Digital Futures

Digital Strategy Report

DEAKIN UNIVERSITY

We acknowledge the Traditional Custodians of all the unceded lands, skies and waterways on which Deakin students and teachers come together. As we learn and teach through virtually and physically constructed places across time, we pay our deep respect to the Ancestors and Elders of Wadawurrung Country, Eastern Maar Country and Wurundjeri Country, as well as the Traditional Custodians of all the lands on which you may be learning and teaching, where education has taken place for many thousands of years.

Digital Futures Statement

This report is prepared on behalf of Deakin's Digital Futures program (formerly known as Deakin Innovation for SME Hub - DISH), which is funded with co-contributions from the Victorian Higher Education State Investment Fund (VHESIF). VHESIF has been developed in response to the significant impact of the coronavirus (COVID-19) pandemic on Victorian universities. This fund is intended to support universities with capital works, applied research, and research infrastructure projects focused on boosting Victoria's productivity and economy as the State recovers from the pandemic.

The primary objective of the Digital Futures program is to help the digital transformation of Victoria's small and medium-size enterprises (SMEs) by providing them with access to a range of services and technologies. According to the latest Australian Bureau of Statistics report (2021-2022), there are currently more than 726,000 businesses in Victoria. More than 98% of them are considered to be SMEs. This is why the activities of the Digital Futures program are so vital to the productivity and economy of the State.

The Australian Government and the Government of Victoria, via the VHESIF program and other funds, are focused on introducing a thriving digital economy by attracting talent, upskilling communities, and businesses, creating jobs, and bridging the digital divide. Given the ever-changing nature of this sector, the intent of this report is for Deakin University to update and further align the scope of the Digital Futures program with the State and Federal Government's Digital Strategy Plans. This report is prepared by using the Deakin 2030 - Ideas to Impact Strategic Plan as a guiding document.

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Digital Futures
Digital Strategy Report

TABLE OF CONTENTS

The Future of Technology

Don Norman

Distinguished Professor Emeritus, UCSD
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"Predicting the future is easy," the Nobel Laureate in Economics, Herbert A. Simon once told me. "People do it all the time. The hard part is getting it right."

Even though I know the difficulties, I cannot stop thinking about the future, not by predicting but by forecasting. What is the difference? A forecaster explores possibilities, sometimes by presenting multiple reasonable scenarios, even though all are different, sometimes (as in the case of weather forecasts) discussing the likelihood of an event happening. The goal is not to be accurate (because that is not possible) but instead to be ready, to be prepared. Technological breakthroughs are infrequent and often unexpected. Moreover, the time between a breakthrough and its appearance in the world as something useful, reliable, and affordable is measured in decades. The activities in research laboratories around the world are important sources of forecasts. Many of these great breakthroughs will never become practical enough for use, but some will. By preparing for all of them, though, we will be ready no matter what happens.

Here are some general forecasts about the future of technology.

The advances in micro-and nanoelectronics will make things smaller, thus requiring less power while increasing speed and accuracy. This decrease in size enables advanced processing by small portable devices that will in turn enable many other new technologies to be affordable and useful. New sensors will enable the measurement of more and more physical as well as biological variables, including deductions from observations of human and animal behaviour.

Communication technologies will become so small and ubiquitous that, when coupled with small, powerful computational devices, and a wide variety of sensors, almost everything of importance in the world will be monitored and observed. Many of these new devices will be mobile, even airborne, flying using propellers as in today's drones, or, for tiny objects, using a variety of biological mechanisms, especially flapping wings.

The world of invisible and ubiquitous computing, discussed and predicted in the 1990s, will be with us even more than it is today. Advances in batteries and motors will enable many things to be motorized: baby carriages, shopping carts, as well as walkers, and rollators for those who have difficulty with gait or balance. Some of these devices may become unnecessary, as exoskeletons become smaller, more powerful, and intelligent. The modern automobile already has hundreds of motors, most of them electric. We already have motorized surfboards and skateboards, and if we can make these things, think of what we can do with almost anything that has moving parts.

Exoskeleton? What is that? It is an external structure – often called an external skeleton, hence "exoskeleton" – worn by a person to compensate for injury to the body to enable walking or the use of limbs, or as a device to allow people to carry heavy objects or exert far more strength than is possible by the unaided human. This is yet another technology that has been worked on for over a hundred years (a US patent was issued in 1890 for an "apparatus for facilitating walking") and is the dream of many science fiction novels and movies. But if the problems of the excessive weight of the skeleton and of energy supplies can be overcome, exoskeletons will one day become common, everyday devices.

The most common energy source is batteries, but the power demands are so high that the battery weight and restricted lifetime are severe impediments. Today, there are commercial units used in hospitals for rehabilitation and in some manufacturing facilities to allow people to manipulate heavy loads, and there are units in various testing stages for the military.

What about biological advances? They will be numerous: sensors for all sorts of ailments; genomic sequencing done inexpensively in a few hours; new biological markers and sensors; new smart systems for diagnosing, monitoring, relieving pain, and improving muscular control – all of which will not be cures but will nonetheless minimize the negative impacts of the underlying disease. Many of these devices will be used in the home or worn on or in the body without the necessity for supervision by medical assistants.

New understanding of biological and neurological processing will enable many advances. The use of biologically inspired products will increase. Advances in medicine will lead to better predictions and treatment of medical conditions, with home analysis & monitoring and individualized medicine appropriate to the needs of each patient.

There will be new sources of energy and increased efficiency in all energy-using devices. And there will be new ways of producing the technologies the world needs to continue to be sheltered and to have productive occupations, education, and lives – all without harm to the world's ecosystems.

The concept of money may very well change. Consider cryptocurrency – a new and rather confusing idea. It is a digital form of money, but with a difference. Money itself is confusing, and very few people understand the concept. Before you insist that it is simple, try to answer why people assume that pieces of paper have any value. They have value mainly because of trust in the government, but what is that trust based on?

Much of the money in the world is digital, not physical, whether in the form of credit cards or wire transfers, and today can be directly and digitally transferred from person to person or from person to store by using a smart device such as a mobile phone rather than by taking it out of your wallet and handing it over: "mobile money" it is often called. The future of money, it is becoming increasingly clear, is digital.

Today, all that digital currency still flows through the banking system, which includes governmental agencies. Does cryptocurrency change this process in a satisfactory, trustworthy way? Some people believe that cryptocurrency is still in its infancy, so what you hear about it today is not what it has the potential to do. Money is simply paper or digital figures in a database. Money works because people have trust in the government that has issued it, which means that the money of different countries has different values of trust. Many people who are deeply involved in cryptocurrency believe that it represents a fundamentally new perspective and view of currency.

Many of the advances in technology, biotech, sensors, and motors will be driven by Artificial Intelligence (AI). How threatening is AI? The main threat is unintelligent use of technology – any technology. It's like a gorilla. Gorillas in the wild are peaceful. They are vegetarians, so they spend much of the day chewing on plants, leaves, seeds, and fruits. If you approach them quietly, intelligently, your interaction with them will be an enjoyable experience. AI need not be a threat, but it must be approached, designed, and implemented intelligently, with full understanding of the people with whom it will interact and with the aim to enhance their activities, not to replace them.

