Laser Technology – Make or Break?

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Mining Equipment Manufacturers of South Africa
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science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

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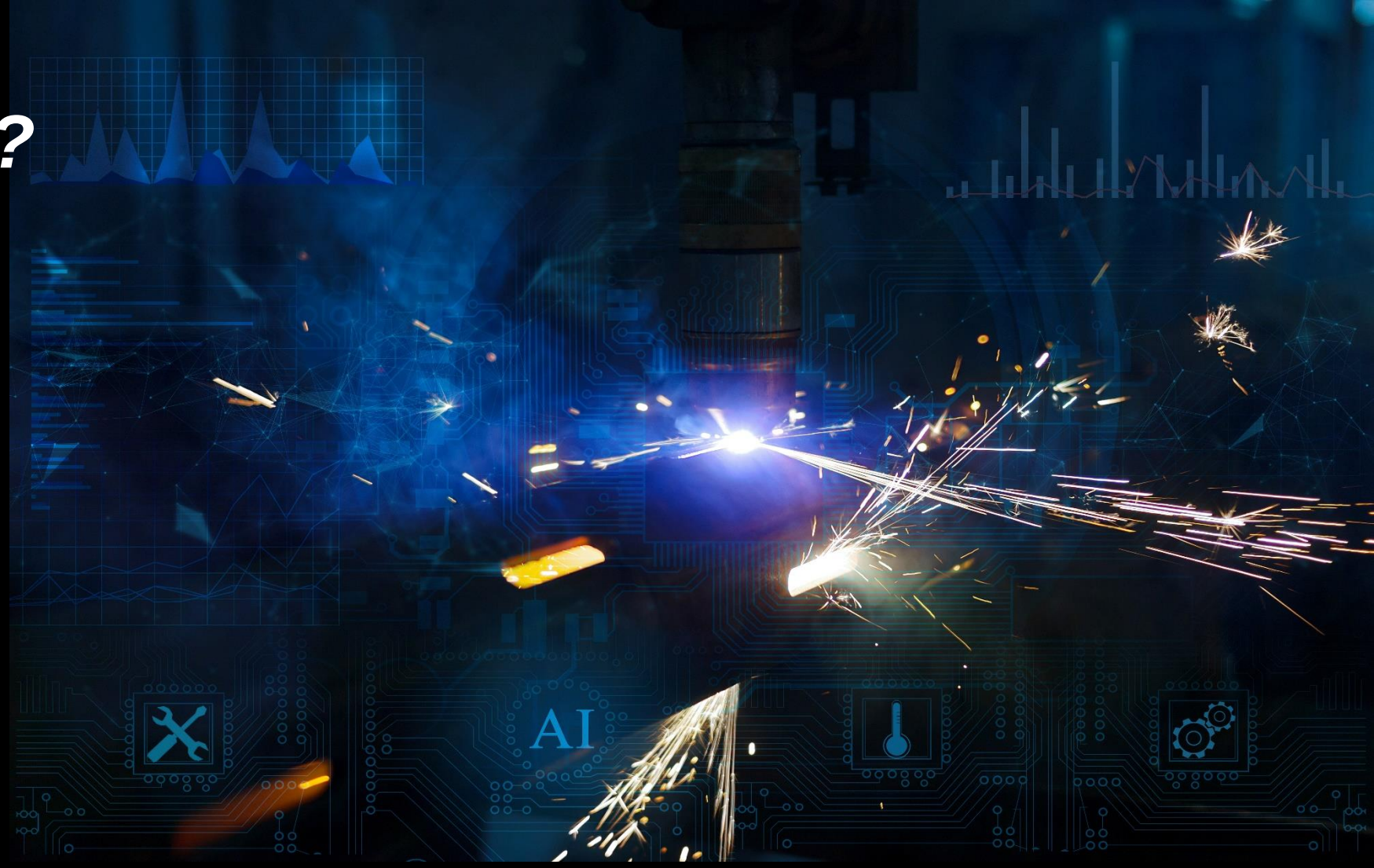
Why the CSIR?



