Conference presentation **- *Mind Shift: Innovation, Digitisation & Skills in the South African Mining Supply Chain.***

MindSHARE

People, processes and technology: science and sector partnerships for the digital economy

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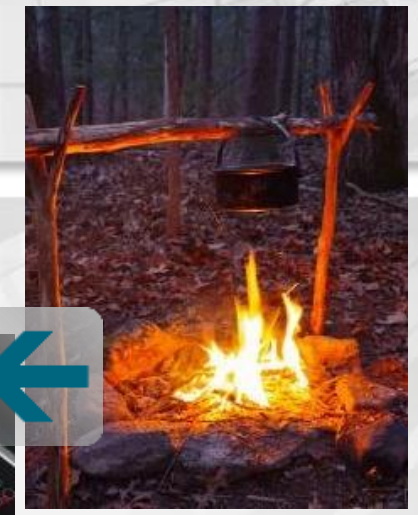

Trends in our digital world

- **High-paced lifestyles,**
- **Local and Global access and**
- **Social status and Connections bringing about…**

- Greater technology accessibility
- Emphasis on convenience
- Greater customisation
- Faster delivery of products
- More personalised technology

Top technologies of the digital economy

- Internet of things
- Automation
- Deep learning
- Virtual reality
- Artificial intelligence
- Cloud computing
- Unmanned aerial vehicles
- Augmented reality
- Robotics
- Digital twins

Virtual Reality recreates underground environment for more experiential mine safety training

Digital twinning simulates autonomous vehicle operations at the mine site to avoid collisions.

The Buzz in Business: Continuously improve people, processes, technologies.

- Technology develops exponentially – and business linearly, creating a gap;
- More insight into systems, interlinkages, the value chain;
- Modular designed systems and higher integration; plus more flexible and agile systems
- Smart systems - high levels of automation and self-optimisation;
- Customisation on a mass scale;
- Client specifications rule;
- Skills shortages – artisans and engineers; Not everything can be automated. Skills needs in mining sector highlighted by recent Fraser International survey of mining countries and reported in the media.
- Other contextual challenges: environmental impact, alternative energy sources, new materials; Lessons from the pandemic regarding virtual working (and increased need for cybersecurity), local availability of parts and materials, to name just a few.

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How digital transformation and the 4IR can re-industrialise the SA manufacturing sector.

The development of appropriate manufacturing processes and equipment;

- Includes product lifecycle management systems, simulation test beds, Downstream materials beneficiation for powder metallurgy, laser-based welding, resurfacing, additive manufacturing in Ti, Al and steel alloys; Ongoing and rapid development of new materials, new processes and new equipment.

The implementation of end-to-end digital engineering and transformation;

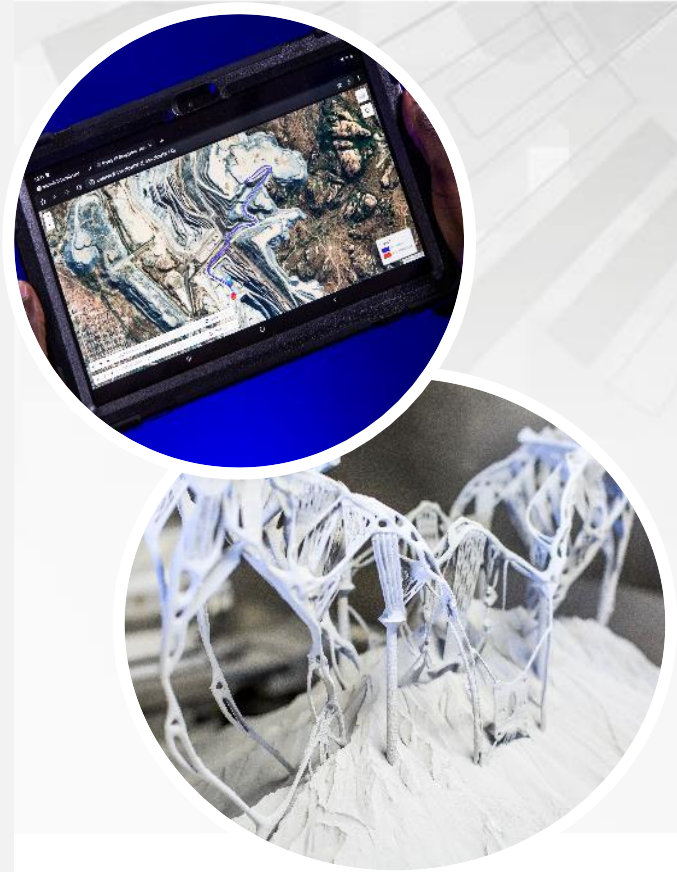
- Automation, system optimisation, supply chain integration, data analytics and dashboarding;

Providing access by industry to industrial services – 'virtually inhouse' and not everything self-owned:

- e.g. training and skills development in technology and processes, contract R&D and access to technology and facilities, mechanical testing and characterisation; services to Original Design Manufacturers.