Unfortunately, technologists who design and release AI – and most new technologies – are proud of their expert technical skills but overlook ethical considerations such as enabling equity, eradicating bias, and ensuring that people are in control. They seldom will think of how to design the new technologies so that people are comfortable with the way they work and perform. All too often, these societal and social issues lie outside the development team's technical expertise. This limitation is understandable, for these technologies require certain kinds of specialization, and human-and humanity-centred design principles like ethics and equity, are quite a different specialty. This is why every team of technologists should have social scientists among them, people who do understand these principles and who will assist the technologists in addressing them. Quite often in the rush to deliver the new, amazing wonders of the world to the waiting public, technologists and designers push the social issues aside, giving AI the bad reputation, it has today.

Automation will change how work is done, whether by AI, robots, or other technologies. This might be virtuous if it allows a change in the notion of work. What if we could move from the notion of work – an activity that many people consider a chore and a burden, necessary for the income provided but not something they look forward to every day – to the notion of an occupation. Let's replace jobs with occupations and professions. Give some meaning to income-earning activities, which will allow workers to have pride in their accomplishments.

It is also important to pay attention to the letter A of AI. The A stands for "artificial." Artificial intelligence and human intelligence are quite different, and that diversity can either be threatening or, if used properly, a source of powerful enhancement of people's abilities.

I once took a course at MIT on the design of rockets in which a homework problem might take a full week to complete, not because it was difficult to understand but because we had to do so many calculations. We invariably got the wrong answers, not because we didn't understand what we were doing but because there were so many calculations that we were bound to make errors in some, and then each error would propagate through the problem. Today, the very same problem can be solved in 30 minutes using a calculator or, better yet, a computer program. Today, the use of computer tools and AI allows students to solve far more complex problems than my class could do and, moreover, lets the students concentrate on the science behind the issues, not just on the mechanics of grinding out numerical answers.

The National Academies of Sciences, Engineering, and Medicine did a study of the use of AI and concluded that "there will be an increased need for AI systems to function effectively as teammates with humans." Moreover, they continued, "when considering an AI system as a part of a team, rather than simply a tool capable of limited actions, the need for a framework for improving the design of AI systems to enhance the overall success of human-AI teams becomes apparent."

We live in an artificial world where we can no longer survive without the artificial artifacts that govern our lives. But today, technology often has priority, forcing people to behave according to its artificial and arbitrary requirements. It is time to change this perspective, put people first, to allow, and encourage people to do the activities they want to do and have technology do whatever the tasks they don't.

What tasks?

They are known as the three D's: dull, dangerous, or dirty tasks.

Don Norman's insights featured in this Foreword have been discussed in greater detail in his new book, ***Design for a Better World***, which was published by The MIT Press earlier this year.

Preface

Gjoko Muratovski

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The Australian Government's vision is for Australia to become a Top 10 digital economy and society by 2030. According to Australia's Digital Economy Strategy (issued by the Prime Minister and Cabinet in 2021 and updated in 2022): "The potential benefits to the Australian economy through digitalisation have been estimated to be as much as $315 billion over the next decade, with the potential to create up to a quarter of a million new jobs by 2025." The Government of Victoria, via the VHESIF program and others, is also focused on introducing a thriving digital economy by attracting talent, upskilling communities, and businesses, creating jobs, and bridging the digital divide.

The overarching intent of the Digital Futures program is to lead the digital transformation of the Australian economy while building on the State and Federal Government's existing digital strategy initiatives and future pathways in this space. In doing so, we want to ensure that our efforts are in line with current industry trends, government funding, and future partnership opportunities.

For the preparation of this report, I have enlisted the help of TATA Consultancy Services (TCS), the largest Information Technology Services consultancy in the world. They operate in 150 locations across 46 countries and have over 600,000 employees worldwide. In addition to this, I have also asked Don Norman, the former Vice President for Advanced Technologies at Apple (now retired) to share some of his insights on the future of digital technologies in the Foreword to this report.

Deakin University, via the Digital Futures program, is committed to becoming a leader in digital transformation in Australia. Working closely with our partners from government and industry we aim to support both businesses and the community by providing advice and access to new and emerging digital technologies services. This endeavour would not have been possible without the support of the State of Victoria and the Victorian Higher Education State Investment Fund (VHESIF).

Executive Summary

Six leading digital technologies are currently transforming industry, government, and academia.

Artificial Intelligence, Cloud and Edge Computing, Cybersecurity, Quantum Technologies, Web3, and the Metaverse are evolving and will continue changing the technological innovation landscape. They are introducing radically new business models that will change how humans interact with and, in turn, are impacted by technology.

AI and Quantum Computing, for instance, have already shown significant potential for revolutionising computing by offering faster and more efficient methods of solving complex problems. Cloud and Edge Computing, on the other hand, are enabling businesses to become more agile and scalable. Cybersecurity is quickly becoming a top priority for every business and organisation due to the increasingly complex and sophisticated nature of cyber threats. Web3, the next iteration of the internet, and the Metaverse are redefining how we interact with technology and each other.

Given the sheer scope and potential of these technologies, it is vital that university research departments dedicate the time and resources necessary to research them thoroughly and create a unique opportunity to play a critical role in developing and nurturing the evolution of these technologies.

Five emergent areas are shaping the future of people and the planet.

Bioengineering, Energy Transition, Mobility, Space Technology, and Sustainability are increasingly becoming front-and-centre initiatives impacting industries and attracting significant levels of government involvement.

These emergent fields are poised to shape the future of humanity by catalysing the adoption of cutting-edge technologies and disrupting traditional industries. These ground-breaking fields offer solutions to some of the biggest challenges facing our planet, from climate change to healthcare, and have the potential to revolutionise the way we live, work, and interact with each other. With a view to leveraging their innovative capabilities, the appetite for long-haul investments in these fields is a giant leap in ensuring a more sustainable and equitable future for all.

This report also reflects on Australia's Digital Economy Strategy 2030. It outlines the critical technologies the government deems necessary for Australia to become a formidable global player in the digital economy.

The Australian government is currently (i) setting the foundations to grow the nation's digital economy, (ii) investing in emerging technologies that drive future productivity and prosperity, and (iii) setting digital priorities by partnering with the private sector to drive digital growth, jobs, and capability.

As part of this report, we have benchmarked the critical technologies of interest to the Australian Government to Deakin University's Impact Themes (see Appendix 1). Our study shows that there is significant alignment between Deakin University's impact themes (Improving Health and Wellbeing; Creating Smarter Technologies; Building Safe and Secure Communities; Advancing Society, Culture, and the Economy; Enabling a Sustainable World). In addition to this, we have assessed the Australian Government investments in digital technologies in 2021-22 (see Appendix 2) and collated the expected government funding in digital technologies for 2023-34 (see Appendix 3).

The only constant is change.

This document recognises that we live in a VUCA (Volatile, Uncertain, Complex, Ambiguous) world. In capturing the current insights into these digital transformation technologies, their trends and their impacts, this report hopes to do its bit to further support Deakin's Digital Futures strategy and the digital technology research capabilities at Deakin University.

Introduction

Deakin University is a leader in the innovative use of digital technologies, and digital is in its DNA. Deakin's investment in digital capabilities and platforms focuses on enhancing the experience of learners and other stakeholders, improving productivity, uplifting agility, and enabling the *Deakin 2030: Ideas to Impact* strategic plan.

