Aerospace Industry Support Initiative

an initiative of the dti

IMPACT REPORT

2017/18

AISI Vision

To position South African aerospace and defence related industry as a global leader, in niche areas, whilst ensuring effective interdepartmental participation and collaboration.

AISI Mission

To enhance the global competitiveness of the South African aerospace and defence industry by:

- Developing relevant industry focused capabilities and facilitating associated transfer of technology to industry
- Providing a platform for facilitating partnerships and collaboration amongst government, industry and academia, locally and internationally
- Identifying, developing, supporting and promoting the interests and capabilities of the South African aerospace and defence industry
- Accelerating the achievement of government strategic objectives including growth, employment and equity.

Contents

Executive Summary

In presenting its Impact Report of 2017/18, the management of the AISI extends its gratitude to the AISI team; its main stakeholder, the Department of Trade and Industry; AISI's host organisation, the CSIR; as well as every organisation that has supported and participated in the AISI's programmes during the 2017/18 financial year.

The Department of Trade and Industry **(the dti)**, through its Advanced Manufacturing Chief Directorate, established the Aerospace Industry Support Initiative (AISI) to support the South African industry to improve its competitiveness.

The AISI derives its strategic direction from government objectives such as the industrialisation of technologies, job creation and industry transformation. The AISI collaborates with other players in the National System of Innovation (NSI) such as industry, Government Departments and academia to address aerospace industry challenges as identified and analysed in the Sector Development Plan and in the Industrial Policy Action Plan (IPAP).

Technological advancements

Rapid technological advances, as well as increased globalisation, present significant challenges to SMMEs in the South African aerospace industry. Substantial investment is required to keep abreast of technological developments such as additive manufacturing, Industry 4.0 and advanced materials including composites. The AISI supports these SMMEs by 'de-risking' of technologies through technology transfer, validation and the provision of product development support. This allows the SMMEs to tap into some of the technological advances that they would normally not have been able to.

Technology roadmapping

During the 2017/18 financial year, the AISI introduced Technology Roadmapping exercises as a tool to identify and select projects for support. This applies mainly to projects supported under the Technology Based Supplier Development Programme. One of the benefits for the SMMEs that participated in the exercise was the ability to identify trends and drivers influencing their businesses, and developing technological interventions to respond to them. Four technology roadmapping exercises were undertaken during the year.

AISI programmes

The AISI strives to ensure the competitiveness and sustainability of the local aerospace industry and executes its mandate through four main programmes namely:

- Technology Based Supplier Development
- Industry Development and Technology Support
- Sector Strategic Support Initiatives
- Coordination, Promotion and Awareness

Figure 1 shows the percentages invested by the AISI in the four programmes. The percentages are aligned with the current AISI priorities and with the strategic intent of its main stakeholder, **the dti**. 75% of the AISI's budget for the year was invested in Technology Based Supplier Development projects. These include technology enhancement, standards and accreditations and supply chain improvement projects. 19% of the budget was invested in Industry Development and Technology Support projects. The remainder was invested in Sector Strategic Support Initiatives as well as Coordination, Promotion and Awareness.

Figure 1: AISI budget breakdown by programme

The AISI supported 14 projects under the Technology Based Supplier Development Programme and 6 projects through the Industry Development and Technology Support Programme. The Technology Based Supplier Development Programme will continue to be a significant pillar of the AISI in the coming years.

AISI impact

During the 2017/18 financial year, the AISI undertook 20 projects benefiting 20 SMMEs directly and indirectly from AISI support. As a result of the AISI support, 20 jobs were created or retained in the participating companies.

Table 1: AISI estimated impact at a glance

Impact Criteria	Value
Number of projects undertaken	20
Number of SMMEs benefiting	20
Number of jobs created or retained	20
Industry scarce skills development	16

The projects supported during the 2017/18 financial year covered technology streams such advanced materials and manufacturing, avionics, sensors, propulsion and aerostructures, highlighting the diversity of projects supported by the AISI.

This Impact Report provides a summary of the projects, as well as the highlights of each project undertaken.

Impact and Benefits

12 New or advanced manufacturing processes

12 Technology developments or advancements

20 Projects supported

14 Technology Based Supplier Development **(9 completed)**

6 Industry Development and Technology Support **(1 completed)**

Technology Based Supplier Development

14 SMMEs supported (5 New SMMEs)

14 People trained (external)

3 Jobs created

16 Jobs retained

15 Industry focussed skills developed

1 Export capability achieved

3 Import substitutions achieved

Industry Development and Technology Support

6 SMMEs supported

1 Import substitution achieved

1 Industry focussed skills developed

1 Job created

PROGRAMME 1:

Technology Based Supplier Development

The AISI's Technology Based Supplier Development Programme provides enabling mechanisms to assist the industry in improving its competitiveness, productivity and quality management systems. This allows for optimisation of operations and procedures to ensure that the South African aerospace industry is able to integrate into global supply chains. The strategic focus remains on SMMEs with the objective to ensure industry transformation, and broadening of the economic base participating in the industry. The programme is made up of three interventions namely:

- Technology Enhancement
  - Technology Transfer and Validation
- Standards and Accreditation
- Supply Chain Optimisation

High level information regarding the Technology Based Supplier Development initiative is summarised in Table 2.

Table 2: Technology based supplier development impact summary

Programme Focus	**Technology Enhancement, Standards and Accreditation and Supply Chain Optimisation**
Predominant technology stream	Advanced materials and manufacturing, propulsion, avionics, sensors and aerostructures
Industry support investment	R14 108 771
% AISI investment of project budget	75%
Number of projects undertaken	14
SMMEs involved	14
Resulting Impact on Industry	
Technology development/advancement	7
Manufacturing process	8
Number of people involved in industry skills development	15
Number of jobs created or retained	19
Academic institutes and science councils involved (access to national infrastructure)	7

Technology Enhancement

The aerospace industry continues to demand lighter, more compact, more durable and more efficient products. Production innovation has become far more dependent on supplier innovation, and such innovation increasingly results in longer-term strategic supply agreements to assure supply and differentiation in products.

By taking a strategic and optimised approach to engineering and manufacturing, medium sized manufacturers will reap the benefits, as aerospace companies look for niche suppliers to help expand their supply chains.

The question is, how can local OEMs and SMMEs take advantage of the innovative technologies and manufacturing processes that are being developed in the global aerospace industry?

Technology enhancement is a critical aspect for OEM and SMME growth. The development and enhancement of new technologies, processes, and manufacturing methods is fundamental to remaining competitive on a global scale. The AISI's technology enhancement intervention is divided into two categories: technology transfer and technology validation.

During the 2017/18 financial year, 12 projects were supported as part of the technology enhancement intervention. The projects and their high-level impact are summarised in the next section.

COMPLETED PROJECT

Waveguide Manufacturing using Additive Manufacturing

Project at a glance

Creating functional waveguide prototypes to motivate future investment in 3D printed waveguide technology for space applications.

Highlights

- Industrialisation of technology, particularly among SMMEs
- Improving localisation of Radio Frequency (RF) manufacturing technology and developing local content
- Transferring industrial capability to lower tier suppliers
- Assisting with new and existing industry development
- Advanced manufacturing and post-processing technique developments
- Radar technology and avionics development
- Driving down size, cost and production times.

Contracted organisation

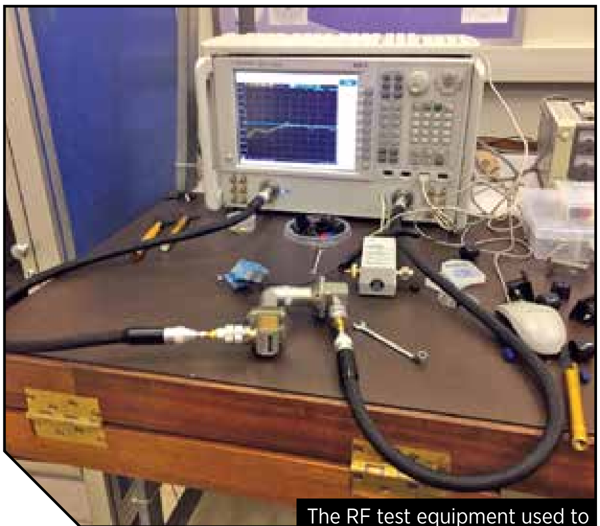
NewSpace Systems is a privately owned South African company, founded in 2013. The company manufactures high reliability components and sub-systems for spacecraft, exporting to 19 countries across five continents.

Benefiting industry partners

- **Metal Heart** is a 3D printing company
- **Galvanotech** is a metal surface treatments company

Made in South Africa: 3D print waveguides

Waveguides are used extensively in aerospace, space and radar programmes with virtually all waveguides currently being imported into South Africa. Imagine the value in creating a new waveguide technology that could see local manufacturers produce high frequency filters, resonators and other products to compete against global producers on cost, mass and performance.



The RF test equipment used to test the printed waveguides

James Barrington-Brown, CEO, provides clarity on the context, objectives and results of NewSpace Systems' Waveguide Manufacturing project.

"Over the past two years there has been an increasing request for low-cost manufacturing of high quality waveguides. As a technology, 3D printing has seen incredible advancement over the past decade, steadily progressing from prototyping to production and other applications. With costs coming down and part quality going up, 3D printing is starting to find its way into aerospace applications, where printing is more cost-effective and you get better parts. Metal additive manufacturing is particularly promising as a production technology, and its accuracy is improving all the time.

3
new SMMEs benefitted

1
job created

"For NewSpace Systems this pointed to potential for the local development of communications pay-load capability in South Africa for a local programme as well as extensive opportunities to export this capability worldwide. One of the key resources needed to achieve this is the capability to design and manufacture waveguide systems at low cost. The possibility of using a new process, based around additive manufacturing, would result in a world-leading capability in this area opening up large export opportunities. Building on this technology breakthrough, other export markets would be easier to penetrate, such as advanced radar systems and satellite communications payload delivery."

NewSpace initiated its waveguide project by setting the end goal first: Developing a new advanced manufacturing process which can be used to produce low cost waveguides and other RF components focused on space applications.

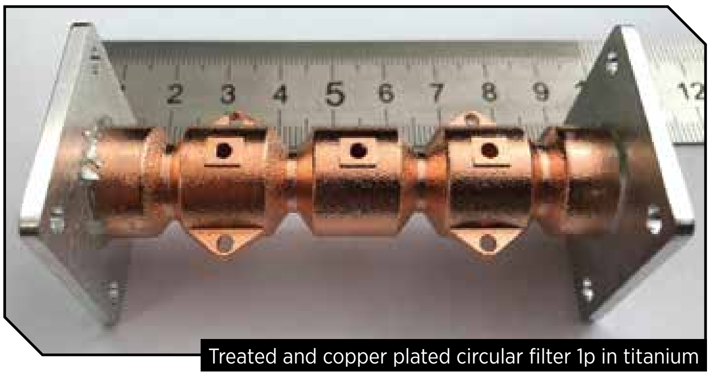
Next, it was critical to divide the project goals into smaller phases, mapping out achievable and low-risk stepping stones to eventual success.

"With a project like this, which spans a multitude of engineering disciplines as well as industry sectors, we knew the project couldn't hope to achieve full scale production of waveguide technology within a one-year time frame.

"In kicking off, our goal was to asses all manufacturing and production risks, and produce functional prototypes as a technology demonstrator to enable private investors to clearly see the market opportunity. To do this, we constrained the scope of the project to the following objectives:

1. The first objective of the programme was to complete market research considering current manufacturers, current manufacturing techniques used, advances in materials and materials processing. This was conducted through a thorough literature search, web tools and direct contact with suppliers and waveguide users, and then extended to NewSpace analysing and evaluating the performance and processes in respect of existing additive manufacturing machines.

One of the circular bends that were treated using post-processing method 1


Treated and copper plated circular filter 1p in titanium

2. The second objective was to develop an economically feasible and adaptable post-processing method to improve the surface finish of the 3D printing process. To mitigate risks, we manufactured and tested prototype and qualification samples. The test techniques used physical measurements to determine the quality and accuracy of the finished surfaces, but the ultimate test was that of the RF performance. The results were then compared to the RF performance of waveguides manufactured using traditional Computer Numerical Control (CNC) manufacturing methods.

"Next, an analysis was conducted to show the potential economic benefits of using 3D printing as an alternative method to produce low cost, high frequency waveguides.

"Initially, the project entailed producing waveguides in titanium alloy (Ti6Al4V), but it was later expanded to print them in aluminium alloy (AlSi10Mg) as well."

The results show that a successful post-processing method was developed to treat both the aluminium and the titanium guides. The process is both economically feasible and adaptable to various geometries.

The 3D printed guides have a significantly reduced mass (as no joints are needed), cost and time associated with the manufacturing process. This, combined with the post-processing methods derived to reduce the surface roughness, makes them functional with comparable insertion losses (as low as -0.3 dB losses achieved) and Q-values, to traditionally manufactured filters and resonators.

The results from the printed and plated aluminium filters and resonators showed Q-values comparable to those obtained with machined filters and resonators. The copper plated titanium

SKILLS AND HUMAN CAPITAL DEVELOPMENT

An engineering graduate from the University of Cape Town was employed as full-time project manager.