New product development and localisation;

- Significant dependency on importation - for example, medical devices and implants, industrial monitoring and measuring systems, prototyping, alloy and composite parts localisation; support SMMEs, support accreditation/certification, access to structures such as Technology Innovation Agency;



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Digital Transformation: Key levers of change

PEOPLE

Strategy and Leadership
Skills
Culture and Communication
Team Structure
Partners

TECHNOLOGY

Infrastructure
Equipment
Laboratories & Facilities
Digi-workbenches

PROCESSES

Optimising Processes
Distributed, Scaleable.
Results, Data

"Digital transformation marks a radical rethinking of how an organization uses technology, people and processes to fundamentally change business performance."…..

George Westerman, MIT principal research scientist

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Example: Digital manufacturing case study from the pandemic

- Shortage of ventilators during pandemic due to halting of importation.
- CSIR produced wholly-locally developed ventilators through National Ventilator Project using a digital product lifecycle management (PLM) approach. (7 months from start to finish/ 18 000units)
- Design, testing, manufacturing processes, that normally run sequentially, ran in parallel.
- All planning, mapping, simulation and testing done digitally before developing physical product.
- PLM software allowed for scalable manufacturing depending on numbers of products required;
- Software covered systems engineering processes, computer-aided design, manufacturing execution tools, plus quality management solutions;
- A ‘virtual factory’ of collaboration without co-location: skills accessed immediately, regardless of location – incl academia, component manufacturers across SA;
- Digital documentation saved compliance and licensing under SA Health Products Regulatory Authority and World Health Organisation guidelines;
- Cost savings: no need to establish a plant first; production optimisation done virtually, easily replicated.
- Practical, on the job training due to workflows, standards and guided execution procedures
- Over 1 000 teleconferences during 60 to 80-hour work weeks emphasised the benefit and enabling nature of digital transformation.

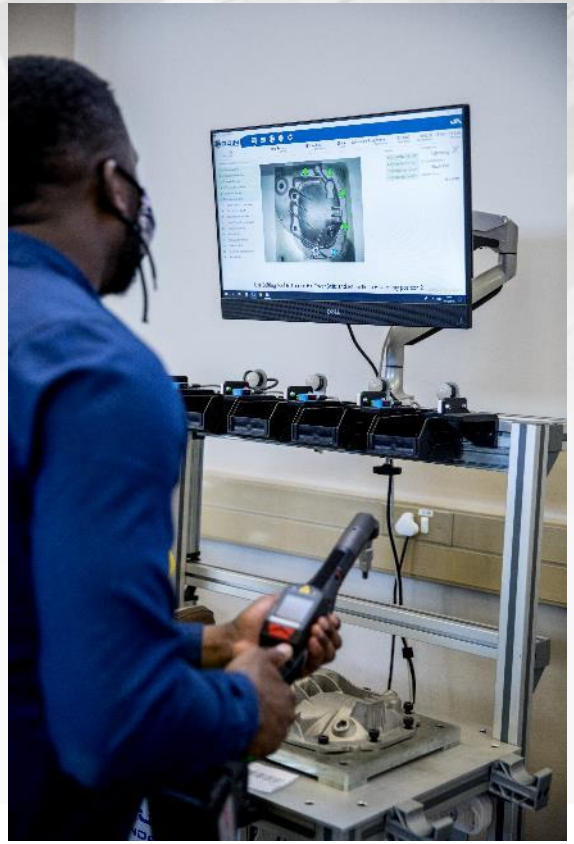
The digital approach is inclusive, allowing multiple design, production, quality software solutions to feed into one true digital backbone.

The ventilator technology will be commercialised with industry partner.

People

Does South Africa have the right skills?

- Rate of technological updates often surpasses the skills development; SA facing low literacy levels and high levels of unemployment;
- Not only skilling, but also re-skilling and upskilling required.
- Limited access to technology (especially SMMEs); Use digital technology to build skills in digital technology?
- Need for skills in digital domains highlighted by government policy and interventions – e.g. Critical Skills audit, National Development Plan, incentivisation of IP generation/research, White Paper for Post-School Education and Training and ‘Decade of the Artisan’ campaign launched by the Department of Higher Education and Training in 2014.
- Also emphasised in White Paper on Science, Technology and Innovation by the Department of Science and Innovation who relies on CSIR as one of its agencies to support innovation and industrial development.



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Skills development in your sector: The Learning Factory

- The pilot site of Learning Factory (LF) was established in 2021 on the CSIR campus.
- Partnership between CSIR and the Sector Education and Training Authority for Manufacturing, Engineering and Related Services (merSETA);
- Skills development and transfer for 4IR within the Manufacturing, Engineering and Related Services Sector;
- Serve as a reference for the establishment and support of LFs at TVETs, with respect to blueprints for technologies, skills and best practices for 4IR;
- Serve as a platform for innovation with respect to applied research enabled by 4IR technologies (de-risking technologies; product development; Techno-economic analyses and product localisation);

Training domains:

Artificial Intelligence, Augmented Reality, Robotics, Additive Manufacturing, the Internet of Things, Big Data Analytics, Cloud Computing and Edge Processing, System Integration, Digital Twinning, Simulation, Cyber-Security.

