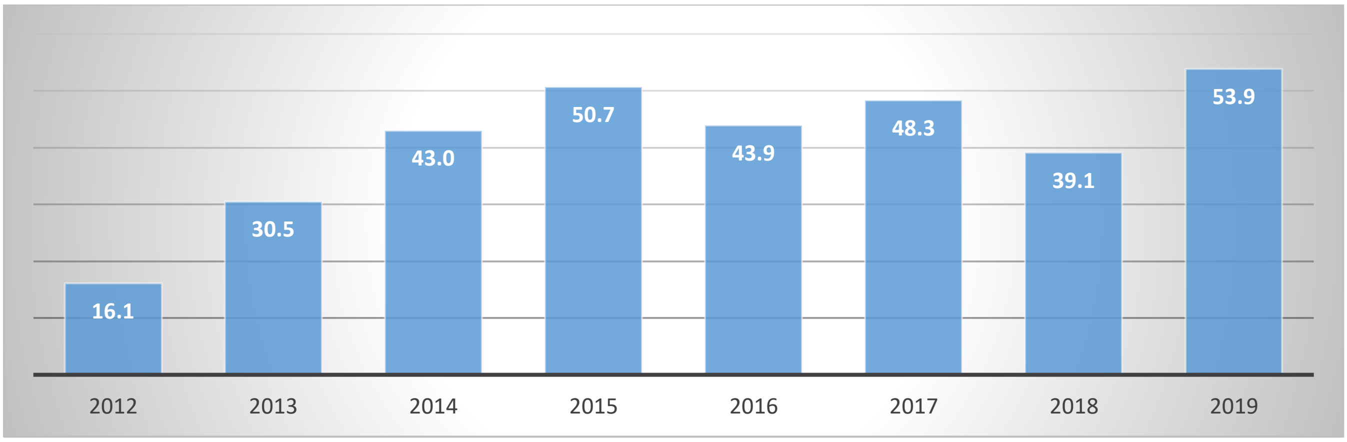


Figure 85: eNtsa's annual turnover (in millions)