This project also supported the manufacturing of a novel Interdigital Filter that was designed, as part of a master's degree, by a student from the University of Pretoria.

It is hoped that further work under fresh AISI support will lead to a new bursary being awarded to a Master's Student.

COLLABORATION OF INDUSTRY AND ACADEMIA

NewSpace Systems collaborated with Central University of Technology, Stellenbosch University and the University of Pretoria, as well as two SMMEs, Metal Heart and Galvanotech – helping to bridge the gap between academia and industry and further improving supply chain integration.

> "Imagine the value in creating a new waveguide technology that could see local manufacturers produce products to compete against global producers on cost, mass and performance."

filters gave excellent results, approaching those of ideal copper, but with much lower mass.

"This project encompassed the development of a new advanced manufacturing capability. If taken further, we believe it has the potential to generate sustainable skilled and semi-skilled jobs with export potential."

Productivity improvement for NewSpace

Aided by its new-found knowledge of the additive manufacturing process, advantages and limitations, NewSpace has been able to use plastic 3D printing as part of its design process, mostly for concept visualisation and fit-checks prior to mechanical manufacture. The company anticipates that it will increasingly use metallic 3D printing going forward, supported by the new process links that NewSpace has built with the in-country supply chain.

NEW TECHNOLOGY BENEFITS

While the project has shown immense potential in providing NewSpace with a new product line with export capabilities, it is important to highlight the possibilities inherent in the development of new technologies for multi-industries, including:

- Post-processing technology, which has the potential to be spun out into various other industries, such as medical
- 3D printing technology, which offers numerous improvements to productivity in general, including unprecedented geometric freedom in designing and manufacturing components at a reduced cost, mass and time
- 3D printing of titanium/aluminium alloys, which allows for the beneficiation of local mining resources (such as titanium) rather than exporting the ore and having to procure finished items from abroad.

If the technique proves to be successful, higher value-add products can be made using the same technique, such as high frequency filters and antennae, further increasing export value. It will also allow South Africa to localise significant parts of the anticipated communications satellite currently being investigated by the Department of Telecommunications and Postal Services (DTPS).

COMPLETED PROJECT

Feasibility of Natural Fibres in Aerospace Structures

Project at a glance

Taking technology to the next level by testing the feasibility of natural fibres in aerospace structures in meeting stringent flame, smoke, toxicity and heat release (FSTH) requirements.

Highlights

- Import substitution – localisation of flax fabric manufactured at Svenmill instead of the imported European flax fibre
- 5 students involved in the project as part of industry focused skills development
- Conducting flame, smoke and toxicity tests on aerospace manufactured structures to determine their compliance with accepted aerospace flame smoke and toxicity requirements
- Determining the effects of flame retardants on the material properties of flax/epoxy laminate through coupon testing
- Determining the effects of flame retardant fabrics on the manufacturing process through subcomponent manufacturing
- Manufacturing a flame-retardant aerospace structure, for example interior liner, for SARA (Small African Regional Aircraft), with the flax fabric developed by Svenmill
- Collaborating with established institutions such as AISI, WITS, TUT and the CSIR to advance and transfer technology.

TRL improvement from 6 to 7

Contracted organisation

Denel Aerostructures (DAe) is the leading Aerospace Company in Africa – specialising in aerospace design and advanced manufacturing. It forms part of the state-owned Denel Group, South Africa's largest manufacturer of military aerospace and landward defence equipment.

Benefiting industry partners

- **Svenmill** is a Cape Town-based textile mill, which has been operational for 50 years, specialising in woven and warp knitted fabric for a variety of uses including home furnishing, apparel and industrial fabrics.
- **Aerontec** a local supplier of self-extinguishing resin

Interior aircraft structures are "Going Green"

To make an impact on the global aerospace market South Africa needs to grow its local composite market – in an environmentally friendly way. This is not a new concept.

Towards the end of World War II, due to the shortage of aluminium, the British built the fuselage of the spitfire aircraft from a natural flax-fibre reinforced resin composite. Today composites are the fastest growing market in the world, with the aerospace sector accounting for 4.5% of the total composites market.

Alcino Cardoso, Chief Engineer of Denel Aerostructures (DAe), talks about the company's ongoing development of a woven fabric made from flax (an environmentally friendly natural fibre), which has the potential to be used for aircraft interiors, providing it meets

ABOUT ADVANCED COMPOSITES

- **5-6%** growth p/a: the fastest growing materials market in the world
- Market estimated at **98 billion Euros** in 2016
- **2%** market share increase for natural fibres. Biggest current user is the **automotive industry,** with expanding market share
- **Worldwide trend** for green technologies and cheaper material and processing costs
- South Africa's current **market share** globally **<0.5%**
- **South Africa** has an **abundance** of natural fibres, making it ideal for this development.

the Fire, Smoke, Toxicity and Heat release (FSTH) requirements of the aerospace industry.

"There is a continuous drive to use green technologies and reduce material and manufacturing costs. Natural fibres, owing to their good strength to weight ratio, are gaining in popularity and are seen as a substitute for the synthetic glass fibres," he says.

"In 2017, the Fiabilin Project revealed the first seat prototype manufactured from flax fibres which met the fire, smoke and toxicity requirements of the aeronautical industry at the JEC Paris Show. With this revelation, natural fibre, especially flax fibres, are getting closer to gaining acceptance for aircraft interiors."

Step-by-step towards application

Cardoso explains the approach and steps taken to successfully complete the project.

"In a previous AISI-supported project, DAe, in conjunction with Svenmill, developed a woven fabric made from flax, an environmentally friendly natural fibre, with potential for use in aircraft interiors. The results showed that Svenmill has the capacity and technology to produce fire retardant flax fabric that meets the flame (F) requirement for industrial applications. This in

Application of natural fibres

turn could grow the local composite market and subsequently natural fibre production locally to an industrial scale which could compete favourably in the international market.

"In this project, DAe, Svenmill and the CSIR resolved to take the technology to the next level by qualifying the locally developed flax fabric to FSTH requirements for aerospace applications. This required the addition of flame retardants which would make it suitable not only for the aerospace market, but also for various industrial applications.

Manufactured interior liners (Flame retardant untreated and treated)

"First, the technology had to be tested through mechanical and coupon testing against FSTH test specifications and then against a full-scale interior liner for SARA, to determine the effect of the flame retardant treatment on the strength of the laminates. It performed positively when compared to a benchmark fabric from the European market and in fact outperformed it in many aspects.

"The treated flax fabric met the Flame, Smoke and Toxicity requirements as per Federal Aviation Regulations (FAR) 25.853 compartment interiors, making it suitable for aircraft carrying 20 passengers or less, as well as for other applications regardless of aircraft carrying capacity. It is also suitable for certain cargo and baggage compartments. For aircraft with carrying capacity for more than 20 passengers the Heat Release requirement as per FAR 25.853 must still be met. Here we identified a gap between the requirement and the test results, therefore another iteration will be required to meet this requirement."

The successful results of this project will enable DAe to qualify an interior liner for SARA, with possible extension to other projects in the near future.

Opening a world of opportunity

According to Cardoso this project enables DAe to offer a superior flax-woven fabric and/or unidirectional fabric with superior strength, which will be suitable for the aerospace and a variety of other industrial applications.

"By developing fibres which are on par with what is available in the global market, this project will help unlock the general local natural fibre and flax fibre value chain. Not only will it be beneficial for the local aerospace industry but for industry at large – automotive, solar and wind energy and maritime can all benefit.

"Further, with increased demand, local farmers will be willing to farm flax and increase their crops and harvests. Successfully employing these technologies will naturally lead to increased market share in the local composite and aerospace industry, resulting in job creation and retention. Once industrialised locally, exporting these technologies will become a reality in terms of not only the materials but the final processed product."

10 jobs created /retained

5 industry focused skills developed

"There is a continuous drive to use green technologies and reduce material and manufacturing costs."

Import substitution

SMME and scarce skills development

"One of DAe's objectives is to offer collaborative and technical assistance to SMMEs, in line with the National Development Plan and IPAP, to increase the content of home grown composites in locally developed aircraft and other industrial applications; to grow the local market with export potential; and to create much needed jobs," Cardoso says.

In developing and testing the feasibility of natural fibres in aerospace structures, DAe continued to develop Svenmill in Cape Town as a supplier of aerospace grade flax fabrics for aircraft interiors for the local aerospace market, thereby also effectively positioning Svenmill as a supplier to the global market. Herdman's in Atlantis, Cape Town, was used to spin the long fibre flax yarn, while Aerontec in Claremont, Cape Town, was used to source epoxy resins with FSTH properties.

Scarce and new skills have been developed through the value chain as a result of the strict manufacturing, testing and quality processes required to meet aerospace requirements:

- Farmers who plant and harvest crops have to grade the fibres to meet aerospace requirements, involving:
  - Researchers
  - Mechanical testing of natural fibres
  - FSTH testing of natural fibres
  - Development of flame retardants for aerospace requirements.
- Material producers
  - Svenmill weaves fabrics to meet aerospace requirements
  - CSIR develops and tests flame retardants to meet aerospace requirements.
- Parts manufactures
  - Developing and adhering to processes and quality standards to meet aerospace requirements such as substituting locally produced flax for expensive imported material.

Fabric treatment process at Svenmill

COMPLETED PROJECT

Commercialisation of the Fixed Wing Flight Trainer

Project at a glance

Commercialising the current Fixed Wing Flight Trainer prototype to a product suitable for small-scale production.

Highlights

- Developing a custom flight dynamics model using the Presagis FlightSIM product
- Updating FlightSIM models to specific aircraft
- Selecting and purchasing suitable generic aircraft controls and seats
- Local manufacturing of replica cockpits
- Local replacement of existing curved screen for the image generation projection system
- Updating of instructor station human/machine interface.

Contracted organisation

Cybicom Atlas Defence (CAD) designs and develops custom engineered solutions for the defence and space industries.

Benefiting industry partners

- **Rugged Interconnect** offers solutions for rugged applications
- **Protea Engineering**, a local designer and manufacturer of monitor mounting systems and cockpits.

Flight training prototype ready for production

Flight simulation can be traced back to World War I, when ground-based simulators were developed to teach new pilots how to aim ahead of a moving target to allow for the time required for the bullets to reach the vicinity of the target (also called deflection shooting). In 1929, the first commercialised and best-known early flight simulation device, the Link Trainer, provided pilots with the opportunity to train in all weather conditions and without the availability of aircraft and flight instructors.

3
SMMEs benefitted

Today, flight simulation has come a long way.

To achieve a local solution for advanced, yet cost-effective products for the South Africa Navy and other South African markets, Cybicom Atlas Defence (CAD) has invested more than R5 million in simulator research and development over the last three years.

Dave Viljoen, Managing Director of CAD says, "We have standardised our development, based on the Presagis tool-set which is an industry standard for high-end visuals and simulation. However, the challenge we continue to face is meeting the demands of local budgets while providing simulators that are competitive with overseas products in terms of functionality and build quality."

PROJECT HIGHLIGHTS

- Technology transfer from CSIR to an SMME (Cybicom Atlas Defence)
- Establishment of an Intern Programme at Cybicom Atlas Defence that benefit from the project

> "The challenge we continue to face is meeting the demands of local budgets while providing simulators that are competitive with overseas products in terms of functionality and build quality."

2
jobs created

In 2016, CAD, in collaboration with the CSIR and partially supported by AISI, developed the first Fixed Wing Flight Trainer (FWFT) prototype: a fixed wing flight simulator suitable for procedural and flight training.

Viljoen explains how new technology, applied in the 2017 project, adds to the FWFT prototype's potential for small-scale production.

"The FWFT is a low-cost flight simulator, with an advanced custom flight dynamics model and affordable Commercial-Off-The-Shelf (COTS) flight controls, which has been based on integration with Presagis' FlightSIM model.

"The benefit of integrating with FlightSIM is its easy-to-use interface that lets you specify subsystem behaviour, including flight management systems, autopilot, and flight controls. This multi-functionality enabled us to develop the FWFT's applications to include pilot refresher training for various aircraft, joint training with a helicopter flight trainer for fire-fighting operations, instrument training and more. In addition, the FWFT's local design and the manufacture of a replica cockpit and visual system, makes it suitable for generic and type-specific pilot flight training.


Pilot Instrumentation

"By locally manufacturing the FWFT prototype we will be able to target an affordable price, suited to the South African and African markets, with development down the line likely extending its export to China and other markets. CAD's intern programme is also further investigating the local development of some of the flight controls to increase local content and affordability."

The project end goal is to achieve European Aviation Safety Agency certification as a level 2 Flight Navigation and Procedures Trainer (FNPT).


Co-Pilot Instrumentation

Updating FlightSIM models to specific aircraft

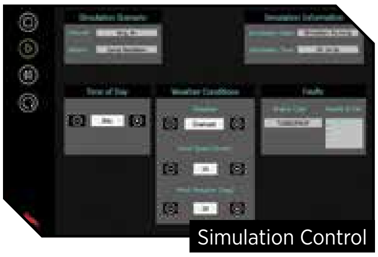
This Flight Dynamics Model is representative of a twin-engined turbo-prop aircraft in the 5000–8000 kg MTOW (maximum take-off weight) range. The aerodynamic database, engine modelling and aircraft physical properties are based on generic data for this class of aircraft. Changes in aircraft behaviour due to flap deflection and undercarriage extension/retraction are modelled, as well as the effects of engine/propeller operation. The influences of payload and fuel burn have also taken into account.