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Why work with the CSIR? Fast Facts:

- Celebrating **80 years of existence** in 2025;
- Established, established by an Act* of Parliament in 1949, to drive **directed, multidisciplinary research and technological innovation** to support **industrial and scientific development** together with **private and public** sectors for **economic and societal advancement**.
- **Largest of the nine SA science councils** and the only to perform **multi-disciplinary R&D and innovation**;
- Launched ‘CSIR C-Cubed’ in 2023 with the aim to **commercialise offerings and transfer technology** to industry;
- Capabilities include high-tech, world-class **facilities and infrastructure.**
- Emphasis on **skills development** and support to **entrepreneurs and SMME’s**.

Scientific Research Council Act in 1949, 1988 (Act 46 of 1988, amended by Act 27 of 2014)

Sector-facing clusters:

- *Advanced Agriculture and Food*
- *Chemicals*
- *NextGen Health*
- *Manufacturing*
- *Mining*
- *Defence and Security*
- *Smart Places*
- *Smart Mobility*
- *NextGen Enterprises and Institutions*

1 555 Total SET base

311 SET base with PhDs

471 SET base with Master’s

Bases:
Pretoria (Main Campus); Johannesburg; Durban; Cape Town; Stellenbosch

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OUR STRATEGIC CLUSTERS

Positioned to drive South Africa's industrialisation

INDUSTRY ADVANCEMENT CLUSTERS

Advanced Agriculture and Food

Improve production through precision agriculture; add value and reduce waste through advanced (agro) processing

Future Production: Chemicals

Strengthen local pharmaceutical, chemical and other industries through advanced product, process and materials development

NextGen Health

Strengthen South Africa's health security by locally developing vaccines, biologics and precision-medicine based treatments

Future Production: Manufacturing

Enhance manufacturing industry competitiveness through digital transformation and 4IR technologies

Future Production: Mining

Support the growth and revitalisation of the mining industry

Defence and Security

Build resilient defence and security capabilities in support of national security imperatives

INDUSTRY AND SOCIETY-ENABLING CLUSTERS

Smart Places

Enable smarter natural resource use, environmental sustainability and smart infrastructure

Smart Mobility

Enable South Africa to have an efficient, effective, integrated, safe and competitive Transport and Logistics sector

NextGen Enterprises and Institutions

Enable digital transformation in government, public institutions and industry

DIVISIONS

- Advanced Chemistry and Life Sciences
- Advanced Production and Security
- Smart Society

About the CSIR's Manufacturing Cluster

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Manufacturing cluster goals and objectives

The CSIR's Manufacturing Cluster was re-constituted in 2019 to align with the needs of local production sectors.

Main objective is to drive digital transformation and fourth industrial revolution (4IR) technologies to contribute to re-industrialisation of South African industries;

How?

The development of manufacturing **processes and equipment**;
The implementation of end-to-end **digital engineering and transformation;**
The provision of **industrial services** and access to unique, capital-intensive equipment and facilities;
New **product development and localisation**, ranging from prototyping to certification.

Taking our cue from national plans – and industry itself

- Aligned to policies such as South African Economic Reconstruction and Recovery Plan (ERRP), DSI Decadal Plan – and in particular:
  - **New sources of growth**: creating and leveraging opportunities from 4IR, green/circular economy and digital transformation;
  - **Building of a capable state**: improvement of service delivery in public healthcare sector, enhancing skills development and training at HEIs; improved operational efficiencies and sustainability of the various SOCs, specifically Eskom, Transnet and the State Diamond Trader;
  - Support to the **health and energy sectors**: localisation of point-of-care medical devices, effective patient data management, skills development across the hydrogen and battery energy storage value chains; localisation of component product manufacturing in energy sector;
  - Supporting **economic inclusion of SMMEs**: improving operational efficiencies, increasing competitiveness through using advanced technologies, commercialisation of CSIR IP, incubation of SMMEs (technology transfer and market development); aiding access to high-end equipment and infrastructure.
- Also aligned to objectives of **the dtic**'s masterplans for selected sectors: metals and machinery, renewable energy, mining, automotive, aerospace and defence, medical devices, and rail.
- **Industry Advisory Panel** was appointed to assist Cluster with input into strategy.

