**NATIONAL SCIENCE AND TECHNOLOGY FORUM (NSTF)**

**DISCUSSION FORUM ON THE IMPLICATIONS OF THE FOURTH INDUSTRIAL REVOLUTION FOR SET, INDUSTRY, SOCIETY AND EDUCATION**

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**DAY 1**

**PUBLIC SECTOR SCIENCE, TECHNOLOGY AND INNOVATION IN THE CONTEXT OF THE FOURTH INDUSTRIAL REVOLUTION (Garth Williams, Research Specialist: Intelligence, Technology Innovation Agency)**

The Technology Innovation Agency (TIA) is a partner in South Africa's National System of Innovation (NSI) led by the Department of Science and Technology (DST). Other stakeholders in the NSI include the Council for Scientific and Industrial Research (CSIR) and the National Advisory Council on Innovation (NACI). TIA is focused on de-risking technology innovation for socioeconomic benefit, with the goal of harnessing science and technology to create jobs and diversify the economy.

The World Economic Forum (WEF) has been very vocal about the importance of the fourth industrial revolution (4IR), emphasising that this is the new wave in which all must be ready to participate and so as not to miss the opportunity. The WEF defines the progress towards 4IR as follows:

- First industrial revolution (1784) characterised by steam power, water and mechanical production equipment
- Second industrial revolution (1870) characterised by division of labour, electricity and mass production
- Third industrial revolution (1969) characterised by electronics, IT and automated production
- Fourth industrial revolution characterised by cyber-physical systems. The advent of cyber-physical systems involves new capabilities for people and machines, representing entirely new ways in which technology becomes embedded within societies and even inside human bodies.

Another prominent aspect of the WEF narrative is the convergence of many different types of technologies such as big data and data analytics, autonomous and collaborative robots, simulations, the Internet of things, cyber-security, cloud computing, augmented reality and human–machine interfaces. The convergence of the physical, digital and biological spheres, and of technologies, society and the economy, is also important. The WEF view is currently the dominant narrative in this domain, but it is not without its critics.

In orthodox economics, growth is mostly dependent on production (involving land, capital and labour), plus a small amount derived from total factor productivity, which is the residual or unaccounted value over and above labour productivity plus capital productivity. It has now been determined that total factor productivity accounts for 70% of economic growth in the modern era.

Long-run economic growth is determined by productivity growth, which in turn is driven by technological change and key breakthrough technologies (e.g. the steam engine) that have underpinned surges in society and the economy. For South Africa to catch up and forge ahead, local scientific research, technological development and innovation (both technological and non-technological) focusing on indigenous challenges and opportunities are crucial. It is also important to build technological capabilities in order to assimilate and adapt foreign technologies for technological diffusion within firms, across the economy and into society.

The narrative is often based on strong technological determinants but lacks agency. Societies have their own choices to make, with which technology should co-evolve, and has in fact always co-evolved. Technology is always located within society.

The question then is what paradigm to choose, and why the WEF paradigm has been chosen? There are many alternatives, for instance the Kondratiev waves of capitalist expansion based on technoeconomic paradigms, or the Japanese Society 5.0 that essentially allows artificial intelligence into all avenues of society. Neil Gershenfeld, the founder of Fab Labs, believes that this is the third digital revolution, while Jeremy Rifkin believes that the confluence of energy, transport and communication systems represents the third economic revolution. Carlota Perez speaks of looking at 4IR through the lens of technoeconomic paradigms.

The idea of 4IR originated in Germany. As the most advanced economy in the world, German industry leaders discussed how to maintain that position and remain competitive. German industry influenced government policy. The German system looked at Industry 4.0 (which incorporates the cyber-physical

system), Factory 4.0 (using robots and autonomous vehicles) and Operator 4.0 (with work aided by machines).

The 4IR movement started in Germany, followed by the USA, UK and many other countries, and the objectives differ from country to country. It is important to focus on the goals determined by each country, rather than on the name. South Africa, for example, has high unemployment and a large number of people who may never be employed in the formal economy. An important issue in this context is how to address the informal economy.

There is much techno-babble regarding 4IR, including the notions of techno-utopia and techno-anxiety, and concerns about the absence of agency in the narrative on the machine-centred environment. The fourth industrial revolution is a heuristic or 'mental' model for understanding and influencing the way in which emerging technologies are changing the means of creation, exchange and distribution across economic and social systems. There are fears of disrupting already-fragile labour markets and creating job losses, thereby widening inequality and deepening poverty. Technological change in society and the economy needs to be just, inclusive and sustainable, and South Africans need to shape their own future.

In South Africa there are several public sector initiatives under way to develop a country-level strategy and action plan. The process was initiated by Cabinet and is being led by the Department of Telecommunications and Postal Services, supported by the Department of Science and Technology (DST) and the Department of Trade and Industry, and reporting to the Presidency.

Possible workstreams include the digital society; ICT policy; regulatory and legislative reforms; innovation, research and development; economic policy and inclusive growth; industrial restructuring and trade; labour market restructuring; education and skills development; and transforming government and service delivery. A parliamentary process is being led by the CSIR with the aim of educating members of Parliament and the legislature, encouraging pubic engagement, and addressing the regulatory framework.

Within the Science, Technology and Innovation committee led by the DST and involving TIA, NACI and the CSIR, several initiatives are under way, including a converging technologies platform, an inclusive development platform and the recent outreach centres initiative. The converging technologies platforms are aimed at building and integrating deep capabilities in niche areas across various technologies. The inclusive technology platform will provide policy, advisory and decision support. It will comprise an inter-disciplinary team of both sceptics and missionaries with a strong international orientation, but a bias towards a developing-country agenda. NACI is working on a research-level baseline study of South African 4IR initiatives, including a literature survey. The South African–European Union policy dialogue will be a companion event at Science Forum South Africa in December 2018.

There are many initiatives in the market place, such as an industry forum driven by Aerosud and a partnership between Telkom and several universities aimed at developing a 4IR agenda, but these tend to be disconnected and characterised by a lack of information sharing.

4IR is not about the name and it is also not only about the technology; it is about what we want to achieve. There is a need for more cooperation and partnerships at several levels.

The South African Cabinet has approved the draft White Paper on Science, Technology and Innovation for circulation, in which 4IR features strongly. The White Paper can be downloaded from the DST website, and comments are invited.

**DEVELOPMENTS IN REGIONAL CYBER-INFRASTRUCTURE AND RESEARCH DATA (Dr Tshiamo Motshegwa, University of Botswana)**

Collaboration across borders is essential, but the key to success is relevance.

The Royal Society, in its report Knowledge, Networks and Nations: Global Scientific Collaboration in the 21st Century, shows that with the USA at the centre, the First World is very connected, but Africa is fragmented without any particular structure for communication. The Southern African Development

Community (SADC) is creating a framework ecosystem document that includes details of organisations, expertise, high-level computing facilities and other expensive research equipment.