Selecting and purchasing suitable generic aircraft controls and seat

The team undertook extensive market research into aircraft controls, ranging from the gaming/hobbyist market to the formal aircraft simulator control manufacturers. The selection criteria included price


Central Gauges

and the functionality of the controls and their suitability for integration with the flight dynamics model. The seat was selected for comfort, adjustability and suitability of the harness. A local manufacturer was found with a suitable product.


Simulation Control


Location Selection


Atmospheric Settings


Aircraft Selection


Time and Date Selection

Local manufacturing of replica cockpit

A local cockpit design was developed after extensive market research into existing products. The final design was made with an emphasis on flexibility in terms of aircraft types and controls. The use of virtual instrumentation (developed by the CSIR using the Presagis VAPS XT product) allows for multiple aircraft configurations with a single simulator.

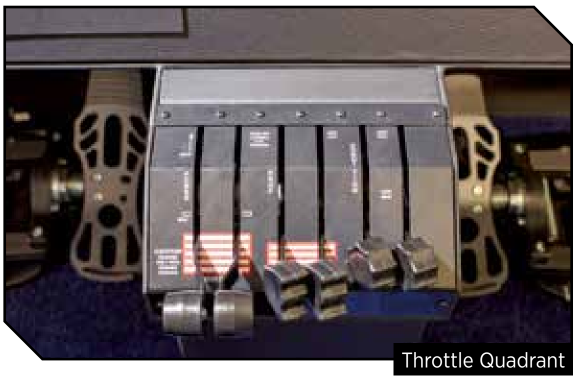
Local replacement of existing curved screen for the image generation projection system

Flight simulators at this level of fidelity often use multiple projectors, with image processing for edge blending and morphing onto curved projection screens. This is an extremely expensive solution. The team developed a custom stand for multiple TVs allowing for a suitable out-of-cockpit view. The use of the Presagis Vega Prime visualisation software allows for multi-channel image generation (sharing the view across multiple displays) without the need for expensive hardware.

Updating of instructor station human/ machine interface

The original FWFT prototype used the Presagis STAGE tool for the instructor. This is an extremely powerful tool but both expensive and fairly complicated to use for an instructor not familiar with the product. For this reason, the team developed a simple human/machine interface for the instructor to control all elements of the training scenario: aircraft selection, weather, time of day, location, exercise type, aircraft faults, etc. This was implemented on a touch-screen tablet, allowing the instructor to provide instruction from the co-pilot seat while maintaining access to the instructor functionality.


Yoke Rudder Pedals


Throttle Quadrant

Results: before and after

Before: concept demonstrator

The original concept demonstrator consisted of a gaming chair, gaming joystick and a projection system. The flight model was developed in-house and was limited to motion equations only. STAGE was used for instructor control.

After:

Prototype ready for production, including improved seating, instrumentation, flight controls and human/machine instructor interface.

Before

After

Seats

A locally manufactured seat was selected for the following attributes: comfort, durability, adjustability, arm-rests and four-way seat-belts.

Instrumentation

The cockpit design provides for a combination of virtual instruments and some physical components. Three touch screen monitors are provided for pilot, gauges and co-pilot views, with the virtual instruments and gauges made using the Presagis VAPS XT product.

Flight controls

The final set of flight controls selected to achieve the design methodology was as follows:

- Desktop KingAir Throttle Quadrant from Elite Simulation
- Control Yoke, LG Trim Unit, Nav/Comm Unit from GoFlight
- Throttle pedals from Simundza.

COMPLETED PROJECT

Aeroelastic Investigation of the JS-1 Sailplane

Project at a glance

Performing new ground vibration tests and flutter analysis on the JS-1 sailplane, to ensure European certification for entry into the European market.

Industry **skills** development in flutter analysis

Technology **validation**

Highlights

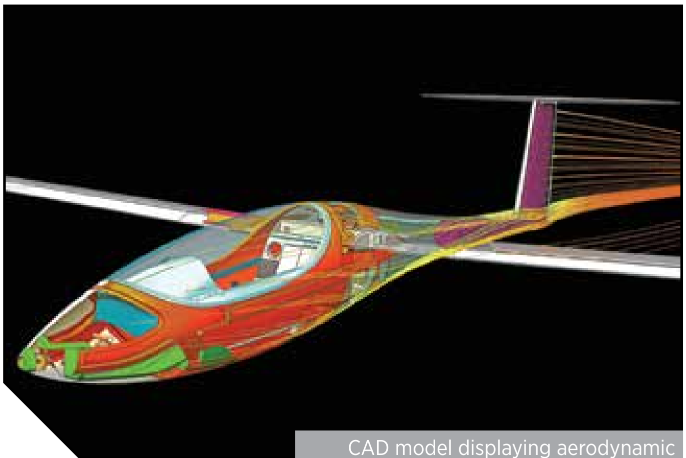
- Building on a strong parastatal and industry partnership
- Investigating the discrepancy between a previous project's flutter prediction and the non-occurrence of flutter during the flight test of the JS-1 sailplane
- Performing three ground vibration tests
- Performing the flutter analysis for three aircraft configurations
- Finding the reason for the discrepancy between the predicted results and the flight test results
- Enabling European certification for the JS-1, thereby creating a global market for South African products
- Export capability enhanced – results of the aerolastic investigation used for European Aviation Safety Agency (EASA) certification.

Main industry beneficiary

Jonker Sailplanes (JS) is a privately owned, South African company that designs, manufactures, and maintains sailplanes from its main facility at the Potchefstroom Airfield. Jonker Sailplanes has received an Aircraft Type Certificate from the SA Civil Aviation Authority (SACAA), the first of its kind to be issued by the SACAA. The certificate confirms that the Jonker Sailplanes JS-1 Revelation is compliant with the certification standard for sailplanes and powered sailplanes, CS-22. Type certification paves the way for the issue of an airworthiness certificate, allowing an aircraft to be operated in the airspace of the signatory states of the International Civil Aviation Organisation (ICAO) Convention of 1944.

Qualifying the JS-1 sailplane for the European market

The first aeroelastic investigation performed by the CSIR was conducted on the JS1-A and JS1-B types in 2009. In 2013 Jonker Sailplanes extended the wings of these sailplanes with the JS1-C model to 21 m and subsequently a number of configurations underwent Ground Vibration Tests (GVTs), conducted by a subcontractor. Flutter analysis, using the GVT results, indicated a number of modes with negative damping at speeds slightly below the maximum design speed.



CAD model displaying aerodynamic performance characteristics of the JS1-C

V SPEEDS EXPLAINED

V_{NE} is the maximum allowable speed for an aircraft. It is not the best speed at which to cruise, but the maximum speed an aircraft has been tested to in level flight. V_D is the design dive speed, a figure at least 20% higher than V_{NE}. The minimum value of V_D depends on the mass, wing area and minimum coefficient of drag of the airframe. V_D is the theoretical maximum speed used in the design process. V_{DF} is the maximum demonstrated dive speed used during flight testing and must be 10% above V_{NE}.

TECHNOLOGY DEVELOPMENT

Jonker Sailplanes: Composite high-performance sailplanes are a new concept for South Africa. The JS-1 is a proven high-performance competition sailplane, designed, manufactured and tested in South Africa, and South Africa's only type certified glider aircraft. A European certified aircraft will make it possible to operate and market the JS-1 aircraft in Europe.

CSIR: The CSIR has done flutter predictions before. However, the test performed in this project enabled the team to refine and demonstrate their actively controlled air supports.

Negative damping implies that flutter may occur above these speed and altitude flight conditions. Intense flutter flight testing was conducted to investigate if flutter would occur at the predicted speeds. No negative damping or flutter could be identified in flight and the discrepancy between the predicted results and the flight test results could not be explained.

The SACAA accepted the flight test results in combination with the GVTs performed, to declare the JS1-C flutter free within the design envelope.

Dr Louw van Zyl from the CSIR explains as follows: "In aviation, V-speeds are standard terms used to define airspeeds important or useful to the operation of all aircraft. These speeds are derived from data obtained by aircraft designers and manufacturers during flight testing, and are verified in most countries by government flight inspectors during aircraft type-certification testing. Using them is considered a best practice to maximise aviation safety, aircraft performance or both.

"The actual speeds represented by these designators are specific to a particular model of aircraft, in this case the JS1-C sailplane with a 21 m wingspan.

"We performed ground vibration testing, i.e. experimental determination of the aircraft's natural modes, and a flutter analysis on the JS-1, which showed that the aircraft structure would be safe up to dive speeds of 300 km/h. This was verified by subsequent flutter flight tests where no onset of flutter could be detected."

In order to sell the JS-1 sailplanes in Europe, European certification must be achieved. During the EASA certification process in 2016 more accurate values of the minimum drag coefficient became available, pushing the minimum value of V_D up to 324km/h.

This new value meant that Jonker Sailplanes had to prove the aircraft would still be flutter free up to the higher V_D speed.

"Typically, this would only require a new flutter analysis to be performed up to the higher speed, using the previously acquired modal GVT data. However, since the previous GVT data showed inconsistencies between the theoretical and flight test values, we concluded that in all likelihood the GVT data determined by the subcontractor provided results that were too conservative," Van Zyl says.

In order to perform the new aeroelastic analysis, a second GVT and flutter analysis for V_D had to be performed in support of the flight test results at V_{DF}. At the same time the reason for the conservative prediction of flutter had to be investigated.

Jonker Sailplanes collaborated with the experienced team of the CSIR in performing flutter prediction. The CSIR has significant experience on both military aircraft and civilian aircraft and has assisted Jonker Sailplanes in the past with flutter analysis on variants of the JS-1.

Export
capability enhanced

After conducting three ground vibration tests, for the different amounts of water ballast that the aircraft can carry, and performing the flutter analysis for the three aircraft configurations, CSIR, in conjunction with Jonker Sailplanes, obtained positive flutter analysis results and determined a possible reason why the previous analysis resulted in over-conservative values. It is believed that the accelerometers in the normal axis followed the profile on the leading edge instead of being normal to the flight line. These small discrepancies resulted in false acceleration measurements in the longitudinal axis, affecting the results of the analysis.

As a result of this 2017 project, new GVT modes were determined which, when used in the flutter analysis, predicted no flutter for the JS-1 at a dive speed of 324 km/h. Depending on the flight test, Jonker Sailplanes will be able to achieve European certification for the aircraft, creating space in the European market for a world class South African product.

> "Creating space in the European market for a world class South African product."

COMPLETED PROJECT

Aeroelastic Investigation of the JS-3 Sailplane

Technology validation

Project at a glance

Performing flutter analysis on the JS-3 sailplane up to dive speed, before progressing to flutter flight tests.

Highlights

- The modal parameters for five configurations of the JS-3 aircraft were obtained
- The control surface modal parameters were obtained
- Flutter analyses were performed for the 15 m and 18 m versions of the JS-3 which included configurations with and without water ballast
- No flutter was predicted for the 15 m configurations. Flutter was predicted for the 18 m configuration 3 km/h below V_d. By implementing the ballast scheme, the predicted flutter speed was increased to above V_d.
- Based on the flutter analysis prediction a recommendation was made to proceed with flutter flight tests
- Export capability enhanced – results of the aerolastic investigation used for European Aviation Safety Agency (EASA) certification.

Main industry beneficiary

Jonker Sailplanes (JS) is a privately owned, South African company that designs, manufactures, and maintains sailplanes from their main facility at the Potchefstroom Airfield. Jonker Sailplanes has received an Aircraft Type Certificate by the SA Civil Aviation Authority (SACAA), the first of its kind to be issued by the SACAA. The certificate endorses the Jonker Sailplanes glider aircraft (named JS-1 Revelation) as airworthy and thus certified to fly in all the signatory states of the International Civil Aviation Organisation (ICAO) Convention of 1944.

Sailplane ready for flight test

On 12 December 2016, the 10-year maiden flight anniversary of Jonker Sailplanes' JS-1 was celebrated with the first test flight of the JS-3 – a 15-meter glider which boasts the highest wing loading on the market, but with an exceptional ability to carry this load while retaining the feel of a light glider.

Five years of intense work done by the company's chief aerodynamicist Dr Johan Bosman resulted in the revolutionary new JS-3 model.

JS-3 in 18m configuration with extended jet engine

Having created the ultimate competition glider for highest performance in extreme weather conditions without compromising feel and handling ability, Jonker Sailplanes made the decision to take the next step: perform a flutter analysis up to V_d – the maximum dive speed which has to be considered when assessing the strength of an aircraft.

Working with the CSIR, the modal parameters were obtained during the Ground Vibration Test (GVT) for five configurations of the JS-3 aircraft. Next, flutter analyses were performed for the 15 m and 18 m versions of the JS-3 which included configurations with and without water ballast.

As a result of the analyses, no flutter was predicted for the 15 m configuration, while flutter was predicted for the 18 m configuration 3 km/h below V_d. By implementing the ballast scheme, the predicted flutter speed was increased to above V_d.

Based on the sufficiently safe flutter analysis prediction, Jonker Sailplanes will now be able to request permission to perform flutter flight tests to confirm that the aircraft is indeed flutter free up to V_d. Should the flight tests verify the analysis predictions, the company will be able to present the aircraft for European certification.