Impact Areas and Centres in the cluster

Centre for Robotics and Future Production

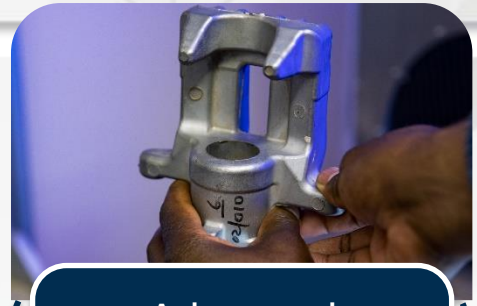
Driving digital transformation and 4IR disruptive technologies – automation, digitalisation, robotics, augmented and virtual reality, etc. Collaboration with academia and private sector; emphasis on skills development.

CSIR Photonics Centre

Laser and photonics tools and processes for mining, manufacturing, health, defence, power generation. Solutions in additive manufacturing (surface engineering, parts refurbishment, cutting, welding, etc), bio-photonic tools. Skills development programmes.

Industrial Sensors

Significant sensor technology and custom product development capability; industrial monitoring and inspection systems utilising electro-optics and ultrasonics.



Advanced Materials Engineering

Structural design and analysis, forensic testing, development of advanced casting and powder metallurgy technologies; skills development establishing foundry technologies.

Industry Connect

Hosted programme; Access to infrastructure and expertise to support competitiveness of small, new technology businesses, perform technology localisation, supplier development; Manages Aerospace Industry Support Initiative (AISI) for **the dtic.**

The CSIR business model

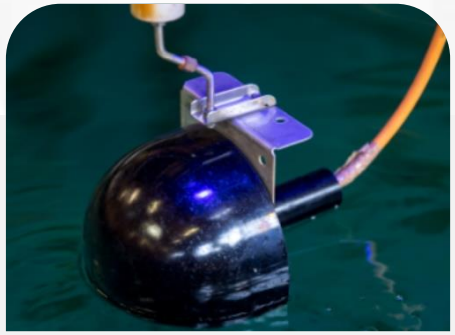
Conducting Contract RDI to meet client and stakeholder objectives

Technology development

e.g. Additive manufacturing technologies, processes for turbine blade repair, technology to increase lifespan/performance of plant/infrastructure.

Product development

e.g. Rapid development of ventilators during the Covid-19 pandemic, Gemlase, Point of care diagnostic products.



Custom solution development

e.g. Broadband Underwater Data Communication (BUDC) system.

Evidence-based decision support

e.g. Digital Twin project for automated vehicles at mining operations.

Hosted programmes

e.g. Aerospace Industry Support Initiative for **the dtic,** the CSIR Laser Rental Pool Program, African Laser Centre, Collaborative Programme in Additive Manufacturing.

The CSIR business model

Conducting Contract RDI to meet client and stakeholder objectives

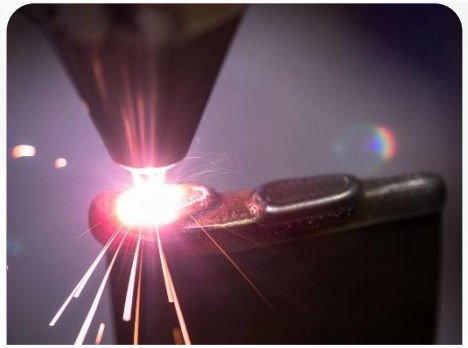
Technology licensing

e.g.

Multispectral camera technology.

Specialised training

e.g. Learning Factory for upskilling and re-skilling for the fourth industrial revolution with merSETA.



Highly specialized services

e.g. Laser repair of steam turbine parts for Eskom.

National Facilities for Test & Evaluation

e.g. photonics prototyping centre, non-destructive testing of metals.

Industry development and incubation

e.g. metal printing, smart factory concept, industry centres such as Foundry technology.