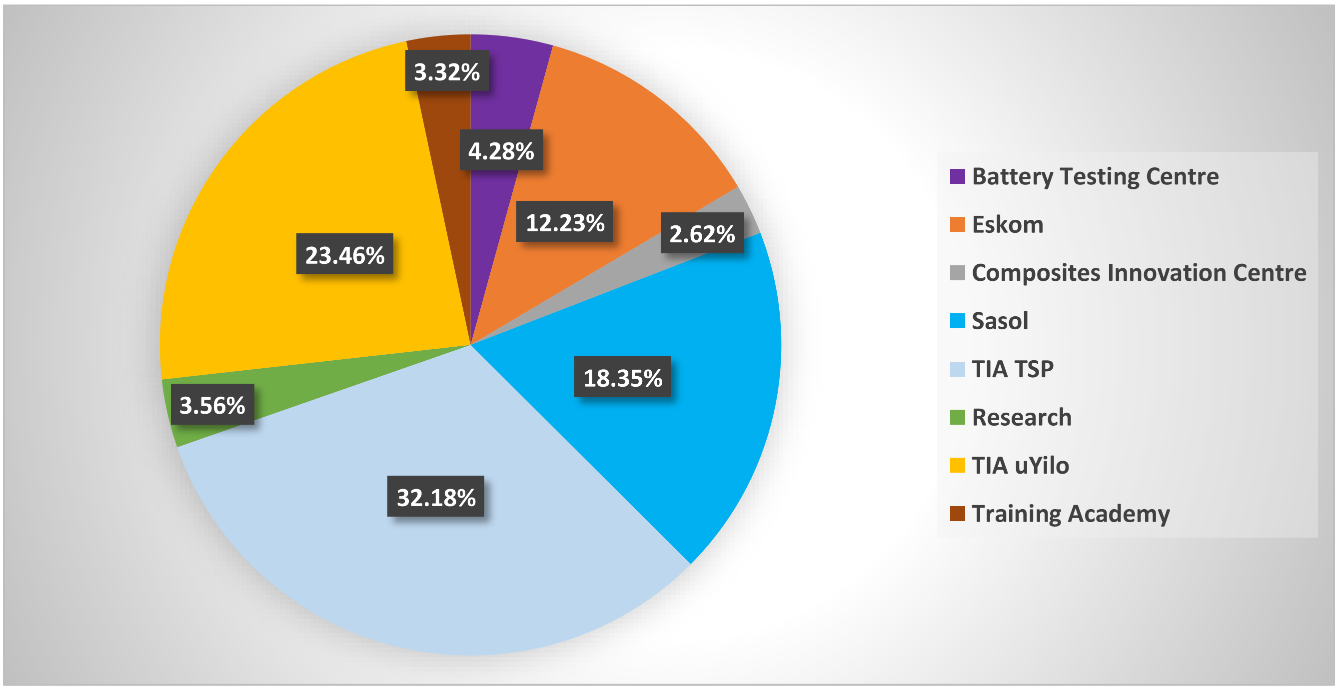


Figure 86: eNtsa's business units (% contribution to turnover)

Figure 87 illustrates eNtsa's business units and compares government funding and industry income.

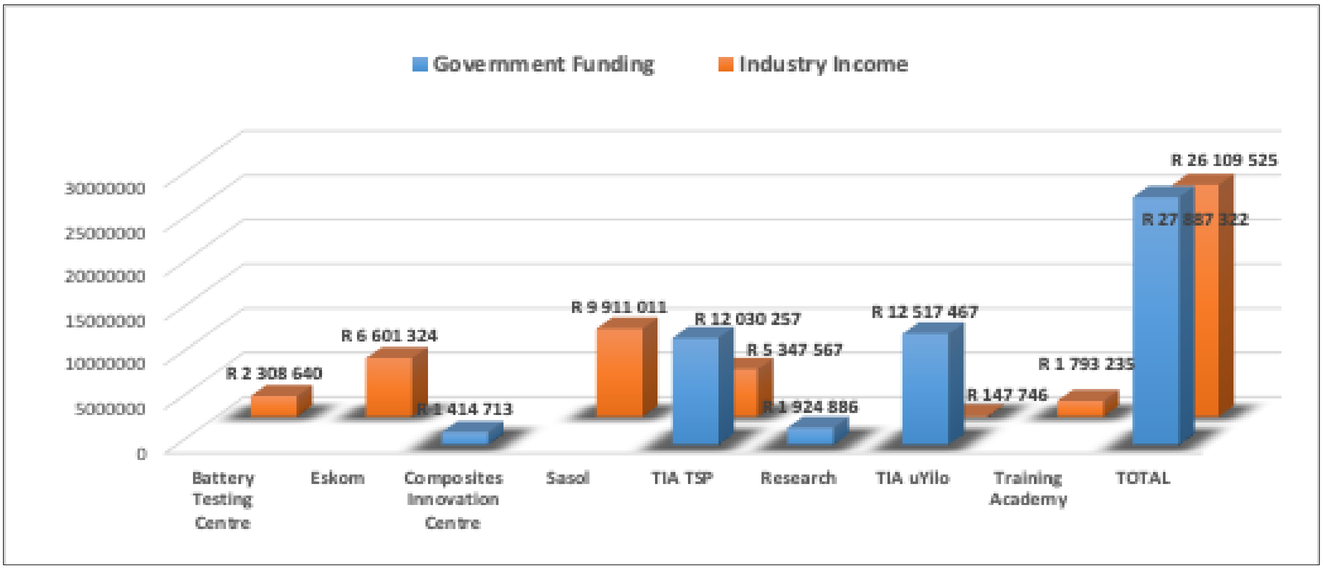


Figure 87: eNtsa's business units (Government Funding vs Industry Income)

Figure 88 illustrates eNtsa's business unit contributions from industry to turnover.