INDUSTRY BENEFITS

Once the JS-3 is certified in Europe (and elsewhere) Jonker Sailplanes can market and sell the aircraft in Europe. This will allow for additional job opportunities at Jonker Sailplanes, as well as keeping CSIR capabilities current and applicable to a local project that can be marketed abroad.

Industry skills development in flutter analysis

Export capability enhanced

"Once the JS-3 is certified in Europe (and elsewhere) Jonker Sailplanes can market and sell the aircraft in Europe. This will allow for additional job opportunities at Jonker Sailplanes, as well as keeping CSIR capabilities current and applicable to a local project that can be marketed abroad."

COMPLETED PROJECT

Laser-based Refurbishment of Invar Moulds

Project at a glance

Reducing downtime costs and production disruption risks by developing a cost-effective local repair technology for Invar 36 moulds.

Production **downtime** risk **mitigated**

3 interns trained

Highlights

- Developing a cost-effective repair technology for Invar 36 moulds based on the laser surface engineering technique of laser metal deposition
- Mitigating production downtime risk for Denel Aerostructures (DAe) by enabling repairs on site with minimal production interruption, resulting in significant cost savings
- Enabling an excellent partnership between the CSIR National Laser Centre (NLC) and DAe, providing future collaboration on projects relating to the improvement of production and maintenance processes at DAe
- Benefiting the South African tooling industry as a whole, thereby stimulating economic growth in South Africa
- Creating employment and skills transfer opportunities.

Contracted organisation

Denel Aerostructures (DAe) is the leading Aerospace Company in Africa – specialising in aerospace design and advanced manufacturing. It forms part of the state-owned Denel Group, South Africa's largest manufacturer of military aerospace and landward defence equipment.

Benefiting industry partners

- **CSIR National Laser Centre (NLC)** provides a critical core of laser-based manufacturing knowledge and expertise through the research, development and implementation of laser-based technologies and applications in Africa. The NLC also collaborates with industry and other stakeholders to understand and respond to their particular challenges.
- **Cermalab** is a SANAS accredited materials testing and materials sector training facility, serving the heavy clay, ceramic and refractory industries in Africa. The company was established in 2002 and is the only laboratory of its kind in Southern Africa.

Local repair technology cuts downtime costs

The high fixed cost base associated with aircraft manufacturing means that even occasional downtime due to breakdowns may be costly in a South African context unless a local repair technology is readily available to repair equipment in reasonable time. To reduce downtime and mitigate the risks associated with late or non-delivery, Denel Aerostructures (DAe) initiated a project for the development of a locally available laser-based repair technology, which would not only result in substantial cost saving for DAe, but also make a significant impact on the South African manufacturing sector as a whole.

Ms Razia Adam, Researcher at the NLC, throws light on the reasons behind the project.

"Invar is a controlled expansion alloy, developed more than a century ago and it is central to composites technologies for the manufacture of moulds. DAe uses Invar moulds in its production line to manufacture dimensionally accurate carbon fibre parts. Over time, as a result of continuous thermal cycling, the moulds form superficial cracks. These cracks then cause a loss of vacuum during the moulding procedure as well as surface defects on the moulded components."

Ms Adam continues, "Invar moulds are high value components and are manufactured and maintained in Europe. Since there are no spare moulds available, a locally available mould repair technology would contribute significantly to security of supply through a considerable reduction in down time for DAe and mitigation of the risk associated with late or non-delivery to its customers i.e. penalties to be paid. Laser based refurbishment is the most suitable process to repair cracks on Invar mould surfaces due to its tightly controlled heat input."

In tackling the project, DAe collaborated with the CSIR National Laser Centre (NLC), which over the past 10 to 15 years has developed laser-based technologies that can be used in the manufacturing of new products; in the repair of existing components, plant and infrastructure; to improve the performance of components

PRODUCTIVITY & INDUSTRY IMPACT

DAe's current repair process to avoid porosity and tool leaks relies on foreign service providers, at significant lead time and cost. With this project, the production downtime risk for DAe has been mitigated, with repairs now able to be made on site, with minimal production interruption. Further, this developed and controlled engineering welding process supports repair processes with a predictable outcome.

Since the future of aircraft development is more reliant on composites, localising the Invar tooling repair process will support future repair strategies – not only in the aerospace sector, but in manufacturing as a whole.

This, in turn, means that skills may be transferred to relevant industries within South Africa, contributing directly to national job creation.

manufactured by industry; or used in infrastructure, plant and equipment during manufacturing, mining or power generation processes.

Technology **transfer** from CSIR to Denel

Some of these interventions have already made significant impact on industry, but adoption is limited owing to barriers to technology uptake, including the cost of developing new applications with slow return on investment, and exacerbated by a cautious approach by local industry to adopting new technologies.

"Our partnership on this project was a natural upshot of the DAe's industry needs meeting the NLC's capability, supported by the AISI," Ms Adam says.

She goes on to describe the process followed to achieve project objectives.

"First, we had to determine the optimum laser process parameters for the Invar mould repair. Metallographic analysis of Invar-cladded samples showed that optimal fusion to the base material is achieved at low heat inputs (60 kJ/m and 67 kJ/m). Parameters were determined that minimised the presence of porosity, and the thermal expansion coefficient results of the cladded layers at the optimal experimental parameters are lower than those of the base material, illustrating that the laser refurbishment process does not alter the application of the material.

"Vickers Micro hardness results showed negligible variation between the base material, heat affected zone, fusion line and the weld. Hot-spot evaluation showed that the welded region did not form a hot-spot during cycling through 180°C for 24 hours."

With the parameters selected for the repair process, the NLC was able to develop a weld procedure specification for the Invar mould repairs. Subsequently, the grooves simulated by DAe could successfully and efficiently be repaired with the laser process – although the groove geometry can be improved.

Ms Adam elaborates on the impact this new repair technology has on the South African tooling and manufacturing industry.

"Since Invar is readily used in the tooling industry, this project not only satisfies the requirements of DAe but will also benefit the local South African tooling industry. Tooling repair and refurbishment technology developed for the automotive, food packing and steel production industry can reduce downtime, reduce maintenance costs and improve product quality.

"More specifically, in the case of high value tooling used in the automotive industry, where turnaround on tooling repairs can take months, downtime penalties can amount to tens of thousands of Rand per minute. The development of new roller cladding technology, that doubled the service life of rollers, resulted in large cost savings for ArcelorMittal in its steel producing plant in Vanderbijlpark," Ms Adam concludes.

"Some of these interventions have already made significant impact on industry, but adoption is limited owing to barriers to technology uptake, exacerbated by a cautious approach by local industry to adopting new technologies."

Precision Engineering towards Industry 4.0

Project at a glance

Taking Daliff's precision engineering operations forward towards Industry 4.0 – ensuring competitive and quality future supply to the aerospace industry.

Highlights

- Real-time machine monitoring of machine signals
- Data analytics of downtime
- Trend analysis of productivity
- Baseline mapping for complete business process digitisation
- Gearing up for predictive maintenance.

Main industry beneficiary

Daliff Precision Engineering is a precision engineering and manufacturing company that supplies machined components to the aerospace, avitronics/electronics and defence industries, with products including CNC turning and milling (including 4 & 5 axis), in batches ranging from one-offs to large quantities. Areas of specialisation include titanium and Inconel machining and thin walled components with deep pockets.

Smart engineering towards Industry 4.0


Operator Tablet Interface

Industry 4.0 is the drive towards the next level of production and manufacturing, and it is revolutionising all industries. Industry 4.0 is especially relevant in the aerospace sector, where suppliers are faced with stringent compliance requirements while under pressure to remain flexible in terms of customisation as customers' needs change and increase.

In 2017, at a Technology Road Mapping exercise held between the Aerospace Industry Support Initiative (AISI) and Daliff Precision Engineering, Daliff identified the development of an integrated digital manufacturing system as part of its goal in reaching Industry 4.0 maturity.

"With automation and digitisation possibilities growing almost daily, suppliers cannot afford to keep their operations in the previous era," says Christiaan van Schalkwyk, Managing Director. "In order for Daliff Precision Engineering not only to retain, but also to grow our competitive advantage in the (global) market, it is imperative to embrace the technologies indicative of the next industrial revolution – Industry 4.0."

The AISI facilitated access to CSIR expertise, through which Daliff embarked on a project to increase its competitiveness in supplying quality products to the aerospace industry by implementing automation and digitisation measures, as well as generally optimising its processes, layouts and operations.

> "To not only retain, but also grow our competitive advantage in the (global) market, it is imperative to embrace the technologies indicative of the next industrial revolution – Industry 4.0."

Van Schalkwyk explains the background that led to the project's inception.

"The main objective of the project was to initialise the implementation of various phased measures at Daliff to take our operations forward and towards Industry 4.0 practices, thereby better securing future supply to the aerospace industry.

Industry 4.0 brings together a constellation of intelligence and modern automation, data exchange and manufacturing technologies. Chief among these are adaptive cyber-physical systems, engineered using seamless integration of computational algorithms and physical components including machine tools.

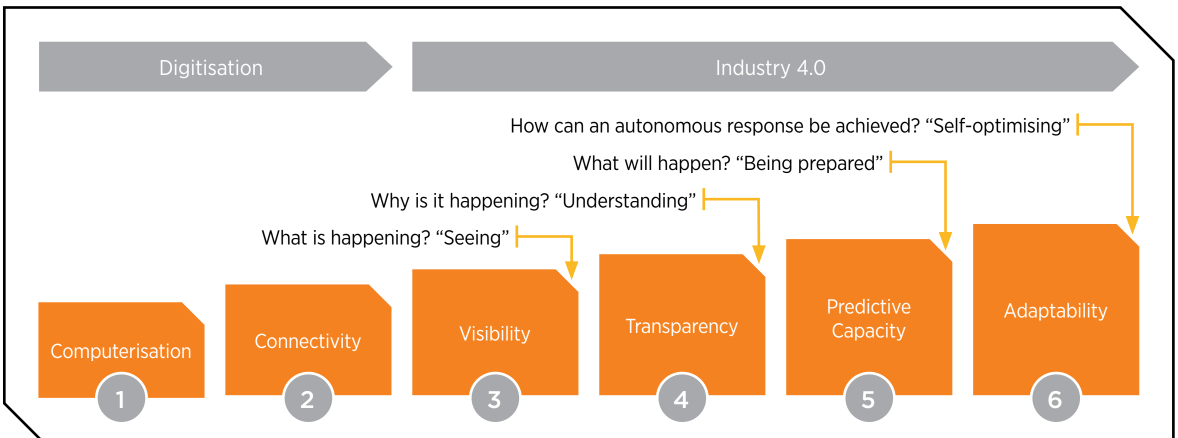
While suppliers to the aerospace industry, such as Daliff, are regulated by strict compliance requirements, we have to balance this by providing customised solutions for specific requirements, for example the aerospace (and medical) industries' need for surface integrity and process traceability," Van Schalkwyk says.

1
intern trained

Industry 4.0
skills
development

"Industry 4.0's approach is to envision intelligent manufacturing solutions that will target fully predictive processes. These could then be readily optimised to best performance with regard to specific but fast-changing requirements faced by complex manufacturing businesses.

Making those solutions possible is digitisation, which forms the foundation of cyberphysical systems. Simply put, digitisation is the conversion of information into a digital format that can be understood by computer systems," Van Schalkwyk explains.



Stages of the Industry 4.0 development path (adapted from Acatech image)

Operator Tablet Mounting

The project was executed through three individual but connected work streams: Process mapping and enabling adherence to the latest aerospace standards; Implementing real time machine monitoring systems; and Investigating automated costing, quoting and planning mechanisms.

These three work streams were executed simultaneously during the period January 2018 to March 2018.

Industry benefit

The various tasks mapped for implementation at Daliff may increase its competitive advantage, not only locally but also globally. These measures are of such a nature that they can also be implemented (rolled out) at other, similar entities within the aerospace Industry.

By advancing the technologies used to produce and manufacture the components utilised in the aerospace industry, quality and competitiveness can be increased continuously, ensuring growth and progression.

Daliff is a Level 2 Broad-based Black Economic Empowerment company. By assisting Daliff to remain not only competitive but also to stay current with global trends, transformation within the industry is further enabled.

For the AISI, the project provided a prime example of the diversity in skills and tasks utilised to deliver solutions to complex problems within multifaceted elements.

WHAT IS INDUSTRY 4.0?

A new approach
to achieve results that weren't possible 10 years ago thanks to advancements in technology.

The fourth industrial revolution
is a worldwide move towards digitisation of processes focusing on higher productivity and cost reductions from using real-time data, the Internet of Things and increased automation, among others.

Smart factories
are at the heart of Industry 4.0, digitally connecting supply chains and production lines resulting in cheaper and better-quality goods or services.

SMMEs
with single-facility enterprises will reap the benefits of optimisation over innovation over time.

The skills gap
can be evolutionised by the availability of new technologies and tools to educate and empower people.

Technology transfer from CSIR to SMME

Residual Stress Distribution in Billets

Project at a glance

Developing a new capability to decrease the machining time and machining cost of slender components, by focusing on the inherent distortion challenges of such parts.