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Priority industries we are supporting

Health (Medical Devices)	Innovation, R&D, regulatory & technical support as well as incubation support to SMMEs; Continue lead role within Technology Innovation/SAMRC MeDDIC Programme to support SMMEs entering the MedTech sector.
Aerospace and defence	Opportunities for localisation; Experience gained by hosting Aerospace Industry Support Initiative (AISI) and strong footing in defence/security sector; Initial focus on surveillance and sensor systems, information systems and maintenance, repair and overhaul or customisation.
Automotive	Largest manufacturing sector, large employer, large export earnings; Opportunities for localisation, skills development, innovation; Priority areas: new energy vehicle sector, micro-mobility, support to heavy vehicle industry;
Metals, Machinery & Mining Equipment	Opportunities in new powder metallurgy, foundry technology and circularity; Strong capabilities in laser metals and metal additive manufacturing machines, as well as laser cladding, peening and welding. Modernisation of mining using 4IR technologies; supporting industry with re-skilling, digitalisation, smart manufacturing.

Laser Technology

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First understand the world of photonics

- Photonics = the physical study of light waves – i.e. the science behind the generation, detection and manipulation of light.
- Over decades, waves of R&D have placed lasers into our everyday world: Laser surgery, scanning, laser engraving or manufacturing;
- Then the photon found its way in telecommunication – right into our smartphones;
- Integrated with modern technologies, sophisticated intelligent systems are measuring and detecting the world around us enhanced with 4IR technologies such as artificial intelligence.

Subdermal fingerprint detection

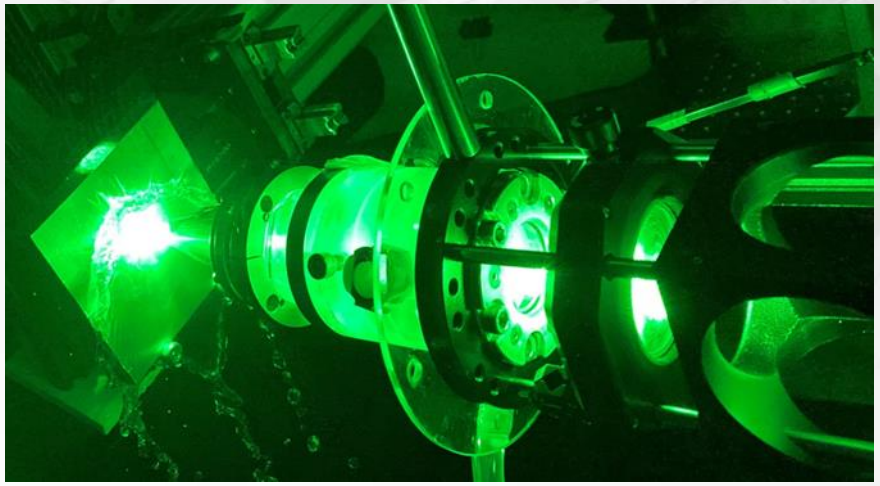
Smartphone app as detects pathogens in body fluids samples – outside sophisticated labs.

CSIR Photonics Centre – making LIGHT of industry challenges.

- The CSIR Photonics Centre focuses on developing technology-based solutions in the field of laser-based technologies. This includes applications in laser-based surface engineering, additive manufacturing and processing technologies. These technologies, expert and world-class facilities are made available to support innovators, technologies industry partners and researchers across Africa.
- The Centre is the managing node of the Africa Laser Centre – a global research network to develop skills in photonics.
- Facilities are available to academia, researchers and entrepreneurs such as the Photonics Prototyping Facility and the rental pool programme.
- Over decades, new welding techniques, process parameters, equipment, and skills were developed to support SA's heavy industry, high value components industry sector.
- This has been done through investments by the Department of Science and Innovation, the CSIR itself and working in partnership with international peers and local industry.
- In this way, we support the development of both the local knowledge economy through skills and capability sharpening, but also the all important impetus behind the circular economy towards more sustainable manufacturing practices and use of resources.

Lasers that break – to build…

- Laser shock peening is a process that induces compressive residual stresses on and beneath the surface of metal components through high-magnitude shock waves causing ‘plasma explosions’ to enhance the surface strength and reduce surface degradation.
- Laser shock peening is applied over a variety of engineering sectors where surface degradation is a major concern. This laser process is applicable for the energy and aerospace industries.
- In addition to prolonging the lifetime of new components, these processes are also extensively used to refurbish worn components, especially components that cannot tolerate high localized heat sources. Such components include turbines, compressors, impellers, generators, pumps, valves and other advanced equipment. It is often more economical to repair such components than to lose production while replacement parts are sourced from abroad.
- The CSIR has been repairing these expensive high wear components high for over a decade by using advanced laser cladding and hardening technologies and processes.