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Practical interaction with 4IR technologies (modular)

Practical application of 4IR technologies (industry focused)

Industry projects in LF Network (Industry bodies, SMMEs, Universities, TVET Colleges, etc)

Introduction to 4IR in SA

Typical LF Impact Domains

LF Educational Pillars

- Theoretical Training
- Practical Training
- Application Areas
- Experiential Learning

Continuous Improvement

- Productivity
- Revenue
- Skills Dev
- Safety
- Environmental considerations
- Ergonomics
- Optimisation

4IR Tech

- Additive Man
- Cyber-Security
- IoT
- Sys Int
- Robotics
- Simulation
- Big Data
- Edge Processing
- AR
- Blockchain
- AI

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Access to technology

Example: Additive manufacturing to improve component localisation in industry

- Swift global uptake of 3D printing technology for rapid prototyping and component development, on-demand spares production;
- Constant innovation in materials and printing/production equipment the world over. Static, articulated components of various sizes.
- Less material is wasted in the production process; (Layers are added – not material chipped away)
- 3D manufacturing has a lower carbon and logistics footprint than traditional technologies.
- Localisation and adoption of 3D printing will benefit SA's re-industrialisation – e.g. component development in mining equipment, automotive, aerospace, healthcare, rail sectors.
- Significant effort is still required for 3D printing to be adopted by SA industry to harness competitive edge.

Priorities:

- developing processes for efficient, on-demand batch production of multiple complex, customised parts;
- techno-economic analyses for parts reduction, light weighting, new materials, etc. plus evaluating technologies and machines suited to specific needs;
- Design, print and post processing to grow the final part 3D printing industry in SA; and
- developing and commercialising novel 3D printing machines, (novel metals, polymers), building on the materials, lasers, automation, mechatronic and sensor capabilities in CSIR and partners across the country;

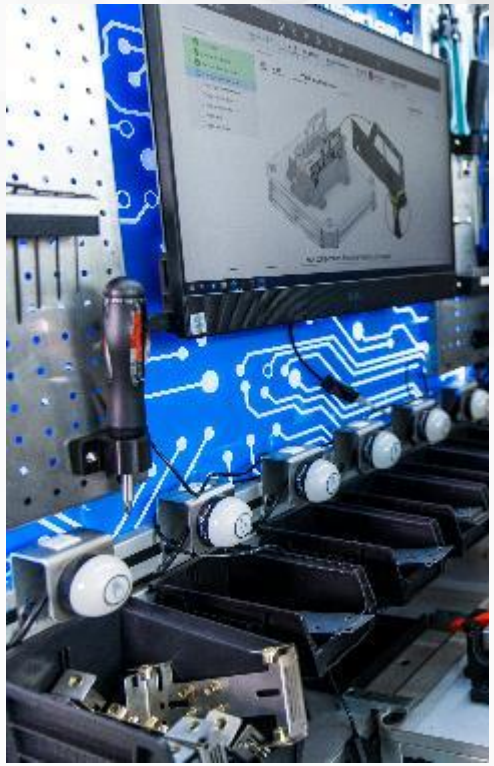
Local company Additiv developed a first SA metal printer. Technology was refined at the Photonics Prototyping Facility, a capability funded by the DSI, located at the CSIR.

Manufacturing services and access to infrastructure

- Support to industry via the Aerospace Industry Support Initiative of the dtic (hosted program that provides -
  - Localisation,
  - qualification of parts manufactured through additive manufacturing,
  - support with standards, accreditation or certification, and
  - access to testing facilities and expertise.
- DSI Industry Innovation Partnership Fund through Photonics Prototyping Facility
- Support to South African medical device entrepreneurs and SMMEs under Technology Innovation Agency funded Medical Devices and Diagnostics Innovation Cluster programme;
- Rental pool program; African Laser (virtual global research network with access to research facilities).
- Production support using Advanced Manufacturing; Laser welding, resurfacing, parts repair and refurbishment at client site; 3D laser cutting of railway carriage components for VSL Engineering; Laser hardening of components.
- Testing, Forensic & Failure Characterisation (ISO accredited).
- Advanced materials and manufacturing RD&I at CSIR to ensure local production of feedstock powders for 3D printing, metal injection moulding, and press and sintering; Establishment of local metal powder atomisation facility.

Manufacturing services and access to infrastructure

- Replica of production line created in partnership with local company Jendamark, for training in human-centered automation.
- Operators assemble complex parts, using industry-standard equipment. Learns to use equipment in correct order.
- Achieves an introductory level of competency in a quick step-through process – and avoids replacing humans with robots.
- Workers gain experience of a production line such as in the automotive industry.
- Can be integrated into the bigger Manufacturing Execution System (MES), which manages, monitors, and synchronises the execution of real-time, physical processes involved in transforming raw materials into intermediate or finished goods;
- Extension of a virtual reality (VR) training desk where operators are exposed to the full production environment in a virtual reality setting that mimics every detail of the physical system.