Highlights

- Forceful correction of parts by means of clamping in-between machining steps (machining trials by Aerosud)
- Minimisation of distortion by means of selective placement of machining within the billet with respect to the residual stress distribution through the billet:
  - Determine residual stress distribution through different billet thicknesses (Necsa)
  - Simulate machining distortion with Marc (ESTEQ/Aerosud)
  - Determine optimal placement of machining within billet (ESTEQ/Aerosud)
  - Machining trials (Aerosud)
  - Develop advanced software integration capability (Aerosud).

Contracted organisation

Aerosud Aviation is an established leader in the South African aviation industry and a recognised and respected brand in the very competitive international market place. Aerosud considers that its business, management and technical skills have the potential for long-term sustainability as a credible, commercially successful private business enterprise.

Decreasing the machining time and cost of slender parts

In the aerospace industry, aluminium raw material is commonly processed using extrusion, rolling, forging, moulding and heat treatment. As a result of these raw material processes it may contain residual stresses before the machining process even begins or, alternatively, residual stresses may be induced during the machining process.

Why is this important? Residual stress may cause distortion, which is a major concern during the manufacturing of structural aerospace components, especially during the manufacturing of thin walled components.

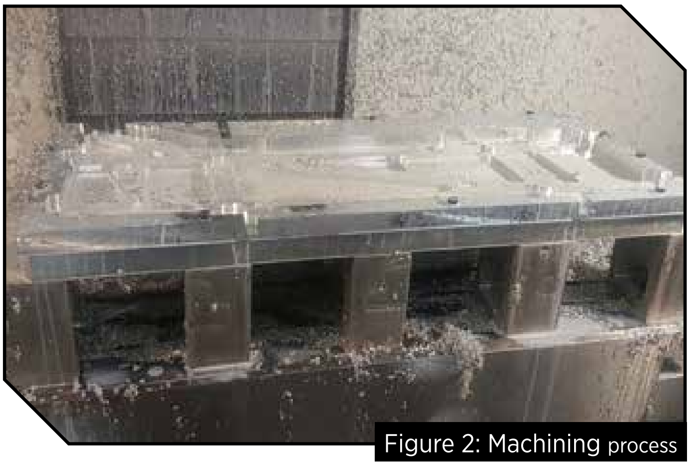


Figure 2: Machining process

Wouter Gerber, Aerosud Research and Technology Director, explains how the project can benefit both Aerosud as well as its supply chain partnerships, in particular its machining supplier, Daliff Engineering.

"The machining time and cost of slender components are typically very high because these parts distort to a great extent between machining steps," Gerber says. "With the support of the AISI, the goal of this project was for us to identify and develop a feasible method to minimise the machining cost and time of slender components during sequential metallic machining steps."

Progress

During the machining trials at Aerosud, three machining stages were used. The first stage consisted of material preparation whilst the second and third stages involved the actual machining of the parts. The parts were forcefully corrected by means of clamping during these machining trials. In this case tags were used instead of actual clamps. Figure 2 shows part of the machining process. The project is progressing well in accordance with the project plan.

Next steps

The next phase of the project will include:

- Determine residual stress distributions through different billet thicknesses (Necsa)
- Simulation of machining distortion with Marc (ESTEQ/Aerosud)
- Determine optimal placement of machining within billet (ESTEQ/Aerosud)
- Machining trials (Aerosud)
- Development of advanced software integration capability (Aerosud).

PROJECT RESEARCH METHODOLOGY

- Publication research to find methods for measuring residual stresses and expected results.
- Machining trials with the part laced at different depth positions to investigate the effect on distortion magnitude.
- Conducting a residual stress survey over a complete billet using the neutron diffraction method.
- Simulation with Finite Element Analysis (FEA) software to predict distortions using the measured residual stresses as input and predict optimal part placement for minimal distortion.
- Machining trial of the part placed at the predicted optimal depth and measurement of actual distortions with CMM.
- Compare predicted results with actual results.

"By developing a new capability to successfully reduce distortion, especially in slender parts, we will be able to save time with less wasted material and costs, and increase productivity and output, thereby expanding our market and creating greater potential for local job creation throughout our supply chain partnerships."

PROJECT IN PROGRESS

Implementing the use of Infrared Thermographic Testing to Augment Non-destructive Testing on Composite Components

Denel Aerostructures (DAe)

Non-destructive Testing (NDT) is the analysis of the properties of a material, structure, or component without any physical damage to the system. The detection of defects in material is an important part of quality control for its safety of system because flaws and cracks weaken the performance of a structure or material (Cartz, 1996; Raj et al.*, 2002). Infrared Thermographic Testing (IRT) is a non-destructive technique which is being applied in industries such as aeronautics. IRT provides maps and movies of the surface thermal field of specimens; in this way, local changes in surface temperature indicate subsurface defects. The technique provides information on the position, size and shape of flaws such as delamination, disbonding or crack networks.*

Project overview

This project involves the assessment of and assistance with implementing Infrared Thermographic Testing (IRT) on Denel Aerostructure's manufactured composite components to augment the Non-destructive Testing (NDT) already performed on the components. In preparation for the project, a new version of the IRT software was installed on a new 64-bit laptop. This software update was necessary as the first version was already 10 years old. Together with the software, additional training material was developed. The training material for the initial training course was also adapted so that the course can be offered in an understandable manner.

Objectives

The initial objectives were as follows:

- Assessing the performance of active IRT on test samples which have already been manufactured and are available for testing. This includes:
  - Determination of system limitations
  - Acquisition and/or manufacture of reference panel samples (solid and honeycomb panels)
  - Assessment of best practices for test set up and execution to limit external factors during testing
  - Creation of a test specification and outcomes list
  - System testing and data analysis
  - Assessment of new limitations on Denel samples
- Training Denel personnel in IRT – both theoretical and practical training – so that they can operate the IRT equipment and apply the tests to newly manufactured components
  - Assessment of suitable personnel for training
  - Training manual completion
  - Determination of training schedule
  - Training of personnel

Flat holes carbon fibre sample

Next steps

The following activities are planned for the next period:

- Drafting the Standard Operating Procedure (SOP)
- Purchasing ISO and ASTM standard for IRT as reference material
- Determining Denel quality and process requirements
- Creating a theoretical and practical training guide

Assistance in compiling an inspection procedure for the use of IRT in Denel Aerostructures.


Thermographic testing setup

PROJECT IN PROGRESS

Small Gas Turbine to Market

Cape Aerospace Technologies

The sophistication of the gas turbines produced by Cape Aerospace Technologies (CAT), and that of the aircraft they power, has blurred the lines of distinction between model aircraft, military- and commercial unmanned aerial vehicles.

CAT is developing a micro gas turbine or turbojet engine with a proposed static thrust of 250 Newtons (N). The project work plan was structured into six stages with stages 1–4 completed as follows:

Stage 1: Preliminary numerical design and analysis of the radial flow impeller, diffuser and axial flow turbine rotor and stator

A 74 mm off-the-shelf turbine rotor and stator were used as the starting point for the design process. Next, an off-the-shelf impeller was sourced with performance characteristics that matched the 74 mm turbine performance.

Similarly, turbomachinery components (such as the compressor and turbine) were matched by means of 1-D and CFD numerical analysis, while the combined impeller and diffuser stages constituted the compressor stage. The respective turbomachinery components were X-rayed and reverse engineered, followed by design validation and a preliminary cycle analysis.

Stage 2: Cycle Performance Evaluation

Stage 3: Final engine design and all components related to the newly designed gas turbine:

- CAT 250 Turbine specifications
- CAT 250 Manufactured components
- CAT 250 Shaft balancing as shown in Figure 3

Stage 4: Experimental testing on the 250 N gas turbine

Next steps

The project is progressing well and the next steps are covered under Stage 5 and 6.

3D CAD Stator Model

3D CAD Rotor Model

Figure 3: CAT 250 shaft balancing

Stage 5

To ensure a top product, CAT wishes to upgrade its current turbine control unit and user interface to stay up to date with current technology and trends. This stage mainly focusses on the turbine control software and user experience in terms of cosmetics.

Stage 6

Stage 6 will make use of intelligent design and investigate processes to streamline the design-to-manufacture process, i.e. minimising material and time wastage. This stage will include the implementation of quality control checks and attempt to avoid bottle necks in the supply chain.

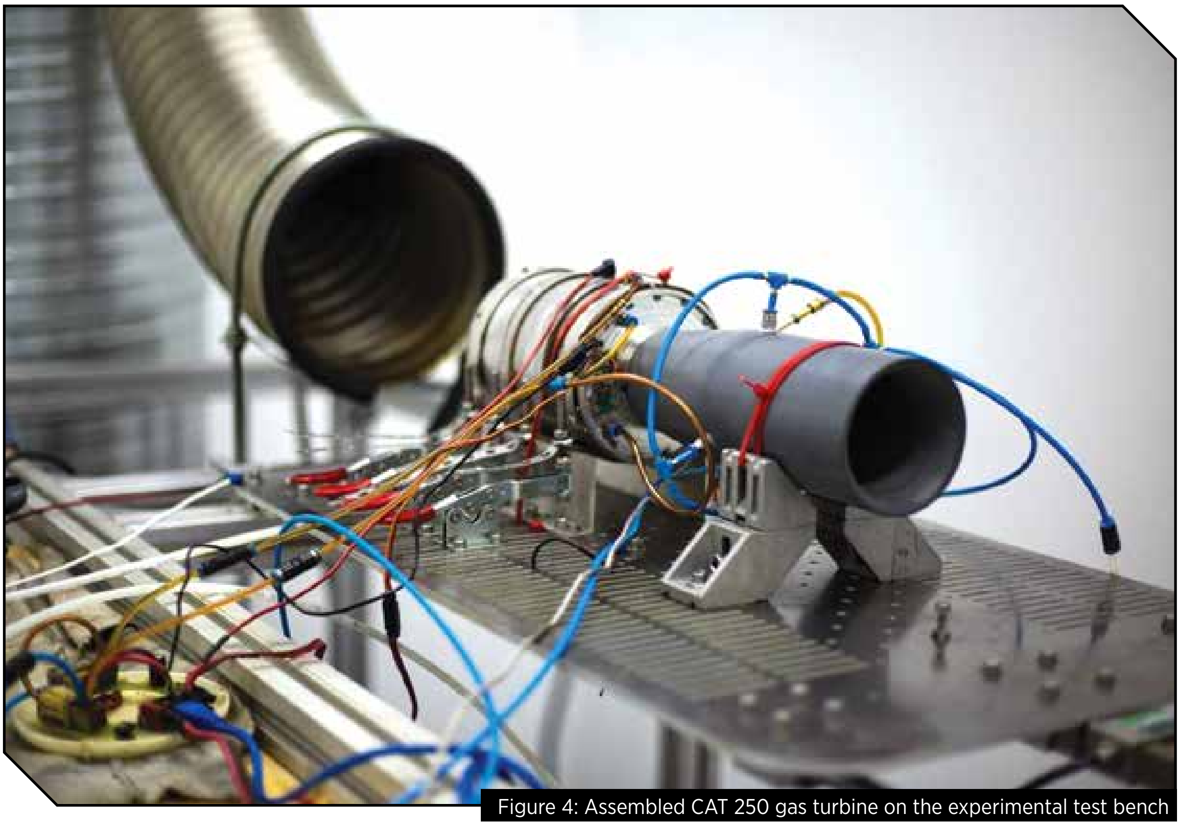


Figure 4: Assembled CAT 250 gas turbine on the experimental test bench

PROJECT IN PROGRESS

Laser Shock Processing for Straightening of Machined Aluminium Spars

Denel Aerostructures

The replacement and refurbishment of metal components in industry costs billions of dollars annually. Metal components typically need to be replaced due to three primary mechanisms – fatigue, corrosion, and wear. Laser shock processing technology has beneficial performance enhancement potential on all three, with significant enhancements especially relating to mechanical fatigue and stress corrosion cracking.

The purpose of this project is to develop Laser Shock Processing (LSP) technology locally to address the distortion of machined aluminium components for aerospace applications that results in geometric non-conformance. It is important that during the process the mechanical properties of the post-LSP part must not be significantly altered.

LSP is one of the most advanced forms of peening technology, as it achieves far superior results compared to conventional mechanical shot peening. LSP uses a pulsed laser to vaporise the surface into a high-pressure plasma, as shown in the schematic in Figure 5. The generation of Giga Pascal pressure acting over a short time frame drives a shock wave through the metal target. The differences in the process mechanisms using LSP result in penetration to and deeper levels of residual stresses of up to 10 times more and a superior surface finish.