Laser shock peening is applied over a variety of engineering sectors where surface degradation is a major concern. This laser process is applicable for the energy and aerospace industries.

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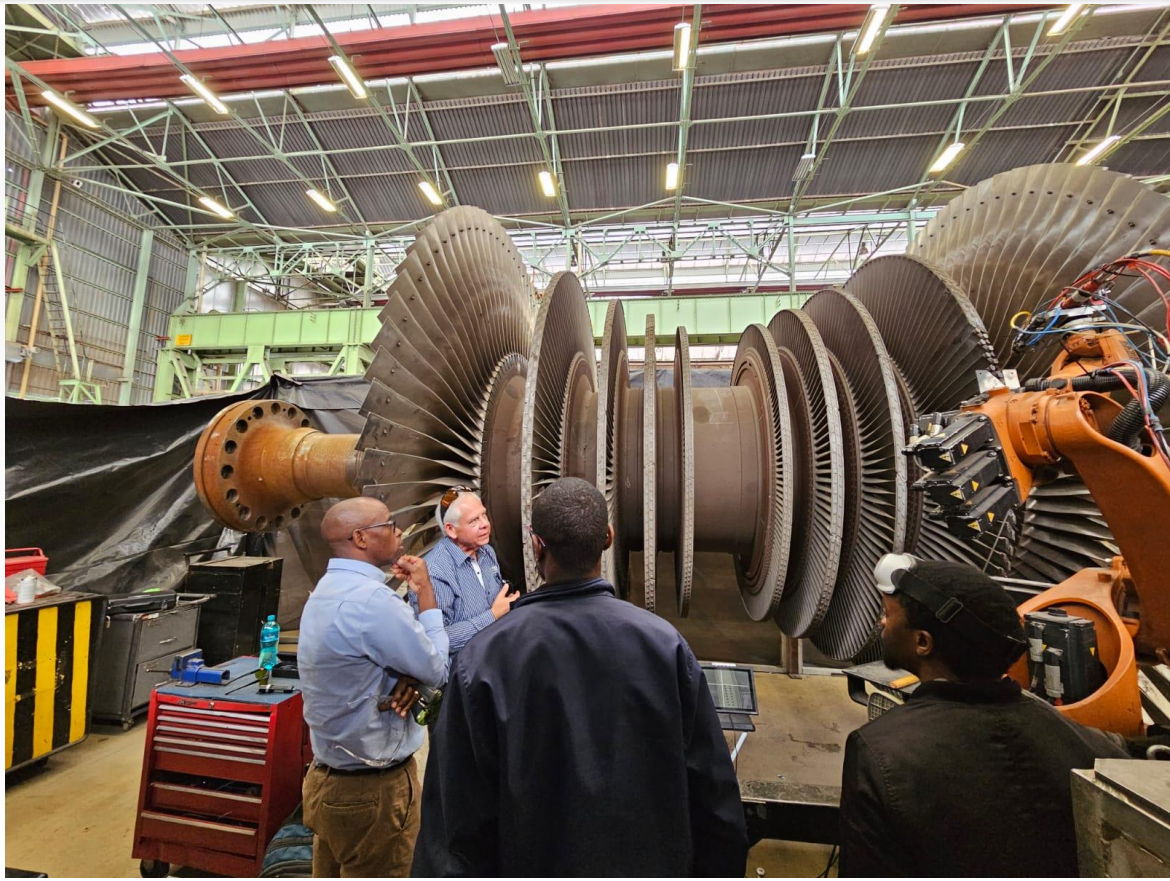
Lasers that build by adding