The way in which data are shared will also have to be included. It will have to be determined what needs to be put in place in order to share effectively. The issues to consider include whether South Africa should focus on science parks, or ensure appropriate interventions at all levels from basic research to the market. There is also an overarching need for capacity building, which must avoid a piecemeal approach and take the form of comprehensive human resource development and sector plans.

In an attempt to involve scholars in science and to illustrate that there is a need for skills not only at the apex of science but also at other levels, Facebook groups have been created featuring Botswana's involvement in the Square Kilometre Array (SKA). The questions posted on these sites are related primarily to the fear that artificial intelligence (AI) will take away future jobs. The response is that scholars need to think about skills that will make them relevant in the future. People cannot compete with AI with respect to automation, but machines are not creative and know nothing about teamwork. Perhaps curricula need to be changed to expose scholars to some of these skills.

Technology singularity occurs as AI surpasses human beings as the smartest and most capable life forms. These doomsday predictions are not altogether unfounded. In the early market stage of the technology adoption lifecycle, only 'techies' and visionaries are prepared to adopt new technology. There is a chasm to be bridged in order to advance towards a mature market, which will also include pragmatists, conservatives and sceptics.

Data are central to the transition from the third industrial revolution to 4IR. Data are being collected everywhere, but there are challenges with respect to making sense of the vast volumes of data that are collected. This represents the data chasm. Ordinary citizens do not have the resources to make use of the available data. Cloud computing is changing this, however, making it no longer necessary for individuals or companies to invest in expensive infrastructure to store data. This advance in technology has helped to bridge the data chasm and brought considerable benefits to companies, the environment and society. Academics must ensure that the enabling architecture and technologies for capturing, storing and using data are included in courses presented at universities.

There is a great deal of hype around AI and machine learning, but the Achilles' heel is the quality of the data. Data that are not clean and trustworthy are not useful. The bulk of the work should perhaps be to ensure that repositories contain clean validated data.

AI and neural networks for pattern recognition systems have been successfully used for some time, but it is essential to understand where the use of technology makes sense, as well as its limitations.

Research is data intensive, and the scientific method will not change. It is good practice to ensure that research data are accessible, reusable and capable of interpretation. The results of publicly funded research must be made publicly available. Data infrastructure must maximise the storage of data and ensure its availability to other scientists and the public at large. There are many examples from around the world of the value of open data to new developments.

The future skills that will be required need to be considered. With the advent of disruptive technologies in domains such as transport, engineering and manufacturing, children will have to be encouraged to become 'T-shaped' professionals who have both the depth and breadth required to deal with new technologies and practices. Teaching techniques will also have to be adapted. Lecturers no longer have all the knowledge.

Most countries have national policies on these issues, which are also addressed in the African Union Commission's Agenda 2063 (The Africa We Want) and the SADC Vision 2050. Botswana has negotiated with overseas organisations and acquired decommissioned equipment and training opportunities for students. Computing clusters are being established for use by students, and students have been able to attend training courses and conferences abroad.

A regional project has been launched to develop cyber-infrastructure, the components of which include national research networks, computational resources, data, policies and human capital. The

impact of cyber-infrastructure is regional integration through collaboration in areas such as energy, education and health, and the effects are felt in industrialisation and technology transfer. Other consequences include the ability of citizens to access data, nationally shared digital information repositories, data sharing and the advancement of open data and open multidisciplinary research.

4IR represents a trend and trajectory in human development that is facilitated by technological development and investment in infrastructure. This revolution is characterised by the escalation of the amount of data available as well as the means to make data useful. There is a need to invest in supporting infrastructure to enhance collaboration as well as human capital development and skills.

**ETHICS AND CYBER-SECURITY (Prof. Elmarie Biermann, Director: Cyber Security Institute)**

Ransomware is not new. As technology develops, criminals adjust their processes to use the new technology. Ransomware encrypts discs, and a ransom is demanded in the form of a payment in virtual currency in order to unencrypt the discs. Pressure to pay the ransom is intensified by setting a deadline for payment of the ransom. Extortion groups that use ransomware operate like a regular organisation and even have a help desk for further information on what is required. There have been a number of cyber-attacks recently, building up to a big anticipated attack. South Africa is not ready for this. Cyber-warfare should be linked to the military, but the South African military is a peacekeeping force without this type of remit.

The Master Deeds data breach of 2017 made the personal data of tens of millions of living and deceased South Africans available online. It is wise to check whether any of one's personal data are available on this database, and to contact companies that might hold that data. It is important to change passwords regularly.

Another Internet security risk is spoof e-mails. E-mails with attached invoices containing banking details are intercepted, the banking details are changed, and the invoice is forwarded to the company that has to pay the bill. The payments are then directed to a bank account other than that of the legitimate service provider.

Smart phones are valuable devices on which people rely, but very few load anti-virus software on to phones. This begs the question why people protect their laptops but not their phones. It is important to understand the dangers of accessing free Wi-Fi at hotels and coffee shops. By creating a hot spot on their phone, it is easy for other people to see the data on one's phone in a free Wi-Fi situation. Protection is available by installing a virtual private network (VPN) on one's phone, which extends a private network across a public network, making it impossible for others to see one's data. One should buy a VPN program rather than using freeware.

The world is moving towards the Internet of things in which computing devices will be embedded in everyday objects, enabling them to send and receive data. A trip to the mall will be detected, and messages regarding items for sale will be forwarded to the prospective shopper's phone. Search engines store a great deal of information regarding individuals. Google is advertisement driven and will therefore give results according to what the algorithms calculate will be most profitable. Different search results are obtained from a search engine that uses a different algorithm or does not build profiles.

Camera systems outside and inside the home, including baby monitors, are easily accessible. We need to become more aware of cyber-security risks. People are aware of protecting their physical space, but do not apply the same rules to the Internet. There was an in incident at a hotel in Sweden that used a card access system; ransomware criminals locked all the rooms and demanded payment to open them. The lifts in a mine shaft could be vulnerable to a similar attack.

Shodan is the world's first search engine for Internet-connected devices. Shodan can be used to discover which devices are connected to the Internet (e.g. webcams and printers), where they are located and who is using them. Devices that are connected to the Internet have an IP address that could provide access to hackers and criminals. The default settings of these devices should be checked, and logins and passwords should be regularly changed.

The deep web is hundreds of thousands times larger than the surface web and is not searchable by regular search engines. The deep web contains information such as medical records, legal documents, subscription databases and government resources. This information is not indexed by search engines and is password protected.

The dark web, which forms part of the deep web, provides near-perfect anonymity, making it easy to subvert the law but difficult to demand accountability. Access to the dark web is through a Tor browser, which can be legally downloaded. The dark web operates according to a protocol with the web extension of .onion. The dark web has company and military information and also sites where it is possible to buy whatever one wants. It is used by drug dealers and people traffickers. The dark web is not readily searchable, and many sites remain live for only a very short time, so it is very challenging to find particular URLs.