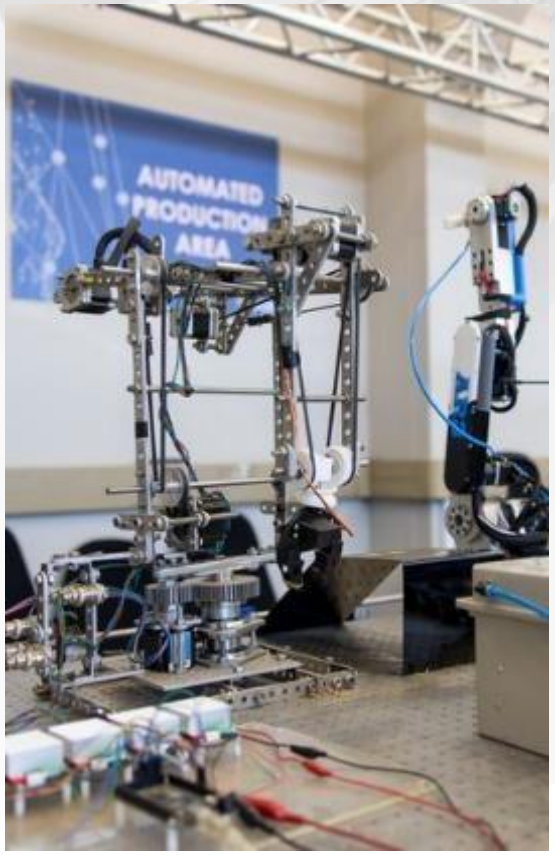


4IR Production Cells
(Jendamark Training Cell)


systems
Processes

Future plans: affordable Manufacturing Execution System (MES)

- A MES is used to monitor, track and schedule various processes, operators and machines required to manufacture products;
- These systems are typically complex and expensive;
- A low-cost MES solution - targeted at small, medium and micro enterprises - developed and used at CSIR's Centre for Robotics and Future Production.
- Currently has the following capabilities:
  - Addition of new products or manufacture, new machinery and operators (as well as editing of existing machinery);
  - Selection of products for manufacture and notification of operators for jobs assigned to them.
  - Various monitoring functions such as power monitoring of machinery using smart plugs/power meters, monitoring of robotic arms, monitoring of quality control;
  - Automated quality assessment systems can also be integrated;
  - Product tracking, operator tracking, and machine tracking with integrated analytics to provide trends and behaviours.
- Partnered with MESA Africa to align it to international standards and guidelines - but tailored to local environment and requirements;
- Intention is to develop into commercial product.



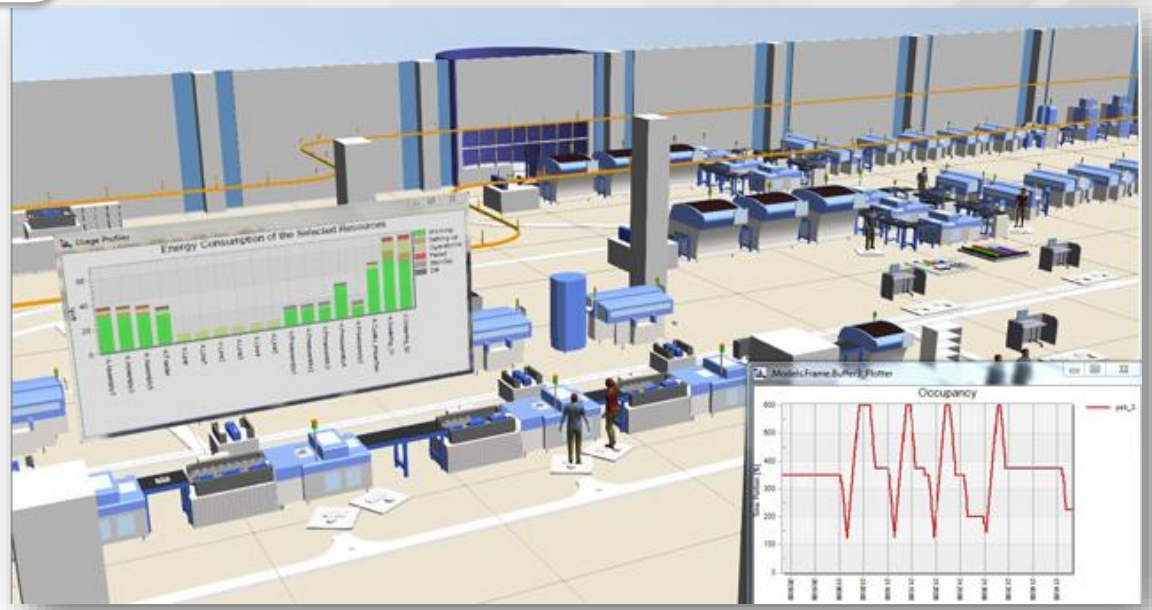
Future Production System: Digital Twin Ecosystem

How do we model and optimize the Interactions?