Deakin's research and innovation addresses focus areas in five Impact Themes:

1. Improving Health and Wellbeing
2. Creating Smarter Technologies
3. Building Safe and Secure Communities
4. Advancing Society, Culture, and the Economy
5. Enabling a Sustainable World

'Digital' is a common thread for enabling and advancing the research in all five impact themes. The digital innovation capabilities span several faculties/institutes within the university. As digital innovation needs are evolving rapidly, the university intends to comprehensively develop central and federated digital capabilities to manage a digital innovation portfolio that can secure competitive research grants and projects.

In this regard, new digital technologies identified by Australian Government as technologies of critical national interest have been mapped to the five research impact themes that Deakin University (see Appendix 1).

What makes the Digital Futures report relevant?

The Digital Futures Report examines digital technology trends globally across various industries. It takes a considered view of emerging critical technologies that are accelerated by the adoption of digital technologies. The report examines how such critical digital technologies – for example, in areas like bioengineering and sustainability – are playing out with the potential to cause paradigm shifts. The report is also informed by the investments and initiatives of the Australian Federal and State Governments in their strategy plans for digital economies.

As such, this report intends to help Deakin University benchmark its digital innovation capabilities with digital value chains that are playing out globally in industry, government, and society. Furthermore, the also report aims to help the university to make informed decisions when it comes to new digital technology investments and pursuit of new digital research projects, grants, engagement of industry clients, and the delivery of world-class research in digital technologies.

Methodology

The Digital Futures report examines the role of digital in business and society based on current trend indicators observed across various industry sectors. The approach is phenomenon-oriented and relies on analysis using a mix of TCS Research and IP, complemented by insights realised from publicly available documents published by entities such as – governments, corporates, and leading analysts. This approach also provides a well-rounded perspective on digital trends and impacts from leading entities that can influence or set global trends.

While creating this report, several key indicators were examined, such as: what are the emergent global and local digital trends; which digital technologies are industries up-skilling and/or re-skilling their employees in; what digital technologies are industries adopting to continue to stay relevant in the economic world-order; what digital initiatives are governments funding; where are technology companies placing their investments; and which digital trends have the potential to influence and change societies.

TCS reviewed multiple research and analysts reports on digital capabilities across a range of industries to identify common emerging themes. The emerging themes were then verified and accordingly filtered through the insights from 'TCS Research' on the trends for future. The emerging trends may have different relevance for each industry or geography. A brief overview of the emerging themes is provided in the report from a high-level perspective and is intended for briefing purposes only.

TCS Research and IP

TCS has a well-established Research and Innovation Centre that conducts research in leading digital technologies and has developed a Co-Innovation Network (COIN™) comprising over 2000 entities spanning Academia, major Technology companies, and Start-ups. TCS' Research unit enables insights into a complex global business landscape marked by digital disruptions and technological breakthroughs – all achieved through extensive research efforts and collaborative innovation. TCS' Research unit explores emerging solutions with a scientific spirit of enquiry to advance industry capability and knowledge and harness customer-focused, domain-specific innovation.

TCS' Research unit has an extensive network of innovators, academics, technocrats, and venture capitalists, who co-create, fund, and develop unique ideas through the Co-Innovation Network (COIN™). TCS COIN™ brings together industry leaders, analysts, scholars, and start-ups to conceptualise breakthrough solutions for industry. It enables the creation of new revenue streams and accelerates go-to-market initiatives to help clients in their digital transformation journeys. Combining insights from stakeholders with primary and secondary research, TCS COIN™ opines on the technology landscape and trends that could be at the helm of the next wave of disruption.

Access to these proprietary insights has played an important role in informing the development of the Digital Futures report.

Secondary Research

Publications from leading analyst and consulting firms that provide quality compelling insights and intelligence on digital trends that impact industries, governments, and societies have also been used in the preparation of this report. In addition to this, publicly available information from the Australian Government on aspects such as the Digital Economy, Critical Technologies, and Research Grants was also included. A bibliography of all publications consulted in the preparation of this report is available at the end of this document.

General Overview

The first quarter of the 21st century will go down in history as a remarkable period where new digital technologies increasingly power people, the planet, and profits. And this is just the beginning.

Significantly higher uncertainty and complexity in global environments coupled with the global pandemic acted as a wake-up call for most enterprises, forcing them to accelerate digital adoption. The Australian Government's Digital Economy Strategy 2030, notes that the measure of success for the strategy is, that "All new businesses are born digital." In a world post-COVID-19, these kinds of initiatives are the new normal.

Over the past few years people had no choice but to embrace new digital behaviours that are now driving a new digital era. As a result, we expect to see continued efforts towards digital inclusion in core service sectors such as Banking and Finance, Insurance, Healthcare, and others. Additionally, there will be a continued focus on optimising value networks end-to-end. We also foresee more human-plus-machine interaction, cognitive automation, and the emergence of purpose-led ecosystems focusing on data, computing, and user experiences.

The theme above was further validated through TCS' global leadership survey that highlighted key criteria for transforming into adaptive, intelligent, and composable enterprises.

1. Participation in cross-industry digital ecosystems will be increasingly important to provide growth potential, enhance business agility, and improve customer experience.
2. Data is the new oil and foundation for digital transformation to specifically drive innovation, build competitive advantage, and respond quickly to changing market conditions.
3. Digital innovation embedded at every level of the business provides holistic outcomes by enhancing efficiency, empowering employees, and improving business agility.
4. A digital economy needs a digitally savvy workforce to maximise the efficiency, collaboration, and communication benefits of its technology. This requires a cultural adoption along with standard training.
5. Businesses with Digital DNA will succeed in the digital age. Such businesses overcome legacy constraints of technologies, business processes and operating models. They can quickly pivot to new opportunities, by adopting digital technologies and practices that prioritise agility.
6. "Secure by design" digital architecture ensures that digital infrastructure is resilient and protected against a wide range of threats, reducing the risk of data breaches, system failures, and other cyberattacks.

Australia's Digital Economy

The Australia Digital Economy Strategy 2030 aims to improve Australia's digital economy through innovation, investment, and infrastructure development. The strategy emphasises the need for businesses and governments to work together to position Australia as a leading digital economy and drive sustainable economic growth and prosperity for the country's citizens. It sets out to achieve four key goals:

1. Improve business productivity and competitiveness by **embracing digital technologies and innovative business practices**.
2. Build a **world-class digital infrastructure** by investing in next-generation technologies and promoting access to high-speed internet and digital technologies.
3. Build a **more skilled and capable workforce** by investing in education and training programs focused on digital skills and innovation.
4. Foster and support **innovation by investing in research and development** and promoting collaboration between businesses, universities, and government agencies.

The Victoria Digital Strategy 2021-2026 aligns with the federal strategy with a strong focus on building a robust digital economy. Its main objective is to leverage the potential of digital technology to drive economic growth, improve social outcomes, and enhance citizen engagement through a digital-first approach.

Some of the common themes emerging from federal and state level digital strategies are summarized below:

- **Innovation:** Supporting start-ups and fostering a culture of innovation to drive growth.
- **Infrastructure:** Improving connectivity to ensure access to services by establishing digital infrastructure.
- **Skilling:** Building the skills and capabilities of the workforce and creating new job opportunities.
- **Digital Inclusion:** Removing barriers to digital access and ensuring that people can participate in the digital economy.
- **Cyber Security:** Protecting digital assets and data through effective cyber security measures.