What is your digital tattoo? How present are you within the social media space? Facebook is dead, and many people now use Instagram and WhatsApp as their main means of communication. There are many social media applications available, some of which are more secure than others. Common sense should prevail, and people should be cautious about the information they upload.

One needs to consider how crime moves. Criminals follow the money. Drugs are traded in the physical space, but human trafficking is prevalent in the online space. Criminals operate as businesses, employing researchers, software developers and others who may not even realise that they are part of the criminal system. Advertisements offering the possibility of making money from home may be placed by criminals. Those who respond to the advertisement may be required to open a bank account, which is then used to transfer money, leaving a residual amount as payment to the account holder. Those who participate are part of the criminal system. Given the high levels of unemployment in the national economy, this type of involvement is likely to escalate.

It is important to understand that people have to take responsibility for keeping their data safe without relying on technical control. Software is available to assist, for example browsers with built-in VPN software. We must spread the word that we are all connected and depend on one another's security.

South Africa has a shortage of skills to deal with cyber-security. The universities have not caught up with respect to the importance of security, and the country has a great shortage of skilled people in that environment. Security is a central issue with widespread ramifications. South Africa has not yet experienced an attack on critical infrastructure such as the water or electricity supply system, so there is a lack of appreciation of the possible consequences. The implications must be considered more broadly, and better understanding of the cyber-security environment needs to be developed.

**THE FOURTH INDUSTRIAL REVOLUTION AND THE CITY (Prof. Babu Sena Paul, Director: Institute for Intelligent Systems, University of Johannesburg)**

Is South Africa ready for the fourth industrial revolution given the large economic gap between the rich and the poor? How will 4IR affect this divide, and will the poor benefit from this revolution? The University of Johannesburg (UJ) is looking at 4IR from the urban perspective, taking into account issues such as smart homes, waste management, health, water, transport and jobs.

In order to plan for 4IR, it is essential to have an overview of the previous industrial revolutions. The first industrial revolution was in the late 1700s with the advent of steam power, mechanisation and the weaving loom; the second industrial revolution came almost a century later with electricity leading to the invention of motors, assembly lines and mass production; and the third industrial revolution came about a century later with the invention of electronics, leading to computers and automation.

The UK had steam power as early as the late 1700s during the first industrial revolution. Africa has steam engines, although the African continent did not take part in the first industrial revolution and it took 60 years for the first steam engine to reach Durban. The Luddite movement protested strongly about the loss of jobs through the introduction of mechanisation, but the current world population of seven billion could not all have been clothed with only hand looms.

There were also protests at the changes brought about by the second industrial revolution and the advent of electricity, mass production and assembly lines. The Ford factory had to be guarded by police to allow production to continue.

The focus of the third industrial revolution created many new jobs, such as programmers and systems analysts. The world is now moving to the fourth industrial revolution with technologies such as cloud computing, big data and 3D printing. The question is what invention caused this revolution? No Nobel prize winners have been identified or credited as the founder of the fourth industrial revolution.

An IBM Marketing Cloud survey found that 90% of world data had been created in the previous two years and was expected to grow by 40% per year, which represents an enormous amount of data. The advent of data lakes in the last five to seven years has meant that data have become cheaper and more available to more people. Deep learning was previously not possible, because computer capability was low and the required investment was enormous. Addressing these challenges was one of the reasons for the fourth industrial revolution. Winston Churchill advocated studying history, but now it is essential to study data rather than history.

Is the smart or intelligent city only for the elite? The concept of the smart city was developed in the West, and South Africa could have bought the technology for such urban living arrangements. However, South Africa must develop what is appropriate for its situation. For the First World and the rich, there has been a progression from the simple knock on the door, to the door bell, and now to image processing by cameras that can also do emotional processing to assess the person at the door. South Africa's housing problems would be solved if low-cost houses could be built within 48 hours using a 3D printer. This is the type of 4IR intervention that the country needs to develop.

Waste management is a worldwide problem. The World Bank projected waste volumes per country, but these projections are not sufficiently accurate to facilitate planning. South Africa currently produces more than 53 000 tons of waste per day, but at 2 kg per capita the country is a fairly low producer of solid waste.

Around the world, only 1% of waste is recycled. Asking people to dispose of different types of waste in different bins is unlikely to succeed on a large scale. We need to find a solution that uses image processing to identify different types of waste and then let machines do the rest. This would mean that the manual scavengers in our cities could be employed in more worthwhile pursuits.

The health sector is very important and would benefit greatly from 4IR interventions. The delays experienced by ambulances in urban traffic are a good example of where technology could help. Helicopters are used for emergencies, but these are only for the rich. It might be possible to develop a GPS system that allows ambulance to communicate with traffic lights. A green channel could be initiated to allow the ambulance through.

Choosing a medical aid that best suits an individual is becoming increasingly difficult with the proliferation of available features. It might be possible to develop an algorithm to assist in making such decisions. When consulting a doctor, it would be useful if family and personal information could be entered into a computer for initial sifting in order to reduce the time that the doctor needs to make a diagnosis. Two-thirds of the national medical budget is spent on chronic medication. Most chronic conditions could be diagnosed in advance and treated before becoming chronic, which would reduce this budget.

Many of these innovations could be made at university or college level.

Some sensor systems are being employed in the water reticulation system, but the introduction of smart water meters, water leak detectors, and pressure and temperature monitors could assist in predicting blocked or burst pipes. Data and data-processing systems are very important in the transport sector, including intelligent fleet management systems, vehicle-to-infrastructure communication, vehicle-to-vehicle communication, and integrated transport management systems.

Historically the industrial revolutions have been accompanied by job loss. Job patterns have changed, and new job titles are expected to emerge in the 4IR environment, such as cloud computing engineers, informatics analysts and cyber-security specialists.

UJ started an initiative to introduce 4IR technologies to beginners. A course with Saturday classes was advertised both inside and outside the university. This course was offered free of charge, and was aimed at people of all ages, from any educational background, and without any prior programming experience. The course was oversubscribed and 100 people were chosen to take part. In a short space of time, this group achieved advanced thinking and mathematical skills without any previous experience. UJ would like to expand this initiative. Discussions with the CSIR are under way regarding a possible online course for the general public.

There is a need for national dialogue involving academia, industry and labour. Policy, programmes, projects and partnerships also need to be developed. To this end, UJ has launched a dialogue on 4IR with Telkom and the University of the Witwatersrand.

Moving forward with 4IR is up to us. We will have to change, but we can choose whether we lead, succeed or just survive.

**DAY 2**

**IMPLICATIONS OF THE 4TH INDUSTRIAL REVOLUTON FOR INDUSTRY (Mr Nimrod Zalk, Department of Trade and Industry)**

There is a great deal of international discussion, based on a large body of evidence, that demonstrates that in order to embrace the 4th Industrial Revolution (4IR) it is essential to transform structurally and to invest in a shift to higher-value activities. Manufacturing is a primary site for this debate, but it is not the only site.