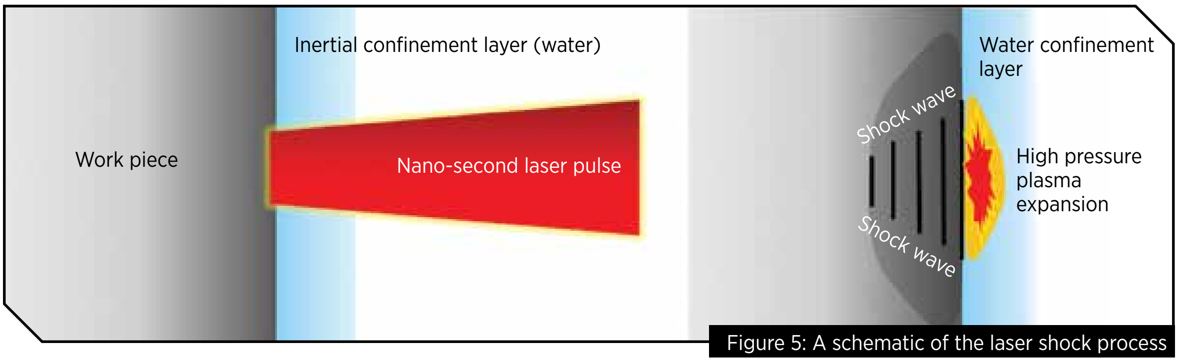


Figure 5: A schematic of the laser shock process

Although LSP is typically used to enhance the life of critical metal components, the precisely controlled impacts can also be used for metal forming applications. Conventional shot peen forming and laser peen forming are already used globally to produce curvatures in aerospace structural components. The high degree of process control and repeatability allows for highly engineered distortions to be introduced into metal components. The ability to produce localised distortions allows for the generation of desired component curvature, or alternatively the process can be tailored to mitigate undesired distortions.

Denel Aerostructures (DAe) manufactures a large number of components for structural airframe applications, using Computer Numerical Control (CNC) machining on the typically thin walled structures from an aluminium billet. Due to a combination of the cutting process (such as cutting strategy and tool wear), as well as pre-existing residual stresses within the machined billet, the resulting machined component may be out of tolerance. Since required maximum deviations for the aerospace industry are known to be exceptionally small, it is not unusual that components are rejected due to failure to pass quality assurance for conformity to the required geometry. The waste of machining time, effort and raw material are of course a cost burden in the advanced manufacturing environment and should be minimised.

In this project, Denel Aerostructures identified a specific component to focus on, as depicted in Figure 6, which may potentially reduce scrapped components if the geometric non-conformance can be addressed.

Figure 6: (Left) The Denel Aerostructures machined aluminium component; (Right) a deviation map on acceptable distortion from the intended geometry

Progress

The current project is phased over multiple years, with the first 12 months (phases 1 and 2) scoped to demonstrate the ability of the LSP process to correct the distortion on the identified component. Phase 1 required characterisation of the effect of the LSP process (to ensure no detrimental consequences arise) as well as development of a suitable LSP process parameter envelope. Phase 2 requires implementation of the LSP process to physically demonstrate the effective elimination of the undesired distortion by introduction of highly engineered deformations.

The initial feasibility study was performed on simple flat coupons as depicted in Figure 7 below. From the deflection characteristics produced, the potential of the LSP process applied to an equivalent sectional stiffness of the actual component could be assessed. A series of parameter combinations have been investigated which have allowed for identification of suitable process parameters with an anticipated minimal alteration of material properties.

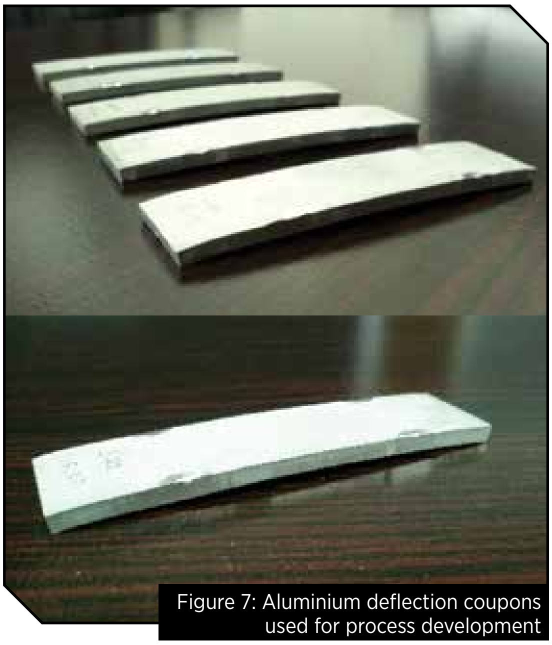


Figure 7: Aluminium deflection coupons used for process development

Next steps

To date, the outlook is positive. The results are promising, with no technical difficulties experienced. Good progress has been made towards the initial requirements, with delivery of the required milestones to date. The next reporting period will see the delivery of:

- A detailed characterisation of mechanical properties
- An Initial Procedure Specification which details processing of the actual component.

Standards and accreditation

One of the key interventions that the AISI offers to SMMEs in the Aerospace Industry is assistance in implementing relevant standards and accreditations. There are a number of benefits for SMMEs in achieving standards certification, including:

- **Improved customer satisfaction and access to new markets.** Understanding of customer needs to better meet their requirements results in increased repeat business and sales. Certifications also assist SMMEs to access new markets or clients where certifications such as ISO 9001 and AS9100 are a prerequisite. This in turn allows the SMMEs to compete globally.
- **Improved efficiency and continuous improvement.** A better understanding of internal company processes and how they interact allows for the identification of inefficiencies.
- **Increased productivity.** Evaluation and improvement of processes leads to better and consistent quality which reduces the number of defects, scrap and reworks.

IMPLEMENTATION SUPPORT FOR AEROSPACE STANDARDS

- AS/EN9100
- ISO9001
- ISO14001

The normal process followed for standards and accreditations is a gap analysis followed by implementation and actual certification.

AS9100 Certification

In the 2017/18 financial year, the following companies received assistance in terms of AS9100 certification:

Ti-Tamed

Type of support:
2017/18 AS9100 Rev C Surveillance Audit

Status:
Complete

Daliff Precision Engineering

Type of support:
AS9100 Rev C Surveillance Audit and AS9100 Rev D upgrade

Status:
Implementation of revision D upgrade is now complete – awaiting certification in June 2018

Compumach Engineering

Type of support:
AS9100 Rev D upgrade

Status:
Complete

AISI and SEDA Collaboration

The AISI in collaboration with the Small Enterprise Development Agency (SEDA) performed gap analysis and implementation of standards at the following companies:

- Micromax: ISO 14001 and AS9100
- Daliff Precision Engineering ISO 14001
- Zolispan: ISO 9001.

Implementation of the standards at these companies is still under way and the next step will be final certification. The AISI will continue to offer this service to industry because it is critical for the competitiveness of the industry and also for opening new markets for the industry players. A number of SMMEs are already lined up for support.

Supply Chain Optimisation

The Supply Chain Optimisation Intervention focusses on improving and optimising the manufacturing processes for SMMEs in the aerospace industry. The ultimate goal is to improve the competitiveness of aerospace SMMEs through reduced manufacturing costs and increased efficiency or throughput of the production processes. This can be achieved through interventions such as:

- Lean manufacturing and Six Sigma
- Total Productive Maintenance (TPM)
- Theory of constraints
- Statistical Process Control (SPC)
- Facility layout and planning, including simulation
- Production planning and inventory control.

During the 2017/18 financial year, the AISI carried out a needs assessment at seven companies, with the aim of determining preliminary needs or gaps in their respective manufacturing operations. The needs assessment was implemented through the AISI by sourcing specific expertise from the CSIR.

The seven companies are summarised in the Table below:

Name of Company	Description of Operations	Location
Cliff's Way Aerospace	• Complex precision machining for the aerospace, defence, rail and power industries • AS/EN9100 certified	Germiston
Compumach Engineering	• High precision machining for aerospace applications and mining • ISO 9001 and AS/EN9100 certified	Germiston
Daliff Precision Engineering	• Complex machining of components for aerospace, rail, energy and defence industries. • ISO 9001 and AS9100 REV D certified	Cape Town
Electro Thread	• Manufacture of electrical harnesses and electrical testing services for defence, aerospace, rail and motorsport • ISO 9001 and AS/EN9100 certified	Centurion
International Jet Support	• Supply of aircraft spare parts and inventory solutions	Kempton Park
Micromax	• Milling and turning of precision mechanical components for defence, aerospace and mining • ISO 9001 certified	Kempton Park
West Engineering	• Machining of precision engineering components for aerospace, defence, automotive and rail industries	Midrand

Results and Recommendations

Based on the assessments made and interaction with the seven SMME's main customers (Aerosud Aviation and Denel), recommendations were made in terms of the following aspects:

- Customer interactions (including improving lead times for quotations, payment terms, client diversification and order date management)
- Theory of constraints training and implementation
- Lean manufacturing training and implementation
- Time, method and work studies (including training, factory layout improvements and recording and measurement of processes)
- Production planning and control (including Enterprise Resource Planning system enhancements, barcode systems, CATiA procurement and implementation, updating of standard operating procedures, production metric analysis and review of shifts)
- Inventory management (including inventory management system, packaging improvements, management of varying wire lengths, stock assessment and control of WIP)
- Quality management (including quality system implementation, non-conformance management, near miss management, CMM capability, configuration control implementation, statistical analysis and scrap reduction)
- Total productive maintenance implementation.

The next phase of the project will involve implementation of the interventions to specific companies that were assessed as part of Phase 1.

PROGRAMME 2:

Industry Development and Technology Support

The Industry Development and Technology Support Intervention focusses on industries in sectors relating to advanced manufacturing in aerospace and defence. These industries are encouraged to industrialise technologies for the advancement of South African niche capabilities and value propositions. 6 Projects were supported through the Industry Development and Technology Support intervention. Only 1 project has been completed and the remainder of the projects are still in progress.

High level information regarding the Industry Development and Technology Support Initiative is summarised in Table 3.

Table 3: Industry development and technology support impact summary

Programme Focus	**Technology Enhancement, Standards and Accreditation and Supply Chain Optimisation**
Predominant technology stream	Avionics and sensors, advanced materials and manufacturing
Industry support investment	R3 559 769
% AISI investment of project budget	19%
Number of projects undertaken	6
SMMEs Involved	6
Resulting Impact on Industry	
Technology development/advancement	5
Manufacturing process	4
No. of people involved in industry skills development	1
Number of jobs created or retained	1
Academic institutes and science councils involved (access to national infrastructure)	1

The projects and their high level impact are summarised in the next section.

COMPLETED PROJECT

Hyperspectral Camera and Calibration Facility Upgrade

Project at a glance

Establishing an industry accessible hyperspectral imager calibration facility suitable for commercial and space environment imagers

1
job created

Highlights

- Creating a new national facility which should in future enable job creation in the Western Cape
- Providing the space industry's small and medium sized SMMEs with the facility, equipment and software to optically calibrate products, using capable and experienced calibration operators
- Increasing the value of space industry export products by enabling the national space industry to test and calibrate their optical imager products as part of the manufacturing process
- Taking a major step towards the South African national space industry's long-term export product technology and capability roadmap
- Producing a calibration performance report for the Gecko-HS hyperspectral imager that will inform product marketing and provide technical performance feedback to design teams for ongoing imager improvement
- Validating the image end-product quality and format
- Collaborative partnerships with Cape Peninsula University of Technology, Simera, Space Advisory Company and Denel Spaceteq
- Access to national infrastructure – upgraded the national optical facility at Houwteq.

Contracted organisation

SCS Space is a commercial satellite mission partner situated in Cape Town, South Africa. Its services are focused on spacecraft production, Assembly Integration and Testing (AIT) and ensuring operational success for satellite missions.

"Technological innovation and reduction in the price of airborne hyper spectral imaging systems in the near future is a key opportunity for market growth in a variety of industries, especially the commercial and defence sectors."

A hyperspectral imager calibration facility for South African industry

Since the early 1970s, a large number of space-borne multispectral sensors have been launched globally. Hyperspectral imaging has undergone tremendous conception evolutions in recent years, maturing from remote sensing for aerospace and defence applications to being used in many other fields like the agriculture and food industry and recently in the medical field of surgery.

Rapid industrialisation and growing demand have propelled the growth of airborne hyper spectral imaging systems in emerging markets. The only factor limiting the use of airborne hyper spectral imaging systems is the cost of acquiring them and managing the datasets produced.

Hendrik Burger, CEO of SCS Space, explains what led to the implementation of this project with the support of the AISI.

"Space imaging products currently offered by the South African industry are superior to those of its competitors in the international market. With similar hyperspectral cameras now being developed internationally, some to be flight tested in 2019, it is essential that, as an industry, we stay current and relevant.

"Technological innovation and reduction in the price of airborne hyperspectral imaging systems in the near future are clearly a key opportunity for market growth in a variety of industries, in the commercial and defence sector," Burger continues.

"What makes this project unique is that more than 80% of the project cost will be invested in a national facility, available to the broader South African space industry.

"By establishing a South African-based hyperspectral imager calibration facility, including the human capital development to sustainably maintain and operate it, we believe that South African enterprises, including SMMEs and OEMs will benefit from increased export opportunities and as a result increased job creation."

Members of the SCS Aerospace engineering team have been successfully developing earth observation spacecraft (satellites) in South Africa since 1993. The team's understanding of the technical problem domain is advanced, and experience in practical design and manufacturing has been gained over the past 15 years. Space imager development projects are usually strongly supported and assessed by non-space optical and mechanical specialists in the country. This co-operative engineering, scientific and earth observation user community collaboration enables the participating teams to offer very competitive performing and value priced products for the international market.