The Australian Government has made significant investments in the critical technologies identified as part of its digital strategy. Over $1 billion has been invested in these technologies in 2021 and 2022 (see Appendix 2). Key investment highlights from 2022 include:

- $70 million to establish a Quantum Commercialisation Hub.
- $22.6 million to further support 5G innovation.
- $3.9 million for helping women transition mid-career to the digital workforce.
- $53.8 million for establishing a National Artificial Intelligence (AI) Centre and four AI and Digital Capability Centres.
- $33.7 million for AI-based solutions to solve national challenges.

Digital Skills Initiatives

Ensuring Australians have the right knowledge and skills to take advantage of, and contribute to digital technologies, is a stated goal of the Australian Digital Strategy. Digital skilling has become vital for success in today's VUCA world. Despite 69% Australians being willing to digitally upskill for better employability prospects, only 28% have been provided with training in the past 12 months.

The Australia Digital Economy Strategy 2030 notes that digital will revolutionise industries, adding up to $315 billion to the Australian economy by 2025. To this end, a key success indicator is that by 2030 all new businesses will be born digital and 95% of all SMEs will have a digital presence or use digital processes.

A challenge though, is that 2.5 million Australians remain offline, as noted in the Victoria Government Digital Economy Strategy 2021-2026. People and businesses with lack of access to technology or digital skills risk being left behind in the race to self-sufficiency in the digital economy. Prior to the COVID-19 pandemic, SME engagement with digital products was low, with only half of businesses having a web presence, 40% using cloud services, and very few citing cyber security as a priority. Over 2020, the pandemic made it an imperative for many Australian SMEs to actively engage with digital technology to adapt to changed conditions. Nearly 9 in 10 Australian firms adopted new technologies to improve their business continuity during COVID-19, with 13% recognising that technology tools were essential to their operations.

While the adoption of digital tools has accelerated among SMEs, the growing gap between connected and disconnected businesses has become more pronounced. Despite the benefits that digital technology can offer, many SMEs remain unaware of its potential to provide solutions for their business challenges. As a result, there is a pressing need to bridge this knowledge gap and create awareness around the potential of digital tools to define a pathway towards success for SMEs. New nation-wide programs for digital literacy, business literacy, and financial literacy will need to be rapidly introduced to the general population (both businesses and consumers) for the Australian economy to become a leading digital economy by 2030. Given that Australia's SMEs constitute 98% of all businesses in Australia this is an important first step.

The need for digital adoption by SMEs

It is imperative that SMEs capitalise on the value of using digital tools and services such as payroll, payments, and inventory management systems, online sales platforms, and social media. SMEs must adopt and adapt digital technology to add flexibility, mobility, and resilience to their businesses, to save time and money.

Government, large corporates, higher education providers, as well as technology practitioners need to work together towards innovative learning programs to enable better access of digital skills for SMEs and close the digital skills gap.

Planned investment to cultivate digital skills

Through its Digital Strategy, the Australian Government is investing in the skills and training needed to make Australia a leading digital economy by 2030. Some of the key initiatives in this space include:

- $10.7 million for the Digital Skills Cadetship Trial to deliver work-based learning opportunities for in-demand digital jobs.
- $43.8 million for the Expansion of Cyber Security Skills Partnership Innovation Fund to fund additional innovative projects to quickly improve the quality and quantity of cyber security professionals in Australia.
- $24.7 million over six years for the Next Generation Artificial Intelligence Graduates Program to attract and train home-grown, job-ready AI specialists through competitive national scholarships.
- $22.6 million over six years for the Next Generation Emerging Technology Graduates Program that will provide more than 200 competitive national scholarships in emerging technologies.

Key Trends for Digital Futures

TCS constantly monitors and assesses technology trends, opportunities, and challenges in the digital space to serve the needs of its global client base that spans industry, academia, and government. TCS has first-hand exposure to how organisations adapt, consume, and innovate to stay ahead of the curve by taking advantage of emerging digital opportunities. This puts TCS at the forefront of anticipating and responding to the latest developments in digital, business, technology, changes in consumer behaviour, emerging digital business models, regulations, and other industry-specific factors.

Informed by extensive secondary research, with inputs from Australia and Victoria digital strategy, and further complemented by TCS' forward-looking perspective of the digital landscape, the below list of digital capabilities is identified as trending high:

1. Artificial Intelligence
2. Cloud and Edge Computing
3. Cyber Security
4. Quantum Technologies
5. Web3
6. Metaverse

TCS is also seeing the advances in the above identified technologies leading to significant impact in five emerging areas. Each of these emergent areas in isolation and together has potential to shape human experiences and, more importantly, how we interact with nature and the spaces around us. They include the following:

1. Bioengineering
2. Energy Transition
3. Mobility
4. Space Technology
5. Sustainability

Industry Impacts

Every industry is impacted by the convergence of various digital technologies. Leading digital technologies and emerging areas listed in the previous section are of varying relevance in the near to long term for various industries.

The figure below paints a qualitative data picture of digital technologies' near to long-term impacts on multiple sectors. It considers aspects such as: (a) the potential of the technology to shape and influence the industry, (b) adoption of the technology as enterprises undertake their transformations, and (c) generate value for the industry and stakeholders.

Each digital technology has its inherent capabilities. These capabilities can be leveraged with varying degrees of relevance for fulfilling the stated objectives of each of the Deakin University's Impact Themes as reflected in the following chart.