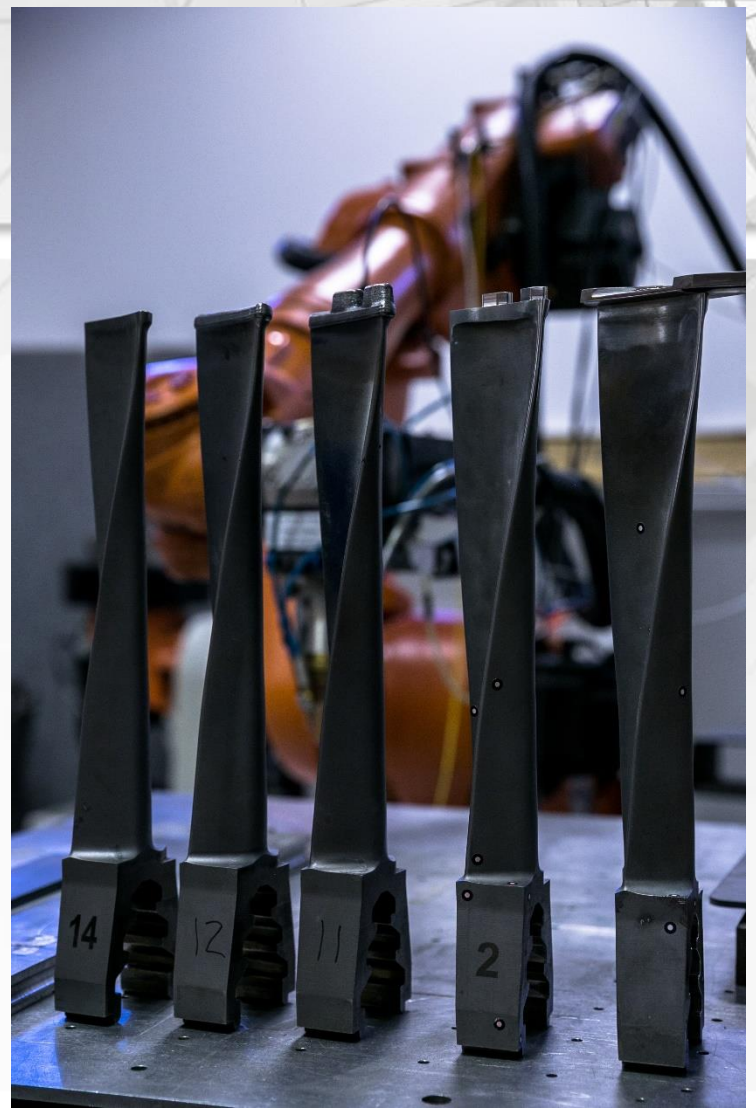
- Laser cladding supports the repair of worn, damaged or faulty components.
- The technology works by adding material to the surface of components, fused by a laser beam, creating a bonded additional layer to it to repair or rebuild to its original state.
- The laser cladding process is applicable for the repair of moulds, shafts, turbine blades and press tools in sectors such as mining, power generations, chemical processing aviation and pulp and paper production.
- Creating a harder and more wear-resistant layer than the base material, the mining and heavy parts industries have become serial users of laser cladding and hardening.



Both laser cladding and welding processing use robotics to deliver light and deposition material to working surfaces;
A mobile unit can perform the work at client site.

Case study: lasers against loadshedding

- Steam turbines are the key contributor to national energy generation. Inside, stages of blades of up to 1.5 m drive the rotary movement of the central shaft.
- Turbines operate for thousands of hours at a time and are tested for any degradation after such a runtime.
- The blade design and construction – the shape, strength, placement and accurate size or length – are critical to the effectiveness of the turbine and prevent vibration during operation that could lead to catastrophic failure. Previously, whole sets of blades were scrapped due to a faulty blade. Laser technology developed by the CSIR has made it possible to repair and refurbish blades at a considerably lower cost and far shorter downtime.
- The blade tenon refurbishment technology was developed as part of a CSIR-Eskom bilateral-funded programme.
- Reduction in downtime, risks associated with removal and replacing blades, the impact of faster turnaround times on reduced loadshedding - all deliver massive impact. As an example, direct savings is in the order of R20m per row of blades, and downtime is 7 days compared to 3 to 6 months.



For over a decade, CSIR has supported Eskom with repair and refurbishment of critical infrastructure components; Help to ‘keep the lights on’ while new facilities are commissioned.