Figure 8: Calibration facility equipment relocated to a new laboratory after 10-year storage

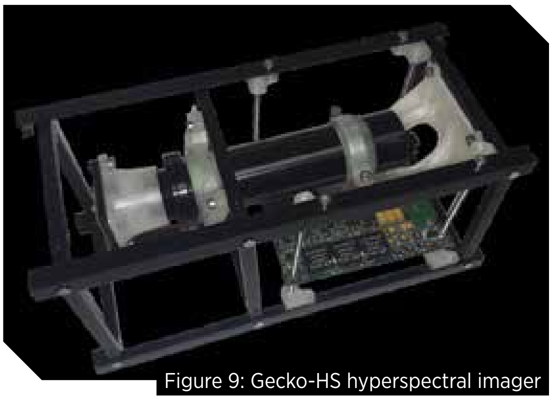


Figure 9: Gecko-HS hyperspectral imager

Figure 10: Gecko imager being radiometrically characterised using the integration calibrated sphere

Step-by-step towards application

- The historic (existing from 2006) part of the facility (called the MSMI calibration table) was relocated from storage rooms at Houwteq to an industry-accessible location at Houwteq and made the responsibility of SCS Space by its owner, the South African Government, specifically the Department of Science and Technology (DST), which funded the initial setup.
- Designing a hyperspectral system is a comprehensive process of selecting optical, electronic and mechanical elements. Following a literature review, the imager calibration plan was designed considering the prototype Gecko-HS, and other imagers' system specifications. The facility to implement the plan was specified and the required equipment, software and knowledge were identified and sourced. Project procurement was constrained by the available project material budget and the scope of project execution. Expensive equipment like the collimator was therefore procured early on and a spectrometer was initially rented, while the CSIR's ASM FieldSpec Pro was used for calibration of the facility equipment.
- During the final period of the project the facility equipment was integrated and a hyperspectral imager was characterised and calibrated using the new facility.
- Analysis, of both the data generated and the resulting insights gained, is an ongoing process and will continue to be central to future design improvements and manufacturing and calibration service processes at SCS Space.

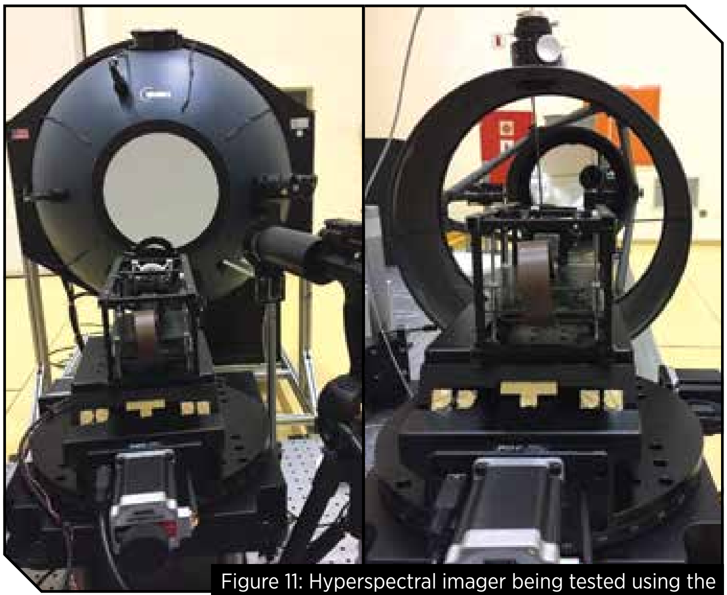


Figure 11: Hyperspectral imager being tested using the integration sphere (left) and collimator (right)

Figure 12: Facility operator, Lordwick Rickhotso inspecting a Gecko imager (top) and the integration sphere (bottom)

Burger concludes, "Finally, we are satisfied that the project complements the national space programme calibration and validation plan by addressing a facility performance scope (primarily aperture size of optics) that is not catered for in the short-term period of the existing plan. The current calibration validation national plan focusses on supporting the current national satellite imager payloads, which require a larger and more costly facility solution. It further complements the national plan by cost-effectively improving an existing facility to the point where there is industry interest in making use of the facility."

PROJECT IN PROGRESS

Helicopter Flight Trainer Firefighting Upgrade

Cybicom Atlas Defence

With previous support from the AISI, Cybicom Atlas Defence (CAD) and the CSIR have jointly developed a Helicopter Flight Trainer (HFT) prototype originally aimed at the SA Navy requirement for a Helicopter Flight Deck Trainer (HFDT). This was demonstrated at Africa Aerospace and Defence in 2014 and the response indicates strong interest in both the commercial and defence markets for a cost-effective, locally developed helicopter simulator.

The stated project goal, namely to commercialise the CAD helicopter image generation (IG) system and the CSIR helicopter simulator to ADM/pre-production model status, has been achieved and the upgraded helicopter flight trainer has been installed at Cybicom House in Cape Town.

Fire becomes a moving object as it blazes through vegetation. This, as well as low visibility due to smoke, and unknown reactions as water and fire collide, spurred CAD and the CSIR to embark on a project providing a major software update to the Helicopter Flight Trainer. The update includes a fire-fighting training module that can accurately display the fire and allow the fire to interact with its environment, as well as estimate, among other things, the location and amount of water being sprayed in relation to the blaze.

Helicopter Flight Trainer

Progress

To date, a system design has been completed to bring the HFT in line with the architecture used in CAD's fixed wing flight trainer (FWFT). This also caters for operation of the HFT without the Presagis STAGE tool. An initial training exercise has been designed around the Camp Pendleton CBD dataset. This allows for fires near the airport involving buildings and vegetation and is located close to the ocean for the replenishment of water.

The AISI support provided the impetus for a major upgrade to the original prototype in a very short space of time with work in progress including the:

- Design of a fire-fighting training module
- Vega Prime updates for fire and smoke effects
- Replacement of STAGE
- Update of instructor module.

The following fire-fighting and rescue helicopter training requirements have been identified:

- It should be an optional add-on module to the basic helicopter flight trainer; selectable from the instructor application
- The user should be able to set helicopter type and helicopter firefighting equipment available
- The user should be allowed to interactively set the location and size of fires on the map
- HeliSim must accurately model the dynamics of a helicopter whilst fighting fires (typically in the form of modelling the effects of underslung loads – such as a bucket of water – on the helicopter aerodynamics)
- The simulator should accurately display the fire and allow the fire to interact with its environment (fire can move/burn through grass, smoke is present, fire and smoke interact with wind)
- The simulator should be able to estimate the location and amount of the water being sprayed in relation to the fire and accurately adapt the blaze to account for this event.

Next steps

The next step of the project is to integrate the HFT with the FWFT to allow joint training of a spotter aircraft and a fire-fighting helicopter.

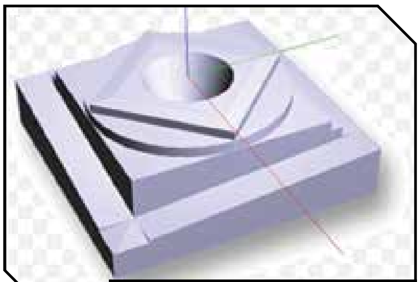
Firefighting Helicopter 3D model with underslung Bambi Bucket

Implementation of Advanced Aerospace Machining Processes

Daliff Precision Engineering

In a technology-based environment with a growing demand for reduced company expenditure and an increasing expectation for growth and efficiency, many companies across the globe are working towards new and innovative ways to improve the market they trade in. In the market of Computer Numerical Control (CNC) machining, local South African trade can be challenging. However, a diverse role for the organisations does exist – be the user working from a domestic property or a larger more refined facility. No matter which end of the scale, the question remains; how does one undertake machining cheaply and effectively?

The effect of high-performance machining is relative and thus must be suitable to the approach, technique, and desired outcome of the component being manufactured. Daliff Precision Engineering has undertaken to implement high performance machining (HPM) through a digital manufacturing environment, applying a relative scale between high-speed machining on the one side and high-accuracy on the other side of the scale – as per Figure 13 below.



Representation of a circle-diamond-square accuracy block

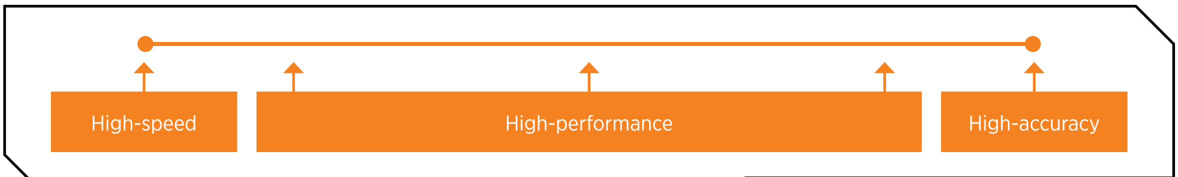


Figure 13: High-performance machining scale

Progress

During the first week of the investigation a gap analysis was performed to identify critical areas that should be actioned in the investigation of this project. An in-depth analysis was performed in each department to identify useful processes that could be adapted, or changed completely, with the objective of improving company performance and efficiency and positioning the company as a more advanced competitor in aerospace machining.

The scope of this project currently remains on schedule. With the gap analysis complete, the set objectives will be used as the core of the investigation and provide a benchmark for theoretical and practical outcomes after implementation has concluded:

- Both human and physical resources as well as CAM software availability will be used as the baseline for this investigation.
- Theoretical and practical investigation and implementation will be governed by the software and hardware availability and work envelope.
- Objectives and/or observations may require further detail or re-evaluation if the investigation proves that the available resources are incapable of reaching the desired objective. In this event, a solution must be derived to effectively advance the resources for better use and effectiveness – the same applies to human resources from a skills perspective.

PROJECT IN PROGRESS

Stellar Gyro Flight Readiness

NewSpace Systems

A stellar gyroscope captures and processes images of stars to determine the orientation of a spacecraft in celestial co-ordinates. A stellar gyroscope could function without the sun sensor and three-axis mechanical gyroscope typically needed for a star tracker; consequently, stellar gyroscopes can potentially reduce the need for the mass, power consumption, and mechanical complexity currently required, and eventually revolutionise attitude determination systems on all spacecraft.

NewSpace Systems' stellar gyro intends to complement (rather than function without or replace) more typical subsystems such as sun sensors and mechanical gyroscopes to improve attitude determination and control performance. The stellar gyro process (i.e., processing of star images to determine angular rates and ultimately orientation) is more robust and less resource intensive than that of a star tracker. This allows NewSpace to use smaller, lighter weight, less expensive optics and components to achieve the desired performance.


Stellar Gyro Exploded

The NewSpace Stellar Gyro Flight Readiness Project oversees the design, production and verification of an operational, flight-ready stellar gyroscope. It is currently being developed as part of a small satellite Attitude Control System (ACS), which further bolsters its utility and commercial value.

Progress

Significant progress has been made over the course of the last few months, both on the stellar gyro and overall ACS design. Owing to the complexity of the systems involved, initial efforts were directed towards refining the proposed concept, thus enabling the various technical and design requirements to be formalised.

Considerable time and effort have since gone into not only considering each individual subsystem, but also the overall functional architecture, including the interface between subsystems, power management strategies, and general flow of information between system nodes. The electrical and mechanical design of each subsystem was also considered, along with the various requirements for testing and verification.

The project is currently in the final stages of the design process, having encountered no major problems. Procurement is already under way, with manufacturing to begin shortly. NewSpace Systems reports that the project is fully on track to conclude within the agreed upon time frame.

PROJECT IN PROGRESS

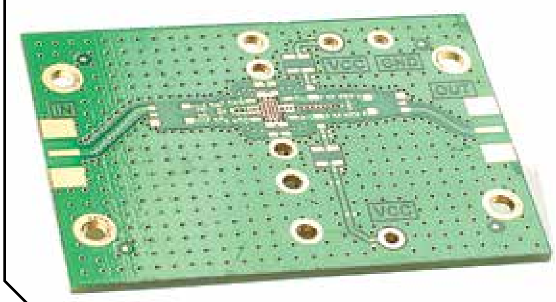
Adhesion Technology of Copper Surface for High Frequency Printed Circuit Boards

TraX Interconnect

During the past five years technology in the Printed Circuit Board (PCB) industry changed so much that many South African manufacturers were left behind and found that it was almost impossible to compete with offshore suppliers. The only option for the industry to survive in this competitive environment is to ramp up technology and concentrate on quality of service and a quick turnaround time.

Due to the rapid developments in high-frequency and high speed transmission electrical wire technology, the surface treatment technique on copper foil has become an important consideration. Copper foils have been extensively used as the conductive layers for high frequency printed circuit boards because of their excellent electrical and thermal conductivities.

TraX Interconnect embarked on a project to find a chemical treatment process that could be applied to copper traces that would promote adhesion of the solder mask but would not adversely affect the high-speed transmission signals passing through the copper traces.



High frequency PCB

Progress

The project has made excellent progress. TraX's primary goal for the initial period is selecting the appropriate process and then placing an order for the required equipment has been achieved. To do this, both the MEC BO-7710 (or CB-5679) and Atotech Novabond processes were evaluated through an academic selection process.

It became clear that the process of choice was the MEC BO-7710 process, which proved to be faster with easier control and effluent treatment. The higher cost of the equipment required to implement the MEC V-Bond process meant that TraX needed to co-invest in the project and was able to obtain finance to do so.