Developing countries cannot catch up with the advanced economies without industrialisation. Successful industrialisation is in turn dependent on sound industrial policy to expedite technology acquisition. There are definite limitations to ‘leapfrogging’. Since the countries best placed to benefit from 4IR are those with an established industrial base, it is important to examine the longer-term context of manufacturing, particularly for South Africa.

The link between industrialisation and employment is very important to South Africa. Internationally, from the end of the Second World War until the 1980s, manufacturing was the primary source of economic growth and mass employment. More recently, this source of direct employment creation has come under pressure. The two most important reasons for this are the statistical phenomenon of how jobs are classified, where services such as cleaning, security and other service components have been moved to an outsourcing model. The other significant change was the entry of China, India and Eastern Europe into global trade and the massive workforce that this brought with it.

Manufacturing is still immensely important for the creation of substantial numbers of direct jobs and has the highest indirect employment multipliers. Every job in manufacturing creates 3.8 jobs in other sectors. Industrialisation generates the income necessary to create and sustain large-scale services sector jobs and facilitates integration across increasingly fuzzy boundaries between sectors. It is often difficult to separate manufacturing and services; for example, sophisticated manufacturing includes highly skilled, high-value services such as engineering and design. In the South African context, the industrialisation of the agricultural sector will provide an opportunity for the South African economy.

The World Bank in their Development Indicators has tracked annual manufacturing growth compared with gross domestic product per capita growth from 1994 to 2016. These statistics show clearly that the growth of the manufacturing sector is in direct relationship to the growth of a national economy.

What we know about the 4IR is that expedited technological change across multiple platforms is real. There is a great deal of discussion and hype around issues such as digitalisation, robotics, the Internet of Things, additive-three dimensional (3D) printing, nanotechnology and biotechnology. Many of the so-called ‘4IR technologies’ are not necessarily new. Technological change often takes place more through evolution than revolution, and it can take time to get technologies widely diffused and accepted. Commercial viability or countervailing forces such as cybersecurity can also influence uptake.

It is essential to integrate 4IR considerations into firm sector and industrial strategies, but this does not mean dropping everything else and focusing only on 4IR. In order to maximise what we have with what we want to achieve, it is essential to achieve a balance. In South Africa the biggest challenge is solving the bigger economic policy difficulties that exist. The automotive and mining nexus and the high-value agriculture sector provide good examples of the impact that technological change could bring to South Africa.

There global shift to electric vehicles will have an impact on the South African mining industry, as the market for catalytic converters will decline, reducing the need for platinum group metals (PGMs). This would mean loss of income and possible loss of jobs in the mining sector. There is a need to develop new sources of demand for PGMs, which could include products for the emerging hydrogen economy and fuel cells. New partnerships for industrialisation will need to be developed; for example, engagement with electric vehicle battery developments. With the vast amount of experience that South Africa has in the field of mining equipment, this is also a possible area for early stage development of vehicles and consumables. Long-term planning and agreement around exploration, investment and industrial linkages is essential. Transformation and social investment in mining communities is necessary to maximise the gains and minimise the risks of possible changes.

4IR is a reality in the agricultural sector. In a recent study completed by the Bureau for Agricultural Policy at Stellenbosch University, it was shown that high-value, labour-intensive, export-oriented horticultural products could create approximately 100,000 jobs. The focus would mainly be on fruit such as apples, pears and citrus as well as nuts, which all have enormous global market potential. The selective insertion of high technology and high skill could catalyse large-scale unskilled employment. In the apple-producing industry, for example, new processes and facilities such as waste to biomass have significantly increased job opportunities. The horticultural products sector employs more people per hectare than the maize, wheat and livestock areas and has potential for the insertion of high technology and high skill. Progress in this domain requires an agreement around security of land tenure, public investment in water, research and development, decent work practices and social investments in rural communities.

**ICT TECHNOLOGIES BEYOND THE 4TH INDUSTRIAL REVOLUTION: CHALLENGES AND OPPORTUNITIES (Dr Fisseha Mekuria, Chief Research Scientist, CSIR Meraka Institute)**

The fourth industrial revolution (4IR) is described as a consolidated and multidisciplinary advanced industry and societal services ecosystem. Some of the necessary conditions for engaging with this ecosystem include the identification and development of enabling technologies. The development of research and development (R&D) institutions, the development of human and entrepreneurial capacity and integrated planning for a multi-sectoral approach are essential.

The CSIR is a multidisciplinary research and development organisation with the ability to develop technology and test systems across a wide range of disciplines in a simulated smart campus environment. This facility provides the CSIR with the capability to invite other researchers and students to use the comprehensive test facilities and to collaborate on research projects.

Some of the enabling technologies for 4IR include edge and cloud computing, smart mobile devices, low latency and reliable high speed networks, small and inter-networked sensors and augmented and virtual reality wearables. A 5G information and communications technology (ICT) standard and associated ecosystem will support 4IR, but it is essential that the impact of 5G is comprehensively tested in order to develop relevant use cases. Universities, industry and research organisations must work together to ensure that the changes that 4IR will bring about are fully embraced. It is important that the concepts and skills required are introduced into the university and school education systems as early as possible.

The International Telecommunications Union 5G Wireless Standard includes the provision of ultra-low latency and reliable networks for use in robotics, affordable broadband, smart inter-connected sensors for use in the health domain and ultra-high definition video and hologram communications to support immersive education. 5G standardisation for rural development and for connecting the next billion people of the world population to affordable broadband is an essential part of the technology development and roll out. With the appropriate R&D and innovation frameworks, 5G could boost the

creation of new service industries and improve the competitiveness of Africa both regionally and internationally.

The CSIR is engaged with the Department of Trade and Industry (dti) and the Technology Innovation Agency (TIA), but there is a need for a wider dialogue and knowledge sharing in order to focus on harnessing and industrialising the technologies that will be required for the services of the future. Universities, the Innovation Hub and other innovation and research agencies should be engaged in this discussion.

Technology testbeds are crucial platforms for the performance of controlled testing of relevant-use cases prior to commercialisation. These testbeds assist in developing expertise and provide support to policy and technical regulation development. Through the provision of an environment to demonstrate actual performance in use cases, testbeds provide opportunities for collaboration both locally and internationally. The testbed environment makes an important input to the setting of standards, conformance testing and peer review processes.

The CSIR has a 5G testbed for use in developing affordable broadband and digital inclusion applications. Using this facility and technology for spectrum sharing and improved 5G network capacity has been patented and is currently being shared, at no cost, with other researchers in this domain. This original work will form the basis for the development of further new technologies in this area. The CSIR is also internationally connected including through the 5G Research Alliance: Emerging Economy Context.