Lasers that build layer, after layer, after layer

- The world has realized the benefits of additive manufacturing in reducing cost, enhancing performance, providing opportunities for innovative design and extend the lifespan of equipment in the industrial market.
- **Many critical parts that fail in the mining industry cannot be repaired. To avoid this, companies need to keep large inventories of very expensive parts to reduce downtime. In many cases where inventory was not kept, plants and production lines can be shut done for weeks while replacement parts are sourced from OEMS, costing mining companies millions of dollars a day in lost revenue.**
- Different sized printers, different and novel materials are used – ranging from aluminium to titanium and precious metals and stainless steel;
- The CSIR has large metal 3D printers (up to 600 x 600 x 700mm^3) to print critical, large metal parts in a fraction of the time it would normally take to ship them from OEMs. This can drastically reduce inventory cost and downtime - especially at remote operations.
- Opportunities abound in areas such as aerospace, automotive, mining, power generation, tooling and medical uses such as prosthetics.

Objects are created from 3D data, layer upon layer – thus adding not subtracting and wasting raw materials as in conventional parts manufacture.

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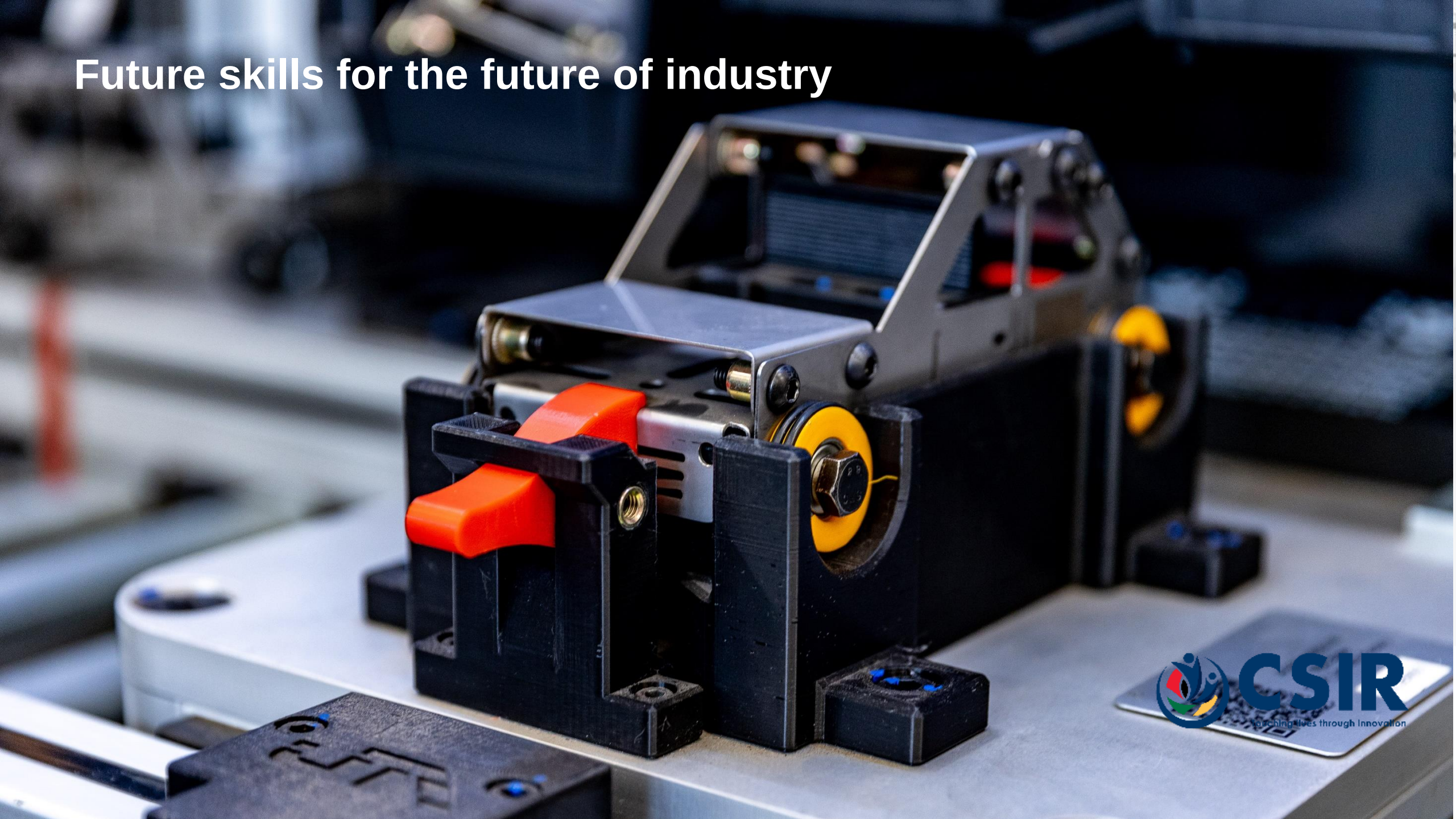
Future skills for the future of industry