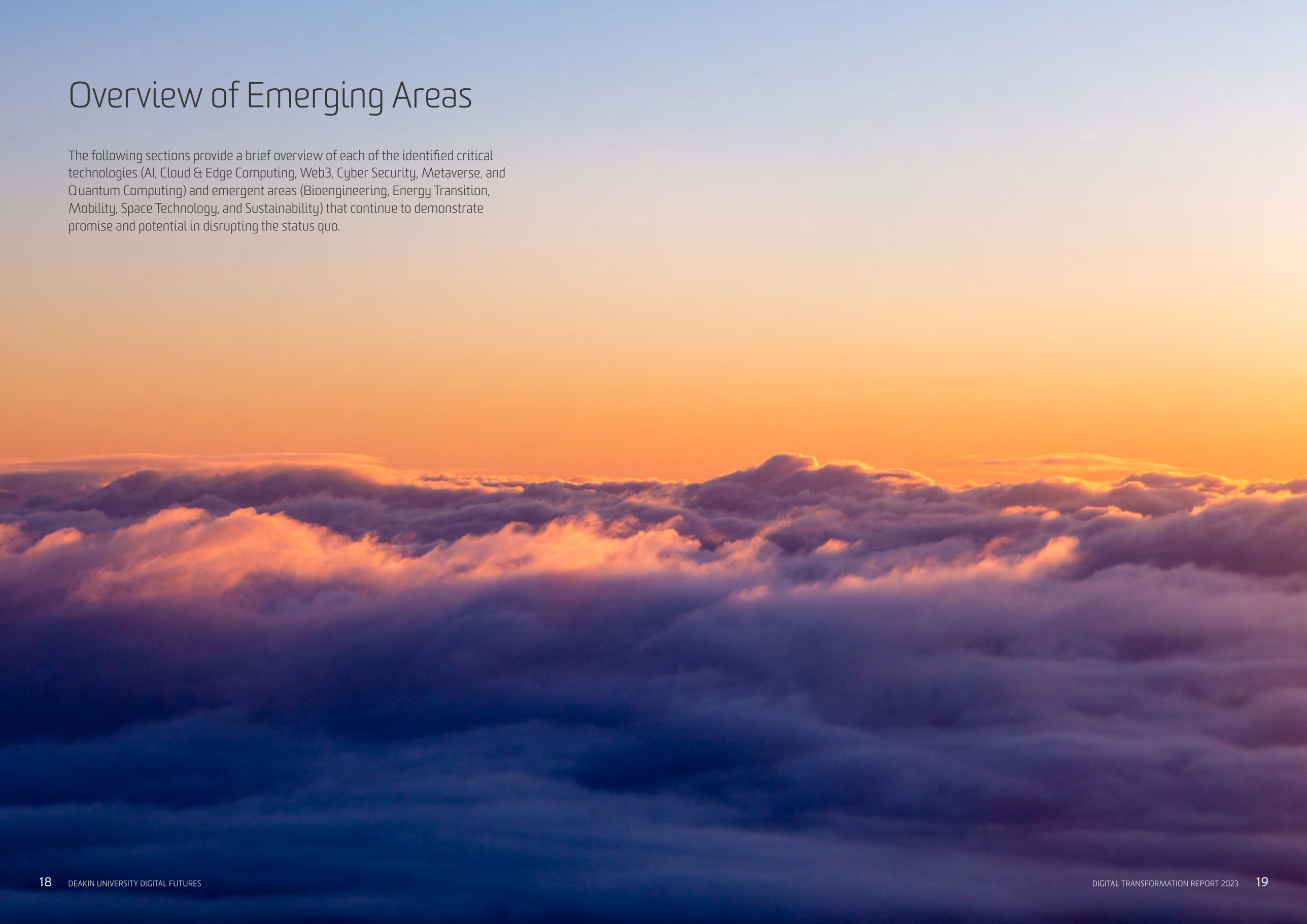
Impact Themes

Minimal Relevance — High Relevance

		ARTIFICIAL INTELLIGENCE	CLOUD & EDGE COMPUTING	CYBER SECURITY	QUANTUM COMPUTING	WEB 3.0	METAVERSE	BIOENGINEERING	ENERGY TRANSITION	MOBILITY	SPACE TECHNOLOGY	SUSTAINABILITY
INDUSTRIES	Banking											
	Capital Markets											
	Consumer Goods & Distribution											
	Education											
	Energy & Resources											
	Healthcare											
	High Tech											
	Insurance											
	Life Sciences											
	Manufacturing											
	Media & Entertainment											
	Public Services											
	Retail											
	Telecommunications											
	Travel & Logistics											
	Utilities											
DEAKIN IMPACT THEMES	Improve Health & Well-Being											
	Creating Smarter Technologies											
	Building Safe & Secure Communities											
	Advancing Society, Culture & Economy											
	Enabling a Sustainable World											

Overview of Emerging Areas

The following sections provide a brief overview of each of the identified critical technologies (AI, Cloud & Edge Computing, Web3, Cyber Security, Metaverse, and Quantum Computing) and emergent areas (Bioengineering, Energy Transition, Mobility, Space Technology, and Sustainability) that continue to demonstrate promise and potential in disrupting the status quo.



Artificial Intelligence (AI)

The power of AI was unleashed to the public in late 2022 through ChatGPT, a chatbot powered by Generative AI created by OpenAI. AI is the enabler of other technologies and powers the evolution of business, government, and societies. The potential value at stake from AI is estimated globally at over $15 trillion by 2030.

AI has several primary areas for research and innovation including Machine Learning (ML), Computer Vision, Natural Language Processing (NLP), Deep Reinforcement Learning, and Knowledge Graphs. Research is shifting from traditional convolution neural network to transformer-based models. Recommender systems coupled with generative AI are leading to further personalisation of products and services. The AI models in use are for text, images, video, voice, 3D, and animation. Models for bioengineering climate science, and multi-modal models are now also emerging.

The race to build supersized AI Models and Large Language Models is intensifying. Unifying learning process through self-supervised learning, transition to textless NLP, amping up diffusion models, AI for code research, AI at the edge, Explainable AI (XAI), AI Chipsets are emerging. Moreover, as AI is making entry into Boardrooms, the focus has shifted from a siloed approach to building Enterprise-wide AI Vision, Strategy, Roadmap, Operating Model, Governance and Culture.

At enterprise level, generative AI will continue to be incorporated into consumer applications. For instance, Canva, the popular online graphic design tool, has integrated Stable Diffusion in its platform while Microsoft has incorporated OpenAI's DALL-E 2 image-generating system into its Microsoft Designer and Image Creator applications. Huge focus from Microsoft, Google, and Amazon Web Services (AWS) to continue to grow their capabilities through partnerships and acquisitions.

Emerging Opportunities

- **Pharmaceutical Research:** Reduced timeline for new medical treatments and drugs to come to market using a combination of Virtual Screening, Machine Learning, Target Identification, and Design Optimisation.
- **Anomaly Detection:** Utilising AI for analysis of scans to identify anomalies significantly quicker and enabling nurses to conduct the analysis using dedicated software.
- **Fraud Detection:** Developing more sophisticated methods for the identification of fraudulent banking transactions.
- **Aviation Design:** Enhanced simulations for aircraft design to optimized and reduce the time to create working models.
- **Predictive Analytics:** Wider application of predictive analytics and improved accuracy as algorithms become more sophisticated.

Australian Government Focus

Australian Government has clear vision laid out for AI to vision for AI to establish itself as a global leader in developing and adopting trusted, secure, and responsible AI by 2030. The government has invested $470M since 2018 ($124.1 M in 2021-22) as part of the Australian Government AI Action Plan. Australia's AI Action Plan focuses on four areas: using AI to transform business, building on Australia's AI talent, using AI to solve national challenges, and ensuring AI is used responsibly and inclusively. The 2023-24 federal budget identified $101.2 million over five years to integrate AI and quantum capabilities into Australian industries and extend the remit of the National AI Centre (see Appendix 3).

Some key initiatives committed by the government in AI are listed below:

INITIATIVE	INVESTMENT
Establishing a National AI Centre and AI and Digital Capability Centres	$53.8 million
AI-based solutions to solve national challenges grants	$33.7 million
Catalysing AI in our regions grants	$12.0 million
Next Generation AI Graduates Program	$24.7 million
Next Generation Emerging Technology Graduates Program	$22.6 million

Things to Watch

- **Ethics in AI:** Legal and ethical issues arising from the use of AI in decision-making processes, particularly in fields such as healthcare and criminal justice. Ensuring trustworthy and reliable AI algorithms and systems is a challenge to avoid AI confidently providing inaccurate or biased responses.
- **Explainability Concerns:** To provide trustworthy and reliable information the AI Model needs to be fully understood. As AI models get more and more complex this is increasingly difficult to articulate with sufficient confidence.
- **Misuse of AI capabilities:** Deepfakes, Hacking and AI Terrorism are examples of potential negative utilisation of AI.

Cloud and Edge Computing

Cloud and edge computing can work together to create a hybrid approach that combines the scalability and flexibility of cloud computing with the speed and efficiency of edge computing.