The development of 4IR systems should be for specific uses and aimed at optimising resources such as energy utilities, water management, health facilities or increased security. Some of the use case scenarios that have been proposed include aids for the handicapped such as human augmented robotics intelligence, smart education and training, and capacity building tools for existing and future human resource development.

Based on the best practices from Sweden and Bangalore, India, it is important to establish a credible science and technology, innovation and enterprise centre that can provide support for incubation and business development. Support is also required for licensing, intellectual property (IP) protection and other legal issues. The R&D community forms an essential part of the team for a centre, but relevant government agencies, academia, local industry and private investors are equally required to participate.

There needs to be a desire to harness and effectively utilise digital opportunities and for synergistic thinking for digital inclusion and the provision of support to resource-constrained authorities. The provision of affordable broadband, multidisciplinary research and transformative technical regulation and policy, and the development of multidisciplinary skills are key. It is important to build an innovation and entrepreneurship framework to benefit from 5G ICT.

**DAY 3**

**IMPLICATIONS OF THE 4TH INDUSTRIAL REVOLUTON (Ms Nontombi Marule, Director: Innovation and Technology, Department of Trade and Industry)**

In order to maximise the impact of the fourth industrial revolution (4IR), it is important to look at what needs to be done and at what we should be doing now. It is also important that we share what is already in place and what is on the radar for the future in order to prompt discussions about where the focus should be.

The first industrial revolution of 1784 saw the introduction of mechanisation, steam power and the weaving loom, and then in 1870 mass production was introduced with the advent of the assembly line and electricity became the main power source. Automation, computers and electronics formed the basis of the third industrial revolution in 1969, and today the fourth industrial revolution focuses on cyber physical systems, the Internet of Things and networks.

The building blocks of 4IR include 3D printing and personal fabrication as the basis for advanced manufacturing, tailor-made products and smart materials; the Internet of Things and cloud computing,

which provide infinite data storage possibilities and the convergence of automation and information technologies; and robotics for the development of robots that will physically interact with humans in a shared workplace. In addition, artificial intelligence will facilitate machine learning to imitate intelligent human behaviour and is based on disciplines such as computer science, biology, psychology, linguistics, mathematics and engineering. Big data is extremely important to enable the handling of the volumes of data that are already being generated on a daily basis and to enable the processing and storage of data produced by smart machines.

4IR has implications for the economy and regulatory frameworks, and our response and agility to adapt are very important. 4IR is evolving at an exponential rather than a linear pace, and disruptions are taking place in almost every industry in the country. The breadth and depth of these changes herald the transformation of entire systems of production, management and governance. Technology advances keep expanding the benefits of the digital revolution across the planet and can assist in advancing economic growth.

The advantages provided by 4IR include improvements in the flexibility, speed, productivity and quality of the production process and faster response to customer needs. Product life cycles become shorter, leading to higher production levels. Robots, smart machines and smart products that communicate with one another will be used.

South Africa is a developing country. Catch-up strategies are in place, but implementation is lagging. Two types of catch-up are used to measure success, namely economic catch-up where a country's growth rate of per capita income has risen above the global average or that of a comparative group, and technological catch-up which is the generation of technological innovations at a faster rate than that of industrialised economies. The successful catch-up demonstrators of Hong Kong, Singapore, South Korea and Taiwan and the 'Asian Tigers' of China and India have shown that technology forms the basis of catch-up strategies.

Key factors for catching up include technological specialisation in terms of cycle times and the degree of originality. The transition from reliance on foreign knowledge to the localisation of knowledge creation, and diffusion and diversified versus concentrated growth strategies are also important. In South Africa we need to focus on our own strategies for solving our own problems. In assessing future strategies and projects, the dti no longer favours the use of imported technologies, which increase our indebtedness on other countries.

South African production industries are generally still locked into the 2nd industrial revolution. The banking and services sectors have moved a little further along the change paradigm. Bridging the gap to the 4IR will be difficult, since our production industries are not yet even embedded in the 3rd industrial revolution.

4IR will require government to embrace agile governance to adapt to a new fast-changing world, and increased investment in R&D and disruptive technologies is essential. A regulatory framework that stimulates industry to use home-grown technologies and the development of standards of compliance for new devices and components will need to be developed. More highly skilled engineers, scientists and industrial designers will be required, and labour laws will need to be adapted to attract a talented workforce and create well-paying jobs. Government will also have to deal with the high costs of connectivity and low bandwidth speeds.

The challenge for the regulator is the issue of big data. Big data is viewed by experts as 'the new electricity'; it is the power source driving change in the way that steam, electricity and digital technology did in earlier industrial revolutions. Data is the next currency, and we need the capability and capacity, including infrastructure, skilled labour, adequate tools and networks to handle big data. The flows and fluidity of data. including access control and flows to unexpected areas during manipulation and interpretation. will need to be managed.

A paradigm shift is required. Some of the main issues that require attention are policy regulation that is more futuristic and agile; reskilling of labour and human capital development; the acquisition of infrastructure and intelligent programming; capacity and capability building of organisations and the development by agencies of a 360° perspective of society.

**IS THIS THE 4IR OR THE FIRST DIGITAL REVOLUTION? (Prof Mike Bruton, author of "What a Good Idea!")**

The question was asked whether the current change process could be called the First Digital Revolution rather than the Fourth Industrial Revolution. The changes and technologies of the so called 4IR are in nature almost anti-industrial or post-industrial and in essence focus on providing mechanisms for solving the issue of connectivity. The first industrial revolution was the move from an agrarian economy to an industrial and urban one; the second to the widespread use of electricity, gas and oil, chemical syntheses and basic communications technology and mass production. Nuclear energy, electronics, telecommunications, computers and synthesis were the drivers of the third revolution, but the 4IR is digitally driven through technologies such as the internet, robotics, artificial intelligence, nanotechnology, quantum computing, the Internet of Things, 5G wireless technology, 3D printing and autonomous vehicles.

4IR was a term created by Prof Klaus Schwab, the founder of the World Economic Forum. Prof Schwab quite correctly described this phenomenon as being about disruption, upended economies and challenges to societal norms, but he was not the first to highlight these changes. In the 1990s, the US military coined the term **VUCA,** which stood for: **V**olatility and rapid unpredictable change; **U**ncertainty or unknowable and unpredictable future trends; **C**omplexity or many interwoven parts; and **A**mbiguity, with changes being open to different interpretations that are not always obvious.

4IR and change are moving extremely fast. Science and technology are advancing so rapidly that they are catching up with science fiction and also outpacing the debates that must accompany the ethical use of the technology that is developed.

The description of this as the first digital revolution is reinforced by the fact that a complete mindset change is required and that it is anti-industrial or post-industrial in nature. Because of the required change in the way of thinking, this digital revolution is capable of undoing the wrongs of the previous three industrial revolutions, and provides an opportunity to harness resources in an unprecedented way to solve global problems.