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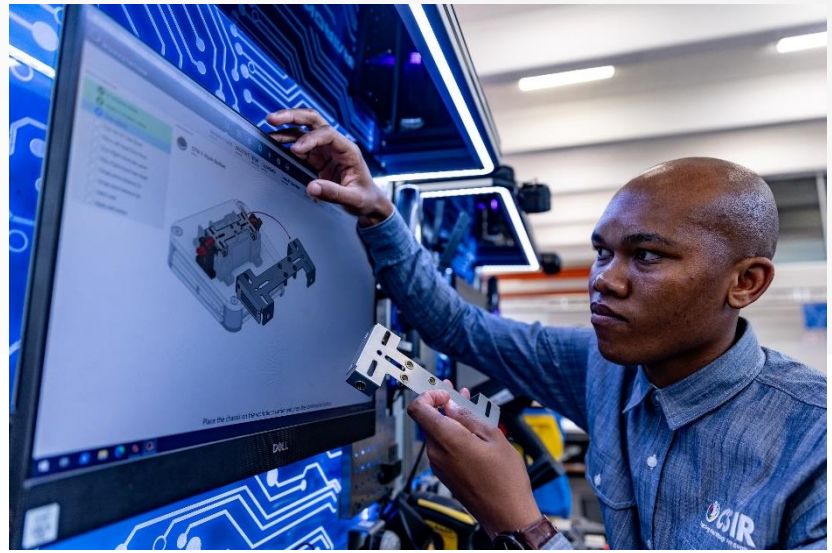
Future skills are essential; Visit the Learning Factory

- Upskilling and reskilling identified as a need in future industrial competitiveness and to sustain employment levels;
- Learning Factory provides a hands-on environment to develop industry-relevant skills – and particularly in 4IR technologies.
- Combining theoretical learning and real-world application and demonstration;
- Modular and customisable per sector – e.g. mining, automotive, aerospace;
- Also used by CSIR for innovation applied to the operation, research, design and deployment of 4IR technologies



Purpose of the Learning Factory

- ***Demonstrator of 4IR Technologies***
  - Industry touch points
  - Research contributions
  - Opportunities / Entrepreneurs
- ***Build and Leverage Human Capital***
  - Training on 4IR technologies
  - Use of 4IR technologies to train such as human/computer interfacing and VR
  - Applied to introductory training, upskilling and reskilling
- ***Support Research and Innovation across CSIR and Industry***
  - 4IR benchmarking, assessments and roadmapping
  - Product development for 4IR training applications
  - De-risking 4IR technologies
  - Industry consulting

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Areas of Collaboration

New Higher Education Institution:

1. Deployment and Support of Learning Factories to bridge the gap between academia and industry
2. Provide industry insights, trends and needs from 4IR audits to help inform curriculum design and content
3. Provide students with practical training
4. Collaborate where research interests align
5. Provide co-supervisors for students undertaking research work

New Higher Education Institution for Crime and Policing Studies:

1. Design digital content for the Crime and Policing curriculum where possible
2. Understand the new technologies being deployed and creating training content and environments for these
3. Aline with the institution in terms of research and development of new technologies to aid in crime prevention
4. Possible Future Work: Aid in designing VR and AR technologies and applications for training scenarios and tactical training

Thank you!

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