Cloud computing refers to the use of remote servers to store, manage, and process data, while edge computing involves processing data closer to where it is generated, such as on a device or at a local server. The global cloud computing market is projected to grow from $480.04 billion in 2022 to $1,712.44 billion by 2029, at a Compounded Annual Growth Rate of 19.9% in the forecast period.

Cloud computing is often used for large-scale data processing and storage, while edge computing is used for real-time data processing and analysis, such as in Internet of Things (IoT) devices or autonomous vehicles. This critical combination allows for more efficient and effective data processing and analysis, which is increasingly important in today's data-driven world. The market for edge is currently estimated to be much smaller than cloud computing but is expected to grow at a much faster pace than cloud computing.

Large corporates are increasingly investing in this space due to factors such as the functional ability of cloud computing to improve business performance, the rising need for hybrid models & Omni-cloud systems and pay-as-you-go models. In addition, continuous push from governments to protect data integrity and safety are leading to growth of the industry.

Emerging Opportunities

- **Internet of Things (IoT) devices:** Edge computing can be used to process data from IoT devices in real-time, allowing for faster and more efficient decision-making.
- **Autonomous vehicles:** Edge computing can be used to process data from sensors and cameras in real-time, allowing for faster and more accurate decision-making in autonomous vehicles.
- **Healthcare advancement:** Cloud computing can be used to store and analyse large amounts of medical data, while edge computing can be used to process data from wearables and other medical devices in real-time.
- **Smart cities:** Cloud and edge computing can be used to manage and analyse data from various sources in a smart city, such as traffic sensors, weather stations, and public transportation systems.
- **Agriculture:** Edge computing can be used to process data from sensors and cameras in real-time, allowing for more efficient and precise agricultural practices.

Australian Government Focus

The Australian government is increasingly invested in cloud and edge computing as a foundational platform to leverage emerging technologies such as AI, 5/6G, big data analytics, and the Internet of Things. The Australian Government's Digital Economy Strategy identifies outcomes which have a focus on cloud and edge-computing:

- Improved government decision-making by enhanced data analysis and manipulation capacity.
- Increased capacity for pre-emptive bushfire prevention using sophisticated models.
- Better performance of big data workloads domestically, reducing the need to transfer them overseas.
- Improved traffic management in major cities during peak hours across modes of transport.
- Higher throughput, rapid data analysis, locally and as part of international consortia to inform public health response.

Things to Watch

- **Security:** Cloud and edge computing can pose security risks, and it is crucial to ensure that data is protected and secure from cyber threats.
- **Data privacy:** With the increasing use of cloud and edge computing, there is a need to ensure that data privacy is maintained, and that personal information is not misused.
- **Complexity:** Cloud and edge computing can be complex, and it is vital to ensure that the systems are properly designed, implemented, and maintained.
- **Interoperability:** As more organisations adopt cloud and edge computing, it is important to ensure that the systems are interoperable and can work together seamlessly.
- **Cost:** Cloud and edge computing can be costly, and it is important to ensure the benefits outweigh the costs.

Cyber Security

The business value of an enterprise is driven by the security of its most valuable assets - (information/operational) technology infrastructure and data.

Companies with strong cyber security strategy, policy, and posture can expand to new geographies, inspire customer confidence and loyalty, and will have business agility in adopting new technologies and innovations to gain competitive advantage. Importantly, security-by-design and privacy-by-design factored into the business strategy would enable secure digital transformation of industries.

Recent analyst reports estimate a cost of $15 trillion annually, equivalent to 8% of Global GDP, for business disruption from cyber-attacks by 2025. A new survey reveals global companies spent about $225 billion on cyber security in 2021 when the estimated market opportunity was $2-3 trillion for cybersecurity technology and service providers, which is about ten times size of the vended market.

Leading Australian corporations that witnessed many major cyber-attacks in recent times include Optus, Woolworth, Telstra, and Medibank among others. This has led to more attention from government, industry, and academia on strengthening nation's cyber security capabilities.

Emerging Opportunities

- **Detection and remediation:** Innovation focused on detecting and remedying cyber threats for fundamental problems like phishing and spear-phishing, ransomware, and malware will continue to flourish.
- **Cyber security as a service:** Building innovative solutions for practical problems in critical infrastructure security and cyber security as a service, as showcased by several case studies developed by Cyber Security Cooperative Research Centre, will become more and more relevant.
- **Awareness building:** Scientific studies around cyber awareness and employee behaviour addressing the human element in cyber security are highly significant, given 95% of cyberattacks are caused due to human error.
- **Skilling:** Australia has potential to become a leading cyber capable nation. For this developing the cyber capability and digital skills of the workforce along with strengthening of the depth of the national cyber ecosystem is essential.
- **Governance:** The research focused on upholding ethical standards in using advanced technologies like AI to build security solutions engineered by security-by-design and privacy-by-design principles for industrial digital transformation problems.

Australian Government Focus

Due to the growing prevalence of cyber threats forcing businesses and individuals to prioritise cyber security, Australian Government has put major focus on cyber strategy in 2023. The Government is developing cyber security policy and initiatives under four key areas:

- A secure economy and thriving cyber ecosystem.
- A secure and resilient critical infrastructure and government sector.
- A sovereign and assured capability to counter cyber threats.
- Australia as a trusted and influential global cyber leader, working in partnership with our neighbours to lift cyber security and build a cyber resilient region.

The 2023-24 federal budget identified $101.6 million with two key objectives in mind, to embed and improve cyber resilience in small businesses through the small business Cyber Wardens program and uplift cyber security specifically related to Consumer Data Right (CDR), expanding CDR to a wider base of industries. In addition, $86.5 million budget was identified to establish a National Anti-Scam Centre (see Appendix 3).

The below table provides a list of some of the key initiatives where the Australian Government has committed investment in cyber security.

MEASURES	INVESTMENT
Securing Australia's future mobile networks	$31.7 million
Delivery of a National Data Security Action Plan	$1.8 million
Expanding the Cyber Security Skills Partnership Innovation Fund	$43.8 million
Strengthening Australia's national system of identity settings	$2.8 million
Cyber Hubs pilot	$18.8million

Things to Watch

- **Collaborative approach:** Collaboration between industry and academia is crucial for building research programs in cyber security that are relevant to the needs of society. Otherwise, academics run into the risk of conducting research with mere academic impact. The challenge for the universities is to build sector-wise partnerships with industry to understand business problems that require innovative security solutions to enable them.
- **Partnerships for efficiency:** Cyber security research to build advanced solutions to mitigate growing numbers of cyber threats can be expensive, requiring specialised equipment, hardware, and software to build solutions and validate them. The challenge is to build national and international partnerships with other academic institutes and corporates for sufficient funds to conduct research with global impact.

Quantum Computing

Quantum Computing (QC) is an entirely new paradigm of computing based on the principles of quantum mechanics, which in turn is based on the behaviour of atomic and sub-atomic particles.

Simply put, unlike classical computers that represent information using bits that are binary in nature, quantum computing represents information using qubits that can assume an infinite number of values between 0 and 1. The immense power of QC emerges from three fundamental properties of qubits, namely superposition, entanglement, and interference. Customer spending for quantum computing is expected to grow from $618 million in 2020 to $12.9 billion in 2027.