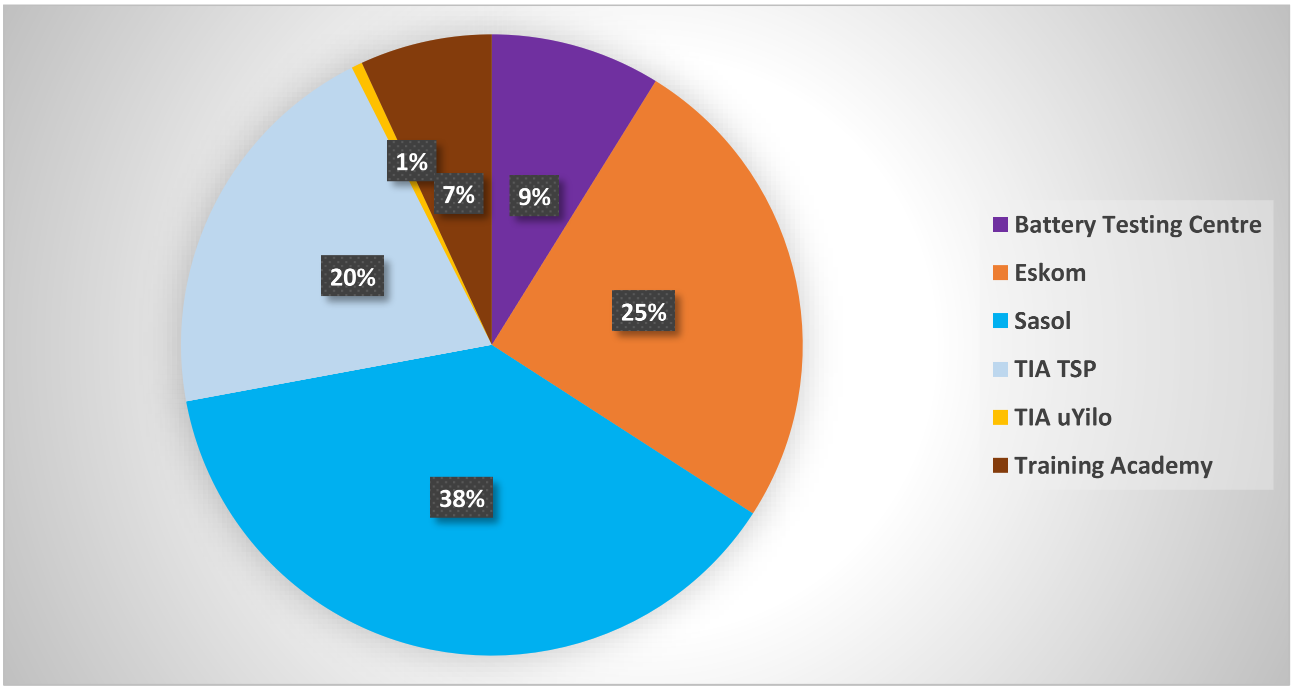


Figure 88: eNtsa's business units (% contribution from industry to turnover)

Figure 89 compares Ntsa's turnover with HR expenditure.