Although the first three industrial revolutions had many benefits, including job creation, product development, technological advances, economic development, globalisation and advanced medical care, they also did considerable damage. Society in general has been harmed through conspicuous consumption, materialistic lifestyles and the widening of societal imbalances. Severe damage has been caused to the environment through the acceleration of global climate change and the promotion of unsustainable lifestyles.

In this digital revolution, everything is different and it is disruptive. ICT forms a tool for social intervention or social domination, which facilitates technology leapfrogging and the spread of technology. Enabling technologies include computer technology, telecommunications, materials technology, energy technology, biotechnology and nanotechnology. A transforming technology, through the ages has been transport, which has moved from the transport of goods and people to the transport of data. Transport has been the most transforming technology and has played a strong role in all the major technological transformations.

The internet is a transport mechanism that reaches over 3.2 billion people and is the most efficient communication medium ever. It does have the disadvantage of deepening the digital divide and is threatened by computer viruses, ransomware, piracy, invasions of privacy and unsolicited emails. Nevertheless, the internet does more than connect us; it entangles us and also connects us with the Internet of Things, which is estimated to connect 50 billion people by 2025. Whereas the previous revolutions were somewhat elitist and exclusionary, this revolution is democratic. Young people today are globally connected, digitally competent, entrepreneurial, ambitious and self-authored.

A further advantage of the digital revolution is the development of social entrepreneurs who are collaborative, can work in adverse environments, generate social value, plough back profit, innovate and do not just follow global trends as opposed to commercial entrepreneurs who work alone in opportunity-rich environments and focus on maximising profits, and not only follow but drive global trends. Social entrepreneurs encourage non-technical people to be involved, and citizen science has become a worldwide trend.

The First Digital Revolution differs from other industrial revolutions in that it is carried out by a multi-brained, multi-generational super organism or collective genius. Group intelligence and co-creation are used as in the European Organisation for Nuclear Research (CERN) paper with 5,154 authors. This mindset promotes evidence-based decision-making and acknowledges the triple bottom line of profit, society and environment. This thinking moves us beyond individual decisions and bias, encourages group think and consensus, and also guards against authoritarianism. Another advantage is that it helps us to be humble and to know our roles and responsibilities, recognise our shortcomings and acknowledge our ignorance.

This revolution and the changed thinking could assist in solving our greatest problem, namely the environmental crisis. Humanity is at the crossroads. We are the most numerous large animals ever, and our ability to manipulate the environment is unprecedented. We have exceeded the planet's ability to compensate for our actions. We survive through the biological process, but we are no longer a part of nature but servants to our machines and trapped in unsustainable urban environments. We have moved from hunter gatherers through pastoralists and become shopper industrialists and information fetishists, and we are the custodians of the biosphere. Our role is to understand and work in harmony with nature, not to conquer it.

It is important to consider the move up the information value chain from information to knowledge and then to wisdom, but also to consider moving from a change in mindset, to a change in behaviour, to influencing others to change mindsets and behaviour. Only then we can address the challenging issues that face our world.

South Africa has a long history of innovation and invention across a wide range of endeavours. We need to maximise our potential and take full advantage of the opportunities offered by the First Digital Revolution and maximise its connecting and problem solving features.

**THE IMPORTANCE OF INNOVATION FOR THE YOUTH (Parthy Chetty, Executive Director: Eskom Expo for Young Scientists)**

There is a worldwide shortage of engineers and technologists. We need to consider when we should start the exposure to innovation in order to encourage young people to become involved in science and engineering. "The only way to predict the future is to have power to shape the future" (Eric Hoffer).

The Eskom Expo is a non-governmental organisation (NGO) started by a passionate teacher in 1980 to encourage the youth of South Africa to participate in science, technology, engineering and mathematics (STEM) activities, to promote an interest in these areas and to develop scientific skills. Another objective of the Expo is the creation of opportunities for young students to develop and pursue their interests in an encouraging and rewarding environment and to improve tertiary education prospects.

Technology is developed by trained professionals with due regard for ethics, but is ultimately handed over to entrepreneurs and others who are not necessarily aware of the ethical considerations. This could lead to abuse, and it is therefore essential to have a better informed society and to start to shape the desired world at the level of learners.

The government needs to create an enabling environment to promote growth, but in order to move from garage level activity to multi-national organisation or from family-run store to large supermarket, it is essential to develop policies and structures for expansion. Similarly, it is also essential to create a science, technology and innovation (STI) enabling environment in order to move into an era of inclusivity, particularly of previously disadvantaged and female members of society. As a country, we need to focus on closing the gap between the digitally advantaged and the still disadvantaged.

There is a need for an STI reality check. The fears that jobs will be lost through the introduction of artificial intelligence and other 4IR technologies are well founded, but we need to manage the change through re-skilling and any other available tools. With regard to green information and communication technology (ICT), it has been calculated that changes in carbon emissions can be limited by using different types of computers, but the question remains 'What about all the technology that is already

out there and the adverse effect that that could still have?' This is again a matter of management and mindset change and an opportunity of make a difference.

Decisions will also need to be made about what the needs of society are. Does society want a lush verdant thriving planet with perhaps less technology, or the ultimate in connectivity and technology and a barren wasteland for a planet? In order not to leave the majority of people in our country far behind, we need to strike a balance between enablement and innovation, and stop being manipulated by clever marketing regarding what we need.

There are 26,000 schools in South Africa and the Eskom Expo supports 5,000 of them actively, so there is still a long way to go. There has been considerable growth since the establishment of the Expo, with one region in 1980 to the current 35 regional science fairs. This shows a 156% year-on-year growth since 2013. The Expo also supports the Southern African Development Community (SADC) region and areas as far away as Nigeria and Ghana.

All African countries would like to be leaders in innovation, but African economies are based on imports. In South Africa we have first world level universities and first world manufacturing capability, but they do not work together. In Germany there are strong partnerships between the leading manufacturers and the universities, which strengthen the national research base. The government needs to create the right environment for a similar collaboration in South Africa through mechanisms such as tax reductions.

The Expo is a national initiative that aims to improve quality and not just quantity, and to redress the inequalities of the past. As part of the Expo activities, 180 university students are allocated to 180 schools for 20 days a year to build systemic capacity. In addition, leading scientists and technologists are invited to interact with the students and to share ideas on innovation, chemistry, physics and ICT. An example of this type of interaction is the meeting between Siyabulela Xuza and Mark Shuttleworth. Siya began experimenting with rocket fuel in his mother's kitchen, which eventually earned him a scholarship to the Harvard School of Engineering and Applied Sciences. Siya is now an acclaimed international scientist with an impressive record of achievements. 21st century skills are passed on to Expo participants to make them internationally relevant.

Learners have participated internationally with great success, and the Eskom Expo International Science Fair is supported by academia, government and the private sector. Bursaries and cash prizes have been awarded, and the initiative is supported by the Department of Science and Technology, the Department of Basic Education, the Department of Public Enterprises, all the national universities and the nine provincial departments of education.