Production

Real World Factory

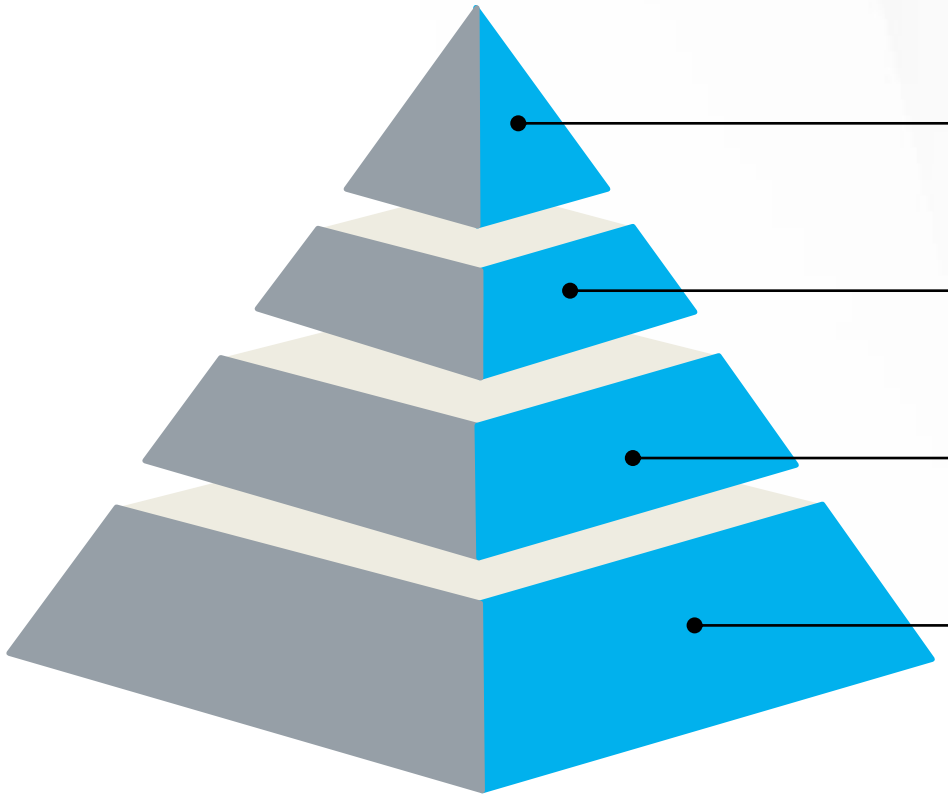
“Digital Twin” Factory



A system is never the **sum** of its **parts** (behavior); it's the **product** of their **interaction**.

Russell Ackoff

Future Production System: “Iceberg Model”