Machine learning (ML), optimisation, simulation, and security are the four broad areas that would be impacted most by the power promised by QC. Quantum ML explores the interplay of QC and machine learning. Optimisation usually involves finding the best solution from a pool of options based on given conditions or constraints. The efficacy of quantum computers in predicting the behaviour, properties, evolution, and configuration of chemical and biological elements, such as molecules and proteins, has been established. QC presents both opportunities and risks to the cybersecurity environment.

Emerging Opportunities

- **QC Ecosystem:** Comprises capabilities offered by providers at various technology layers (hardware, systems software, cloud, tools, accelerators, solutions, and more).
- **Quantum Value Discovery:** QC has witnessed a steady increase in investments, start-ups, venture capitalist (VC) funding and patent filings.
- **Quantum Cryptography:** The magnitude of the threat and the persistence of encrypted information has spurred efforts to develop quantum-resistant algorithms.
- **Quantum Sensors:** Going forward, quantum sensors might replace traditional sensors as they are more powerful and can get into granular levels.
- **As-A-Service Model:** Making QC services available over the cloud through subscription-based models.
- **Hybrid Quantum Computing:** A combination of traditional computing and Quantum computing.

Australian Government Focus

The government has announced a $111 million investment in Australia's quantum future, having identified quantum technologies as a significant area of focus. A new Quantum Commercialisation Hub will see further support for innovative research. The 2023-24 federal budget identified $101.2 million over five years to support a Critical Technologies Challenge Program focussing on quantum and create an Australian Centre for Quantum Growth and enable quantum capability and adoption in Australian industries. Following are the critical technologies identified in the Australian Government Digital Economy Strategy in this space:

- Post-quantum cryptography
- Quantum communications
- Quantum computing
- Quantum sensors

Things to Watch

- **Possible new threats:** QC would also make it easy for malicious elements to break current cryptographic schemes, resulting in new threats. It is, therefore, crucial for businesses to not only look at opportunities but also ensure readiness against any new threats that may arise due to QC.
- **Noisy Intermediate Scale Quantum:** Current quantum computers are severely constrained by their limited number of qubits. In addition, they are sensitive to environmental elements such as temperature, inter-qubit interdependence, and other 'noise', making them prone to errors and decoherence. It is therefore accepted that we are today in what is known as the Noisy Intermediate Scale Quantum (NISQ) era.
- **Fault Tolerance:** NISQ-era computers are evolving in capacity as well as in their resilience to errors. These continuous improvements will eventually result in the next frontier of Fault Tolerant QC (FTQC). Quantum fault tolerance refers to avoiding the uncontrolled cascade of errors caused by the interaction of qubits.

Web 3

A cooperative principle is at the heart of Web3. This is the emerging iteration of the internet that uses decentralised technologies to build value in purpose-driven ecosystems with a range of participants from business, social, and public sectors.

Web3 also provides the functional platform on which communities are built. It is an ideal operational mirror for the organisational structure of decentralised ecosystems. As a result, Web2 enterprises have two options: they can share proactively in the experience of shaping Web3's final form, or they can wait and adapt reactively after their competitors have defined how the decentralised internet operates.

Web3's ethos encourages us to think beyond the traditional concepts of organisational structure, value creation, and competition. Instead, it brings together diverse participants—partners, competitors, customers, prosumers, entrepreneurs, and more, to collaborate in democratised communities that work toward a common goal and share equally in the economic, social, and environmental value created.

Research and innovation potential exists across the five layers of Web3, i.e., infrastructure, protocols, utilities, services, and applications.

Blockchain is one of the technologies powering the Web3 movement by providing a high level of trust in these ecosystems as it connects members, data, and machines with intelligence, transparency, efficiency, and interactivity. However, the blockchain's distributed structure also demands – and guarantees – democracy.

Given blockchain technology's fast growth rate and transformative potential, organisations in virtually every industry assess emerging blockchain ecosystems, measure their potential impact on legacy business models, and take decisive steps to adapt.

Emerging Opportunities

- **Decentralized Finance (DeFi):** Protocols are becoming increasingly popular as users can participate in financial transactions without the need for intermediaries.
- **Non-fungible tokens (NFTs):** New digital assets with unique properties that enable new applications and use-cases.
- **Blockchain Integration:** Interoperability protocols to facilitate seamless communication and exchange of data and value across different blockchain networks.
- **Enhanced Security:** Web3 protocols are utilizing advanced cryptography techniques to ensure data privacy, security, and transparency.

Australian Government Focus

Web3 provides a level of security that will be utilised by most of the digital capabilities that are being evolved. The requirement for this security is acknowledged as part of the Australian Digital Strategy and the Federal Government has acknowledged that it will consider new legislation to help Australia play a part in the emergence of Web3. Through a new Digital Services Act, the Government hopes to enable Australia to grasp the opportunity presented by crypto currencies or blockchain technology.

Things to Watch

- **Decentralisation:** Web 3 is characterised by decentralised technologies, such as blockchain and distributed ledger technology. This means that there may be a shift away from centralised control and toward more collective decision-making and ownership.
- **Interoperability:** Web 3 platforms and systems may need to be able to seamlessly communicate and integrate with each other to provide a cohesive and functional ecosystem.
- **Privacy and Security:** With the increasing amount of digital data being generated and shared, Web 3 technologies will need strong security measures and privacy protocols to protect user data and prevent unauthorized access.
- **User Empowerment:** Web 3 technologies may give users more control over their digital identities and data, allowing them to manage and monetise their personal information as they see fit.
- **Regulation:** As with any emerging technology, there may be regulatory challenges to overcome as governments seek to balance innovation and growth with consumer protection and national security concerns. It is important to stay aware of regulatory developments and policy shifts in the Web 3 space.

Metaverse

Built with state-of-the-art technologies like blockchain, AI, Virtual Reality (VR), and Augmented Reality (AR), Metaverse unleashed seemingly limitless economic possibilities for businesses.

The Metaverse has not only introduced a new world of digital and social interactions but has also opened fresh avenues for life-like experiences and digital twins. The Metaverse market is estimated at $800 billion, and although this saga began with Facebook, big tech companies like Microsoft, Google, Apple, and a host of others soon followed.

Preliminary estimates for the Metaverse's total economic impact by 2030 ranged from $5 trillion to $13 trillion. However, at the start of this year we have seen a downfall in this area with many companies reducing their funding in this space, and some major companies like Disney and Walmart ending their Metaverse projects entirely. Nevertheless, things may change if new Metaverse applications are introduced and if Meta continues investing heavily in this area. For instance, despite the challenges faced by Meta with lowered brand valuation, layoffs, and privacy tracking changes, the company claims that it plans to spend a nearly 20% of its total expenses in developing Reality Labs (the Metaverse segment of the company) in 2023 which includes both VR and AR.

Emerging Opportunities

- **Immersive customer experience:** Immersive realities such as virtual events, virtual shopping, or virtual travel, could allow companies to create more engaging and interactive experiences for its clients. Companies can also use virtual spaces to target new customer segments. For instance, Chipotle and Chick-fil-A used it to influence young gamers in Roblox.
- **Increased efficiency and productivity:** Virtual reality could allow for better remote collaboration and communication as experimented by Microsoft Mesh in partnership with Meta on hybrid co-presence. Learning and training experiences can be improved by allowing for real-time virtual applications for industrial and manufacturing use.
- **Technological advancements:** There is huge scope to improve the technology behind AR and VR to solve for real world convenience needs like navigation and contextual information.