We need to decide where interventions should be targeted, but it is clear that we need to make major investments in education in order to maximise return on investment and ensure a satisfactory end game. We need to create opportunities for learners to fulfil their ambitions and dreams.

## APPENDIX 1: RECOMMENDATIONS

The following is a consolidation of the comments, notes, and trends that were made during the NSTF Discussion Forum 'Implications of the 4th Industrial Revolution for SET, industry, society and education #4IRsciZA' from 11–13 September 2018. They are based on the presentations and discussion points around these. (SET stands for science, engineering and technology.)

There are 10 recommendations with explanation points below.

### We need a common understanding and definition of what the 4th Industrial Revolution (4IR) means.

- The first speaker noted: "Don't get hung up on the name." However, there is a need for a common understanding and definition. There are various explanations, sometimes with commonalities and sometimes with contradictions.
- This leads to standards. While the United Nations is developing these, there is a need for a South African context-specific understanding.
- There is also a need to work on common messages around ecosystems. We hear various messages with specific slants due to people's areas of specialisation. However, it's not just about skills or just about data, we need more information on ecosystems and understanding systems and systems thinking.

### The common understanding/definition must show that South Africa needs to have initiatives and collaborations that focus on local and regional challenges and that show agency.

- The conversation is about taking up the opportunities but with agency – i.e. it is not thrust upon us (deterministic). It is a co-evolution of society and technology as technology is embedded in society. It's about building technology capabilities to localise or adapt foreign technologies, as well as to build our own technologies.
- The common understanding needs to be very clear. What does 4IR mean across industries and sectors? What does it mean in a practical and implementation sense?

### The message is that it is more important to align and integrate 4IR to national and global goals than to focus on 4IR for its own sake. However, the SET community and the entities that lie within it also need direct goals and actions around 4IR.

- While it is important to create something with depth of information, we need communications that can be understood at a glance for example, 'Rationale for interventions' slide. (See slide 21 on the presentation link.)
- Make actions concrete. Then encapsulate these concrete actions with the conceptual framework. This will put concepts into context.
- Need a clear understanding of the limitations and the potential harm – and the ethics around the various issues.

### Provide an information campaign that addresses people's concerns rather than repeated conceptual information.

- For example, 'localise solutions and develop local context technology solutions'. What does that mean for different levels of society? What does that mean for the marginalised?
- It is important to show sources (i.e. follow through on evidence-based thinking). There is confusion about 4IR, as people provide their own perspectives sprinkled with information from other sources.

### There is a need to understand the process.

- Once there is a government-wide 4IR country strategy and action plan – how will we know where the process is? How will we keep track of the discussions, conclusions and output? Will there be a central repository? The same point goes for Department of Science and Technology (DST) actions around 4IR.
- Understanding the process will assist in developing a change in mindset.

**There is a need for transparency and education about the processes of coordination, cooperation, and collaboration.**

- The issues of 'coordination, cooperation, and collaboration' come up all the time. How is this going to work? There needs to be more transparency around what needs to be done. Even if it is: "We are trying everything and hoping it sticks."
- We hear that there cannot be a piecemeal approach. We need to see the links between different areas (i.e. the links between education and business?) It is important to know how 4IR will become integrated, the areas it affects etc. This is a perfect opportunity to use technology as a communication tool to further understanding of the 4IR.
- Consider working with existing groups. It is not always about creating a new collaboration. There are ecosystems and collaborations that exist. Think evolution, as well as new and disruptive methods.
- If an initiative is created and it 'wants' to plug into the larger picture, how does it create the connection? For example, the Telkom/industry/University of Johannesburg initiative. It also needs to be noted that business will just forge ahead if government does not move quickly enough. This means that there will not necessarily be alignment with larger national and global goals.
- It is so important to move beyond the talk of 'taking down silos' and political manoeuvring. Collaboration needs to start happening.
- There is a need to understand the mechanisms of the coordinating bodies. How entities can fit into this. How the process works. How different entities can have a say or an impact… from individuals to regional and continental spaces.
- There need to be wider collaboration processes where people on various levels can give input.

**What does technology and 4IR mean for the move towards multidisciplinary SET/STI (science, technology and innovation) initiatives?**

- There is a focus on the implications of big data and data management for research data, but the issues are more significant than that. There is cross-fertilisation of technology across fields. Does that mean there should be data management and coding courses for SET practitioners? What other technology fields/skills are needed in SET/STI? Is there a need for organisations to have regular audits to ensure technology is embedded effectively for output?
- There is a lot of talk about information-driven decision making but this occurs on all levels not just policy and high-level business. People should be taught how to use technologies for informed decision making.

**Cybersecurity is critical.**

- The following points come from a previous NSTF Discussion Forum 'ICT Security and Privacy Issues' on 15 May 2015. (See media release and proceedings for further information).
    - With more large systems being automated and governed by artificial intelligence, the damage caused by a security breach is vast and the risk is ever-increasing. Already digital information systems are hacked and leaked, rendering individuals very vulnerable. Large scale and up-to-date cybersecurity measures have to be taken by Government to avoid far-reaching future disruptions to systems like water and electricity distribution, transport, etc.
      The South African Police Service (SAPS) has to be enabled and trained to use technology to detect criminal activity and find information to convict suspects. The SAPS also needs the necessary expertise to identify cybercrime and take action before too much damage is done.
    - Data sets, including research data sets, have to have a high level of security to prevent leaking of confidential information as well as tampering with research data.
- There needs to be a national awareness campaign. Managing cyber security needs to be embedded in society.
- We need policy direction on this. However, there needs to be discussion around this including input from the SET community

**Address the issue of jobs more clearly and more transparently – and for specific areas such as the SET environment.**

- There is a need to address job security and the fear of being left behind, as well as creating more jobs and more jobs that are inclusive. Job losses among the unskilled and semi-skilled workers are already a significant issue. Trade unions tend to object to the introduction of new technologies

because they fear that less jobs will be available and people will be retrenched. They are correct, in general, and it was confirmed by presenters at the discussion forum that there will be less job opportunities. However, reskilling certain workers is an option to remedy the situation somewhat.

- Job security and job creation should be approached honestly and transparently. Reskilling or upskilling should be investigated, and be clarified in communication with the public – what it actually means and the real potential. People want actual figures, specific affected industries etc.
- Keep people's concerns as part of the discussion so issues can be addressed. Consider people's fears of the point of singularity (i.e. robots eventually being equal in capabilities to humans in every respect) and the fear of machines replacing and enslaving humans. These matters also involve ethical issues. Legislation, strategies and agreements should anticipate such problems – even if it might happen only in the far distant future.
- While keeping people's fears as part of the discussion, authorities/communicators/legislators should also reassure people on the likelihood of anticipated developments, like artificial intelligence (AI) is unlikely to replacing creativity and that creative aspects of jobs will expand.