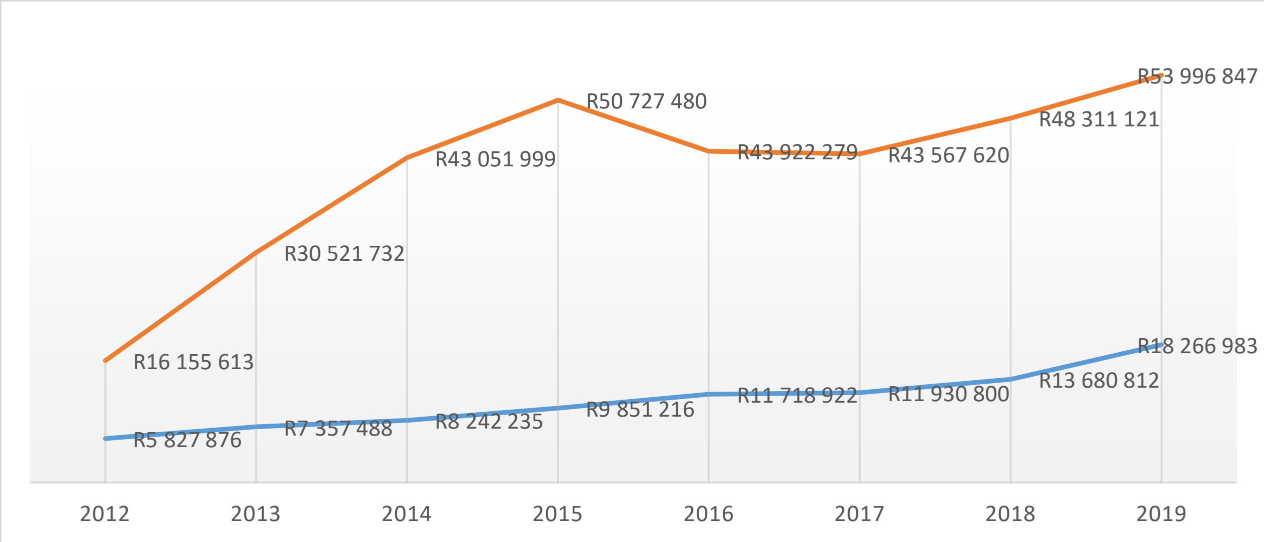


Figure 89: eNtsa's turnover vs HR expenses

9.2 Marketing and Branding

By Ms Keziah Tommy (Marketing co-ordinator)

Over the years, eNtsa has always been perceived as an academic institution, housed within Nelson Mandela University, and it is easy to understand this perception.However, it has became important for eNtsa to establish its own brand within industry. Having built a client base through various networks within the team, the reality is that not many companies in the wider engineering, manufacturing, automotive, power and petro-chemical industries knew of eNtsa and the services that were offered.

Since 2018, there has been a bigger drive with regard to eNtsa's branding and marketing to keep a presence with eNtsa's current client and to bring in new clients. A slightly new look was developed to set eNtsa apart from the academic environment and become more recognisable with clients. However, to remain a preferred service provider for our clients and to attract new clients, a few things needed to be changed. It was found that eNtsa's online presence was a big contributor to why many potential clients did not know about eNtsa. Having a good online presence is key to attracting new business, thus having a social media presence as well as a good website design became important.

Initially, eNtsa only had a Facebook page, thereafter, a LinkedIn profile was created as well as a Twitter account. From these platforms, the drive to post regular content on social media platforms began in an effort to famillairise users with what eNtsa offered.

Going into the new financial year, eNtsa has entered a new phase and has made marketing and branding efforts a priority. They partnered with a modern agency to increase the current national footprint as well establish a greater international presence by refining the current brand and expanding its digital footprint. From this partnership, a website revamp will result to match the eNtsa brand and further establish eNtsa as a recognisable brand in the engineering industry. The creation of relevant content and the sharing of knowledge through social media platforms is an integral part of becoming a trusted industry leader. Efforts from the entire eNtsa team to contribute to this will see this partnership developing new business leads in the future.

10. Our Staff

eNtsa, initially established as the Automotive Components Technology Station (ACTS), started with a staff complement of three people and has now grown into a highly-skilled team of more than 50 staff members, comprising of engineers, technicians, administrative professionals, postgraduate researchers and interns. Our staff, operating as a coherent team, are undoubtedly the most valuable assets of eNtsa. In addition, eNtsa's operation and sustainability thrive because of the unique abilities of our team, who daily execute eNtsa's slogan by actively living out our values (see Figure 90).

Figure 90: eNtsa staff photo (May 2019)

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Rapulenyane Nomasonto

PhD Chemistry (Full-time)

Willem Pentz

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Master Candidates

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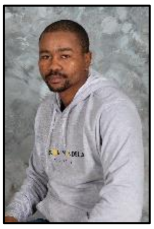
University of Oldenburg, Germany

Amy Van Gend

MEng Mechanical Engineering
(Part-time)



Aphelele Gili

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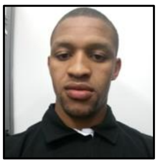
(Full-time)



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Boniface Tambro

MEng Mechanical Engineering
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Charmaine Gelant

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Francis Le Roux

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Julien De Klerk

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Narishe Mohlala

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Nompilo Ntombela

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Prince Chikamhi

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Sheldyn Botha

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Vatiswa Mgijima

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Musengeli Ndalamo

BTech Mechanical Engineering

Phelelani Baca

BTech Mechanical Engineering

Nozipho Sibambo

BTech Metallurgy

Interns

Atupele Bunu

Dip Analytical Chemistry

Ivan Madihlaba

NDip Mechanical Engineering

Jacq-Mari Human

Advanced Dip Analytical Chemistry

James Friend

NDip Analytical Chemistry

Karabo Nkhwashu

NDip: Metallurgy

Jaydrian Jansen

NDip Analytical Chemistry

Keegan Kroutz

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eNtsa

innovation through engineering