The next steps include training of plating shop operators and laboratory staff, as well as processing dummy boards made on different laminates. As different laminates and foils will process differently, these differences need to be learnt and evaluated, and will be included in the work instruction documents of the quality system.

Finally, after successful testing of the new process, it will be incorporated in the production process.

PROJECT IN PROGRESS

Local Canopy Production for Sailplanes

OnTrack Technologies

Light aircraft canopies can be constructed using the free blown method, the dry draping method and the wet draping method. Complex shaped canopies, like those used by Jonker Sailplanes in their sailplanes, have complex curvature in two axes, requiring the need to use the wet draping technique. Currently, all glider canopies using this method are manufactured in Switzerland and the Czech Republic. As Jonker Sailplanes is the only manufacturer of sailplanes outside of Europe, exporting 90% of its product to Europe, the company is highly dependent on a reliable and cost-effective supply chain. This presents a unique opportunity to develop and produce optically sound, complex shaped canopies locally, further enhancing the South African aviation sector's competitive edge in the global market.

In an effort to minimise cost and reduce long lead times from overseas suppliers, Jonker Sailplanes has requested local manufacturers to develop the technology to manufacture canopies in South Africa. To address this requirement, OnTrack Technologies plans to produce and supply complex shaped canopies to Jonker Sailplanes that meet the required quality standards. Once this has been achieved, the product line can be extended to produce canopies for other sailplane maintenance organisations worldwide.

OnTrack Technologies is an SMME located in Potchefstroom. Since 2005, the company has focused on aerospace design work in composites and on low speed aerodynamic work. OnTrack Technologies is the official SACAA-approved design organisation for products manufactured by Jonker Sailplanes.


Canopy end product as used on gliders

The project goals are to develop not only the technology for wet draping of Plexiglass® or Perspex® canopies, but also to design and set up equipment to manufacture these complex shaped aircraft canopies locally. Progress of the project is on schedule to complete the following activities without overdue deadlines:

- Research the requirements
- Select and test suitable barrier materials
- Develop manufacturing processes
- Design suitable equipment, including heating ovens and draping frames
- Manufacture high temperature resistant canopy moulds for Jonker Sailplanes
- Perform a pilot run of eight test canopies
- Recruit and train production personnel
- Start up local production.

PROGRAMME 3:

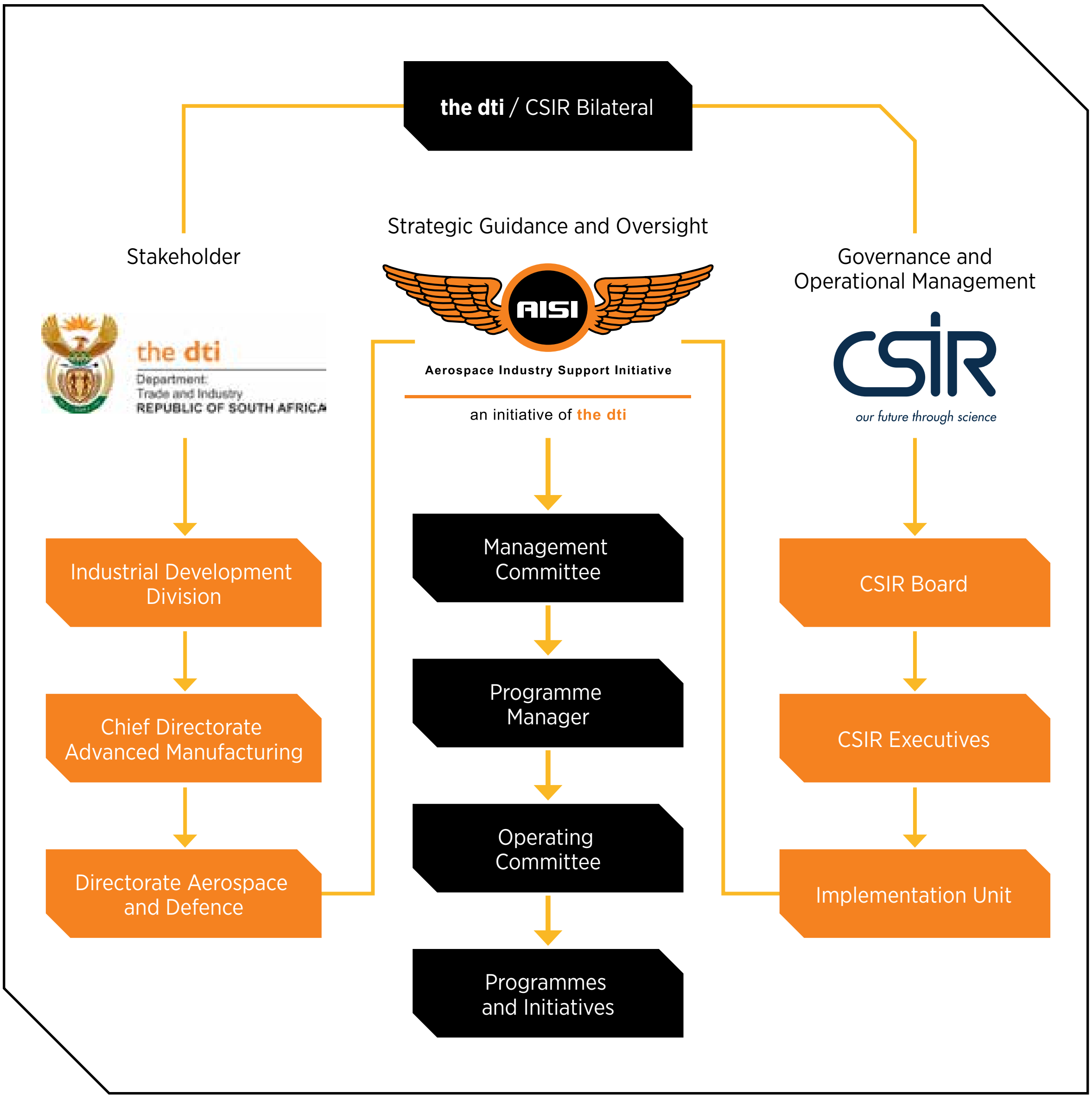
Sector Strategic Support Initiatives

Sector Strategic Support Initiatives create a platform for industry to facilitate interactions which under normal circumstances would not be possible, allowing industry, academia and government to engage with potential clients, partners and thought leaders. The Aerospace Industry Support Initiative (AISI) utilises existing outlets to enhance the presence of the South African aerospace and defence industry, which enables both local and international role players to gain an understanding of the value proposition and competence offered in the country.

The Joint Aerospace Steering Committee (JASC) was established to provide strategic guidance and positioning to the local aerospace and defence industry. The focus of this programme is firstly the hosting of the JASC and its secretariat, and secondly, the hosting and implementation of projects on behalf of JASC, and guided by the IPAP. These projects are technology advancement projects with the specific aim of addressing technology gaps in strategic areas, as identified by the JASC, its subcommittees, or defined in IPAP.

AISI Governance

The AISI is a government-funded industry support initiative of **the dti**, hosted at the CSIR, and fully complies with the Public Finance Management Act (PFMA) and the Preferential Procurement Policy Framework Act (PPPFA). The AISI operates within the procedural framework of the CSIR, and reports to the AISI Management Committee on a quarterly basis. It also provides reporting input to **the dti**.



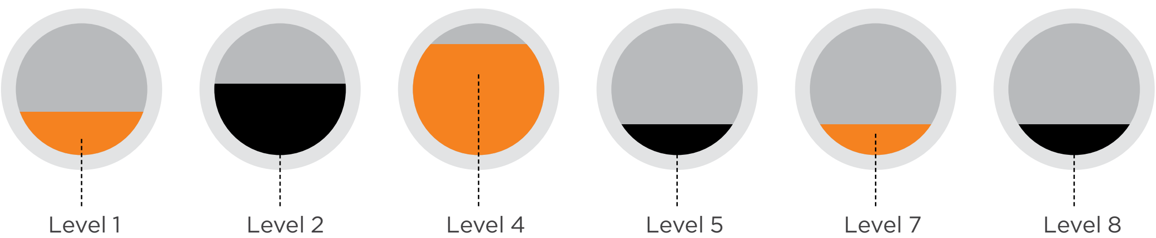
Summary of Organisations Benefiting from AISI Support

Organisation Name	Organisation Type	B-BBEE Level	Project Name
Main industry beneficiaries and contracted organisations			
Aerosud Aviation	OEM	4	• Residual Stress Distribution in Billets
Cape Aerospace Technologies	SMME	4	• Small Gas Turbine to Market
Cliff's Way Aerospace	SMME	2	• Supply Chain Optimisation
Compumach Engineering	SMME	4	• Standards and Accreditation • Supply Chain Optimisation
Cybicom Atlas Defence	SMME	5	• Commercialisation of the Fixed Wing Flight Trainer • Helicopter Flight Trainer Firefighting Upgrade
Daliff Precision Engineering	SMME	2	• Precision Engineering Towards Industry 4.0 • Standards and Accreditation • Supply Chain Optimisation • Implementation of Advanced Aerospace Machining Processes
Denel Aerostructures	OEM	4	• Feasibility of Natural Fibres in Aerospace Structures • Laser-Based Refurbishment of Invar Moulds • Implementing the Use of Infrared Thermographic Testing to Augment Non-destructive Testing on Composite Components • Laser Shock Processing for Straightening of Machined Aluminium Spars
Electro Thread	SMME	Non-compliant	• Supply Chain Optimisation
International Jet Support	SMME	1	• Supply Chain Optimisation
Jonker Sailplanes	SMME	7	• Aeroelastic Investigation of the JS-1 Sailplane • Aeroelastic Investigation of the JS-3 Sailplane
Micromax	SMME	8	• Supply Chain Optimisation
NewSpace Systems	SMME	4	• Fluid Inertial Actuator • Waveguide Manufacturing Using Additive Manufacturing • Stellar Gyro Flight Readiness Project
OnTrack Technologies	SMME	4	• Local Canopy Production for Sailplanes
SCS Space	SMME	4	• Hyperspectral Camera and Calibration Facility Upgrade

Organisation Name	Organisation Type	B-BBEE Level	Project Name
Ti-TaMED	SMME	4	• Standards and Accreditation
TraX Interconnect	SMME	2	• Adhesion Technology of Copper Surface for High Frequency Printed Circuit Boards
West Engineering	SMME	4	• Supply Chain Optimisation
Zolispan	SMME	1	• Standards and Accreditation

Organisation Name	Project Name
Benefiting industry partners	
Aerontec	• Feasibility of Natural Fibres in Aerospace Structures
Cape Peninsula University of Technology	• Hyperspectral Camera and Calibration Facility Upgrade
Central University of Technology	• Waveguide Manufacturing Using Additive Manufacturing
Cermalab	• Laser-based Refurbishment of Invar Moulds
Galvanotech	• Waveguide Manufacturing Using Additive Manufacturing
Metal Heart	• Waveguide Manufacturing Using Additive Manufacturing
Protea Engineering	• Commercialisation of the Fixed Wing Flight Trainer
Rugged Interconnect	• Commercialisation of the Fixed Wing Flight Trainer
Stellenbosch University	• Waveguide Manufacturing Using Additive Manufacturing
Svenmill	• Feasibility of Natural Fibres in Aerospace Structures
University of Pretoria	• Waveguide Manufacturing Using Additive Manufacturing

B-BBEE levels



Type of benefiting organisation

Abbreviations

AISI	Aerospace Industry Support Initiative
AIT	Assembly integration and testing
CAD	Computer aided design
CAD	Cybicom Atlas Defence
CAT	Cape Aerospace Technologies
CFD	Computational fluid dynamics
CFRTP	Continuous fibre-reinforced thermoplastic
CMM	Coordinate measuring machine
CNC	Computer numeric control
COTS	Commercial-off-the-shelf
CSIR	Council for Scientific and Industrial Research
DAe	Denel Aerostructures SOC Ltd
DTPS	Department of Telecommunications and Postal Services
ECD	Enterprise Creation for Development
FAR	Federal Aviation Regulations
FEA	Finite Element Analysis
FNTP	Flight navigation and procedures
FSTH	Fire, smoke, toxicity and heat
FWFT	Fixed wing flight trainer
GVT	Ground vibration tests

HFDT	Helicopter flight deck trainer
HFT	Helicopter flight trainer
ICAO	International Civil Aviation Organization
IG	Image generation
IPAP	Industrial Policy Action Plan
JASC	Joint Aerospace Steering Committee
JS	Jonker Sailplanes
MTOW	Maximum take-off weight
Necsa	The South African Nuclear Energy Corporation
NLC	National Laser Centre
OEM	Original equipment manufacturer
PCB	Printed circuit board
PFMA	Public Finance Management Act
PPPFA	Preferential Procurement Policy Framework Act
RF	Radio frequency
SACAA	South African Civil Aviation Authority
SARA	Small African Regional Aircraft
SMME	Small, medium and micro enterprises
SPC	Statistical process control
STL	Stereolithography
the dti	Department of Trade and Industry
TPM	Total productive maintenance
WIP	Work in progress

Aerospace Industry Support Initiative

an initiative of **the dti**

An initiative of the Department of Trade and Industry, managed and hosted by the CSIR

the dti
Department:
Trade and Industry
REPUBLIC OF SOUTH AFRICA

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