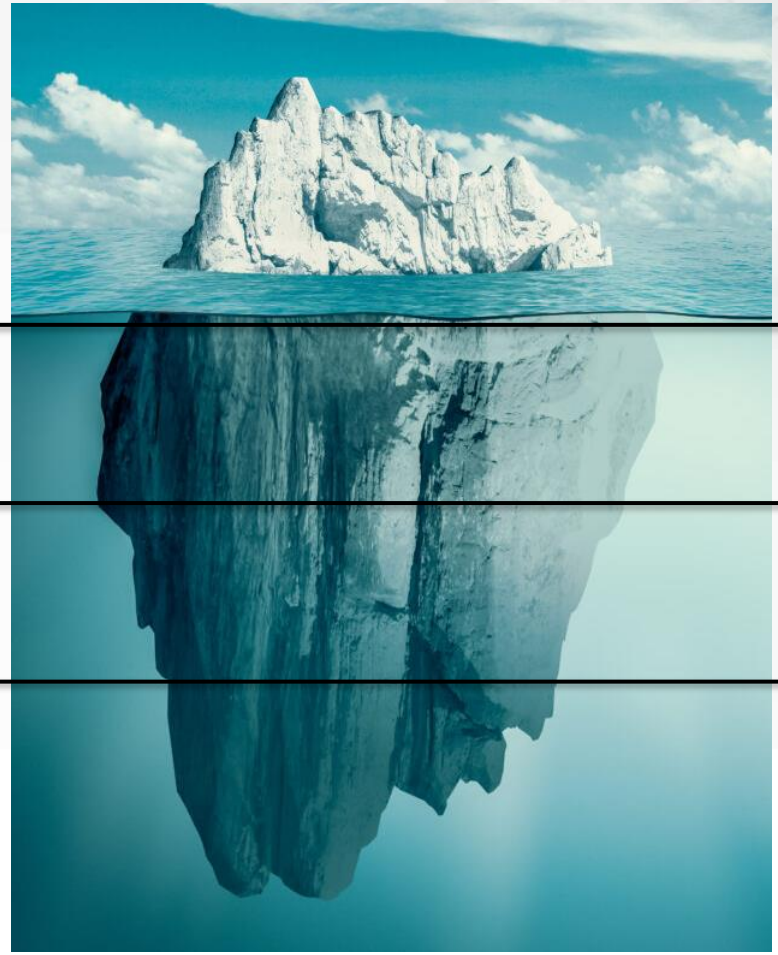


Events

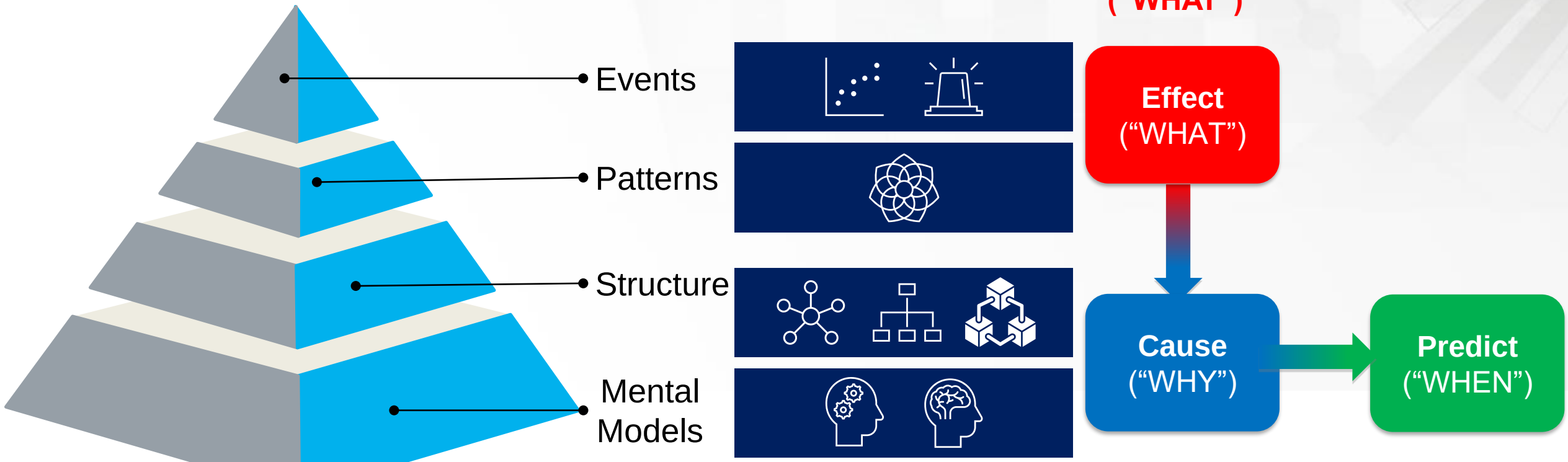
Patterns

Structure

Mental Models

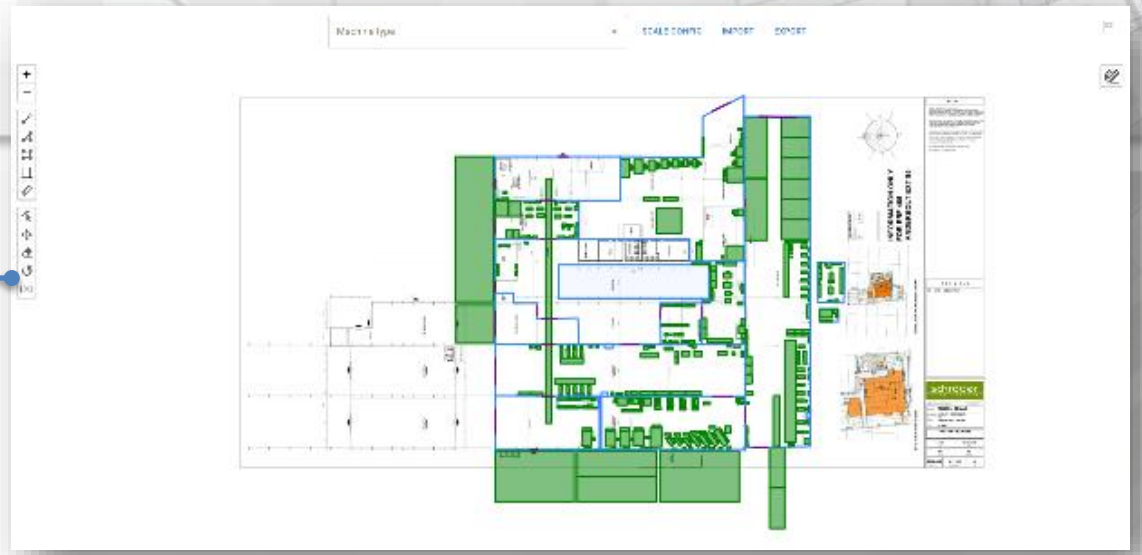


Future Production System: "Iceberg Model" : DT Ecosystem

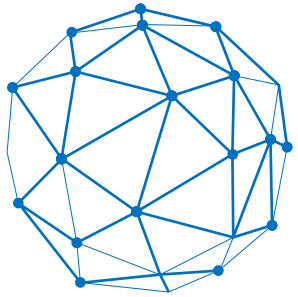


Digital Twin Ecosystem:

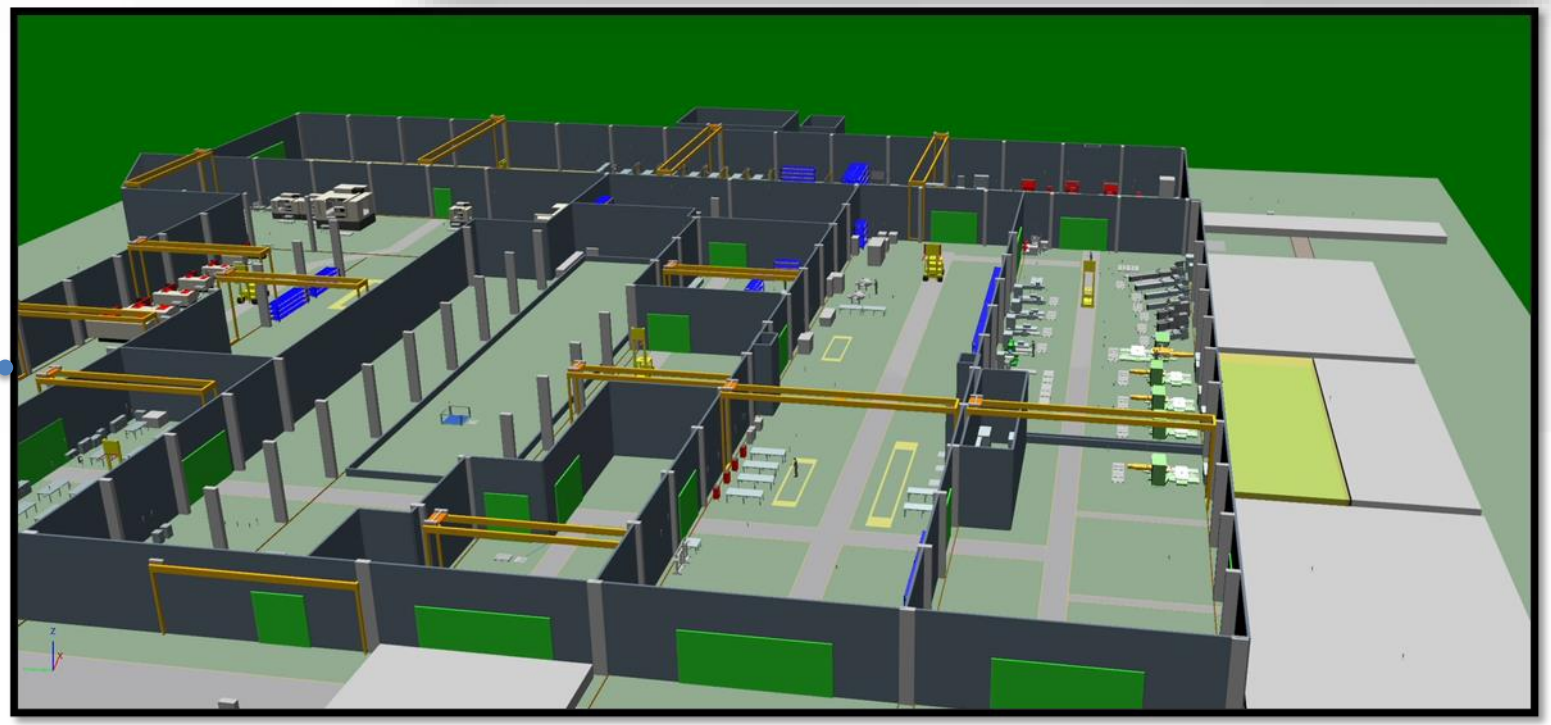
Factory Digital Twin
Creation Tool



“Client-in-the-Loop”
Iterative Model Creation



Factory Digital Twin
Simulation Ecosystem



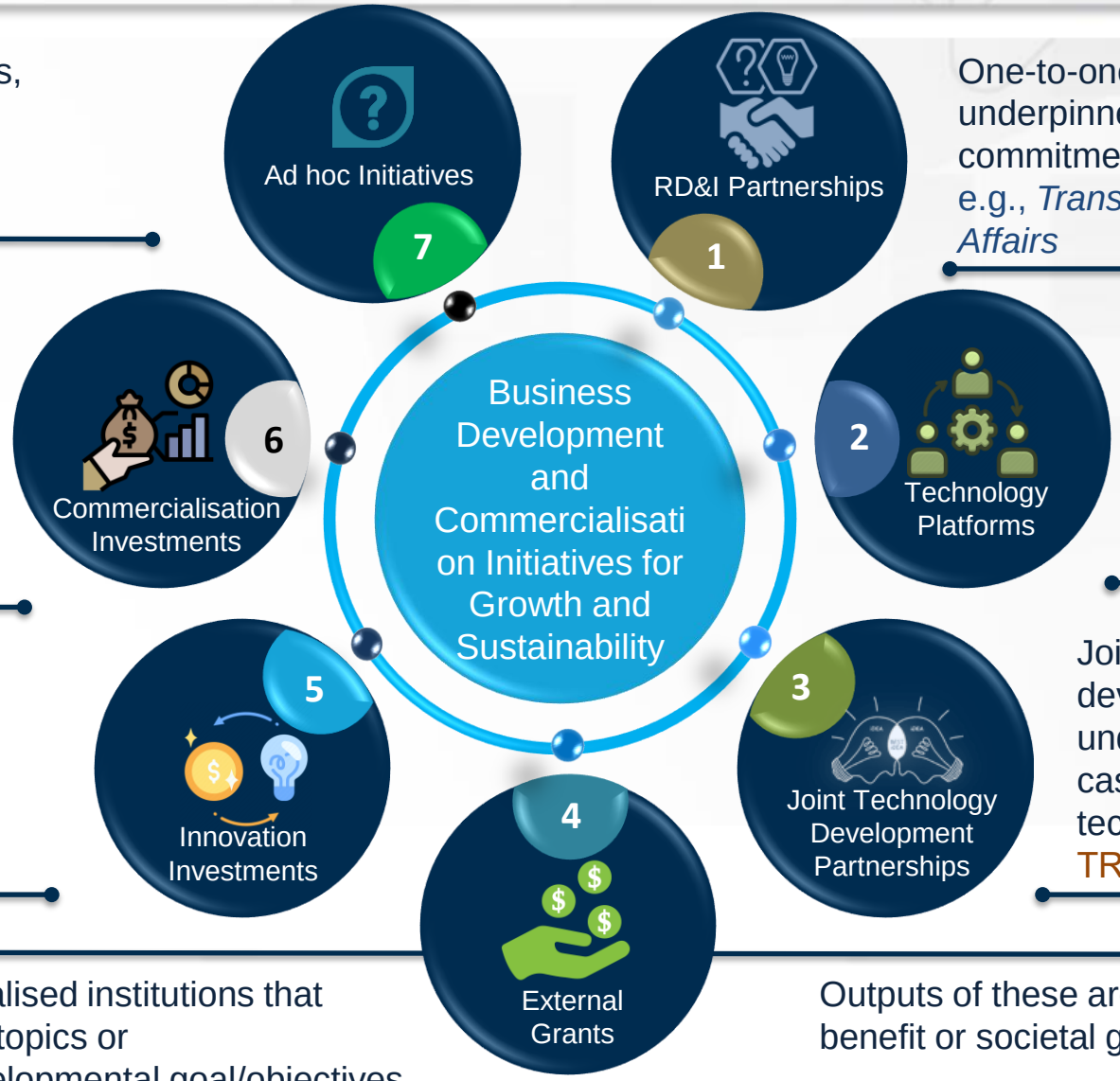
Partnership models : How do we engage?

Ad hoc initiatives: once-off contracts, quick turnaround requests, tenant income, etc.

CSIR and/or external partners' investment on further development and commercialisation of CSIR technology(ies) in return for benefit in future commercial transactions .TRL>5

CSIR or national programme-linked investments aimed at developing capability, technology and/or human capital. 1≤TRL≤ 4

Public entities, foundations or specialised institutions that provide funding for R&D on specific topics or solutions/technologies linked to developmental goal/objectives



One-to-one relationship of mutual interest underpinned by a medium to long-term strategic commitment by both parties, e.g., *Transnet, Eskom, Department of Home Affairs*

Multi-stakeholder (typically a consortium form) initiatives aimed at building technology or capability platform(s) to achieve a set of common objectives. Preferably TRL ≥ 6, *e.g., Impact Catalyst*

Joint investment, shared risk and co-development programmes, underpinned by a strong business case, aimed at innovating or maturing technology/product for market uptake. TRL ≥ 5, e.g., *Hensoldt, MAS*

Outputs of these are typically aimed at public benefit or societal goo, e.g., horizon2020.

In Closing

- Digital transformation has been demonstrated to significantly contribute to improving profitability in South African industry;
- Adoption of digital manufacturing will require the right skills, agile and robust processes, and partnerships to make technology accessible and provide space for co-creation and innovation;
- Industry needs to be an integral part of the National System of Innovation to improve technology adoption and leverage its benefits;
- CSIR mandate – and founding purpose - is to enable industry through access to the required skills, technology incubator mechanisms and co-innovation to de-risk technology implementation. ***We remain committed to this!***

Let's lead by example and go out of our way to find opportunities to work together for the benefit of all South Africa

Thank you