**For all the issues, policy and communication to stakeholders should be informed by evidence – examples, case studies and test beds. We need to see the practicality around the implications of the 4IR across education, across employment issues, with business growth etc.**

- Research should be supported on topics such as: how the 4IR is affecting various sectors of industry, society in general and particular groups of people, as well as education at all levels. There is already much innovation across all of these areas involving sophisticated technology, with the potential to bring improvement to people's lives. These developments should be studied while they are being implemented for evidence-based decision making to contribute to a vision of the future and its anticipated challenges.
- When communicating about 4IR, there should be examples of multidisciplinary models that are successful and unsuccessful. This should include what the worker in a specific industry does and what sets of skills are needed. It should be communicated clearly and 4IR and the concepts around it demystified. The more people know about it, the more it will help with resistance to change and people's ability to prepare and adapt. When communicating, information sources should be cited. For example, claims about industries/employers that provide the most jobs should not be made without credible sources of information.
- Evidence should inform efforts to improve the basic education system. There needs to be coordination and communication around what is happening in the various education departments, as well as academia and business. 4IR technologies have the potential to improve the education system dramatically, and it is therefore important to harness this potential to solve long-standing and apparently intractable problems in education. Information technology, digital skills and a digital ecosystem must be embedded in education systems. We need to address – clearly – employment and education through the lens of 4IR and STI/SET.

## APPENDIX 2: LIST OF ACRONYMS

| | |
|---|---|
| 3D | Three dimensional |
| 4IR | Fourth industrial revolution |
| AI | Artificial Intelligence |
| CERN | European Organisation for Nuclear Research |
| CSIR | Council for Scientific and Industrial Research |
| DST | Department of Science and Technology |
| dti | Department of Trade and Industry |
| ICT | Information and communication technology |
| IP | Internet protocol |
| IP | Intellectual property |
| IT | Information technology |
| NACI | National Advisory Council on Innovation |
| NGO | Non-governmental organisation |
| NSI | National System of Innovation |
| NSTF | National Science and Technology Forum |
| PGM | Platinum Group Metals |
| R&D | Research and Development |
| SADC | Southern African Development Community |
| SET | Science, engineering and technology |
| STEM | Science, Technology, Engineering and Mathematics |
| SKA | Square Kilometre Array |
| S&T | Science and Technology |
| STI | Science, technology and innovation |
| TIA | Technology Innovation Agency |
| UJ | University of Johannesburg |
| UK | United Kingdom |
| URL | Uniform resource locator |
| USA | United States of America |
| VPN | Virtual private network |
| WEF | World Economic Forum |

## APPENDIX 3: LIST OF DELEGATES

| Delegate | Organisation |
|---|---|
| Naziv Kalla | Amka Products Pty (Ltd) |
| Prof. Mike Bruton | Author |
| Miss Meekness Lunga | British Council |
| Grant Greyling | Cancer Dojo |
| Mr Admire Mhlaba | Central University of Technology (CUT) |
| Mr Itumeleng Phage | CUT |
| Mrs Gillian Juries | Council for Scientific and Industrial Research (CSIR) |
| Dr Eliya Vukani Madikane | CSIR |
| Dr Fisseha Mekuria | CSIR |
| Dr Daniel Visser | CSIR |
| Prof. Elmarie Biermann | Cyber Security institute |
| Mr Mathala Mokwele | Department of Agriculture, Forestry and Fisheries |
| Alex Allie | Department of Economic Development and Tourism, Western Cape |
| Mrs Siphiwe Mthombeni | Department of Science and Technology (DST) |
| Mr Ndivhuwo Munyai | DST |
| Mr Modikoe Patjane | DST |
| Mrs Duduzile Phungwayo | DST |
| Miss Obaheng Pitsoane | DST |
| Miss Elelwani Ramabulana | DST |
| Mr Johann Strauss | DST |
| Ilse Karg | Department of Trade and Industry (the dti) |
| Mrs Nontombi Marule | the dti |
| Charles Mnisi | the dti |
| Takalani Ramuthagu | the dti |
| Mrs Nonkululeko Shinga | the dti |
| Mr Nimrod Zalk | the dti |
| Teboho Qholoshe | Eastern Cape Socio Economic Consultative Council |
| Mr Parthy Chetty | Eskom Expo for Young Scientists |
| Lyndon Mana | Exposcience |
| Rethabile Maimane | Golden Goose Catering |
| Viwe Sigenu | Human Sciences Research Council (HSRC) |
| Moses Sithole | HSRC |
| Shabier Jacobs | IMA Media |
| Mthunzi Malibongwe | Izenzo |
| Prof. Kedibone Phago | Mangosuthu University of Technology (MUT) |
| Mr Dave Pons | MUT |
| Esa Alexander | N Projects Media |
| Mr Aadil Essop | National Metrology Institute of South Africa |
| Prof. Khaled Abou-El-Hossein | Nelson Mandela University |

| Delegate | Organisation |
|---|---|
| Luveshnee Reddy | Old Mutual |
| Kim Wentzel | Old Mutual |
| Dr Agnetha Arendse | Parliament |
| Mrs Fatima Boltman | Parliament |
| Dr Renée Osborne-Mullins | Parliament |
| Mr Jurgens Pieterse | Parliament |
| Mr Lechesa Tsenoli | Parliament |
| Sizwe Mnamatha | Phumelela Solutions |
| Ms Taonga Chilalika | Program for Appropriate Technology in Health (PATH) |
| ED Magan | Rail Pro |
| Mdu Biyela | SA Tourism |
| Tshepo Maseko | SA Tourism |
| Nokwanda Mkhize | Saldanha Bay IDZ |
| Kwanele Makeleni | SB Connect SA |
| Mrs Bev Russell | Social Surveys Africa |
| Mr Sekwanele Kubeka | South African Bureau of Standards (SABS) |
| Miss Lunghile Mhlaba | SABS |
| Mr Richard Sadiki | SABS |
| Mr Tshepo Segoko | SABS |
| Mr Bjorn Hufkie | South African National Conventions Bureau |
| Anneline Morgan | Southern African Development Community |
| Mr Simon Ratcliffe | Square Kilometre Array |
| Dr Katherine Foxon | Sugar Milling Research Institute |
| Tanya Farber | Sunday Times |
| Jaspa Rees | Technology Innovation Agency (TIA) |
| Mr Garth Williams | TIA |
| Miss Tumisang Sepeng | The Platinum Incubator |
| Dr Tshiamo Motshegwa | University of Botswana |
| Prof. Tania Douglas | University of Cape Town (UCT) |
| Mr Francois Oosthuizen | UCT |
| Mr Gerard Verhoef | University of the Free State |
| Prof. Babu Sena Paul | University of Johannesburg |
| Dr Busisiwe Alant | University of KwaZulu-Natal |
| Prof. Abram Madiehe | University of Western Cape (UWC) |
| Koena Moabelo | UWC |