Australian Government Focus

Metaverse hasn't featured in the list of critical technologies identified by the Government, and no significant funding is available. However, The Future Transport: Smart Cities report by Roads Australia has mentioned the Metaverse and its impact.

Some investments by the private sector in this space were noted. For example, the Australian creative technologies business Two Bulls and Thailand's Translucia Global Innovation are developing a Metaverse R&D Centre in Australia. This $148 million centre will be one of the largest in the world when operational. A recent (December 2022) study published by Tenable, noted that 64% of Australian businesses were planning to invest in the metaverse in the next six to 12 months.

Things to Watch

- **Safety and security concerns:** Whiles all technological advancements pose these challenges, but the risk of data theft, financial fraud, bullying and sexual harassment, etc. is compounded with the Metaverse.
- **Regulations:** Deepfake regulation and synthetic media literacy are concerns. Australia's code of practice on disinformation is a good step in the right direction.

Bioengineering

How we live our lives will change over the next few decades with the convergence of biological technologies, information systems, and next-generation platforms.

The breakthroughs in biotechnology and innovations in other fields, such as information systems, will unlock vast opportunities in healthcare, agriculture, energy, sustainability, manufacturing, and consumer products. As a result, bioengineering is predicted to globally influence $3-5 trillion annually by 2030.

Bioengineering includes biology-related technologies such as cell therapy, CRISPR, and synthetic biology, as well as platform technologies like precision medicine and DNA sequencing, will have a profound impact on society. Reversing the aging process, producing "living drugs," and developing innovative defences against novel viruses are just a few examples of how bioengineering will positively impact society.

Emerging Opportunities

- **Viral-vector gene therapy:** Development of modified viruses to treat diseases such as cystic fibrosis.
- **mRNA Therapy:** is used to create synthetic mRNA for immunising patients against infectious diseases or treating diseases by restoring damaged proteins. For example, both the Pfizer and Moderna COVID-19 vaccines use mRNA to trigger the immune system to produce protective antibodies without utilising parts of the actual virus.
- **Cultivated meat:** This area of tissue engineering provides the mechanism for growing meat for consumption.
- **Biological computing systems:** It can accomplish computations without consuming excess energy.

Australian Government Focus

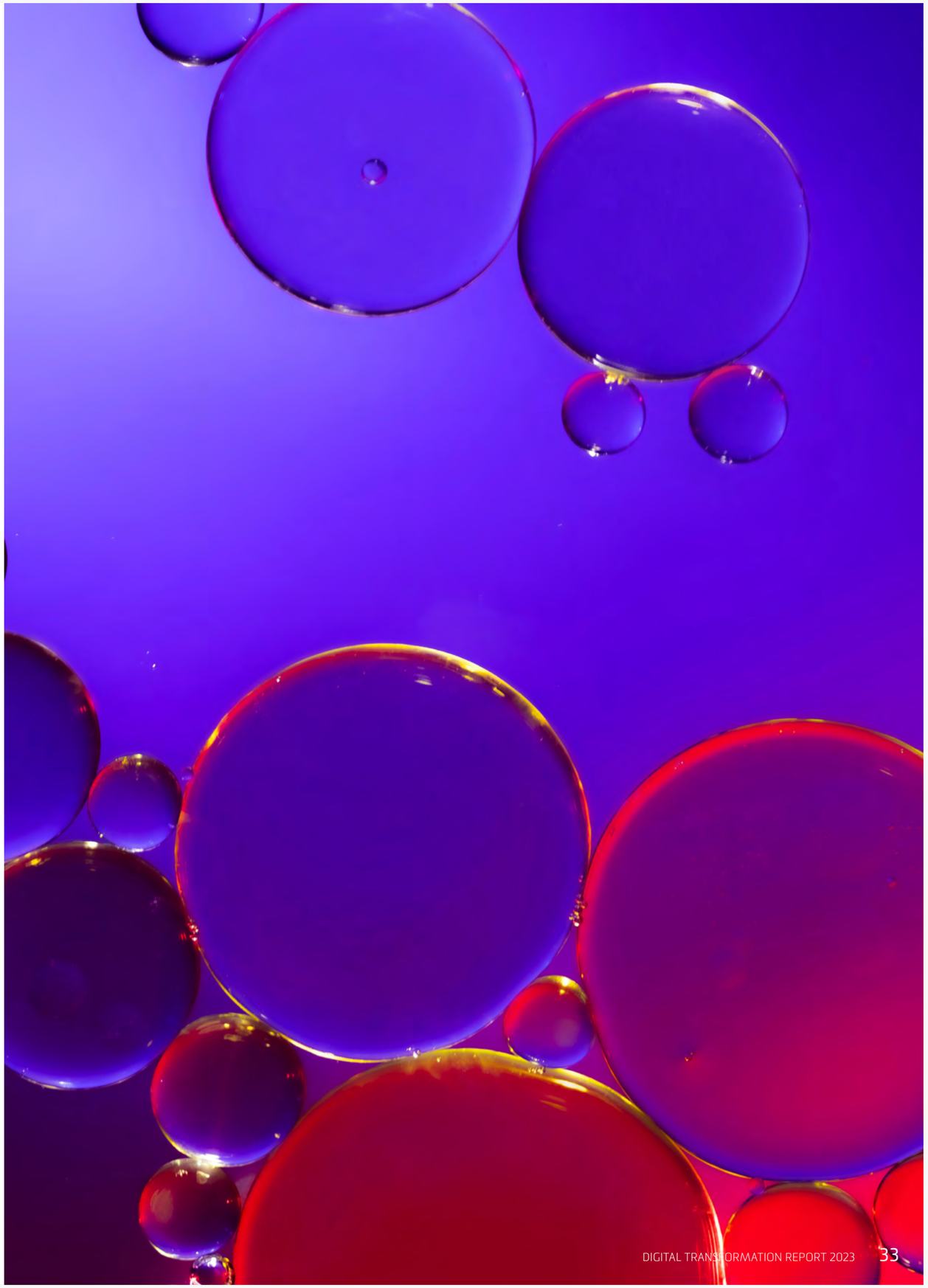
The Australian government has identified Biotechnology as an area of specific interest and has highlighted the requirement for Australia to have sovereign capability in bioengineering.

The "Biotechnology in Australia Plan" aims to strengthen Australia's biotechnology industry by encouraging innovation, investment, and collaboration. The plan focuses on improving regulatory frameworks, increasing access to funding and infrastructure, and developing a skilled workforce in Australia. It also prioritises research and development in areas of national importance, such as health, agriculture, and environmental sustainability.

In addition, the plan seeks to capitalise on Australia's unique biodiversity and research strengths while fostering international partnerships and promoting the commercialisation of biotech products and services. The plan aims to support economic growth, job creation, and improved quality of life for Australians through these strategies.

Things to Watch

- **Bioengineering Governance:** With the significant level of opportunity in bioengineering soon, there is a growing need for a global governance framework for bioengineering.
- **Bioengineering Ethical Usage:** There are concerns regarding the ethical use of bioengineering on living systems such as human genes and embryos.
- **Long-term View:** The long-term impact of bioengineering needs to be investigated to understand if there are any long-term/multi-generational implications of its usage.



Energy Transition

The transition towards cleaner and more sustainable energy sources is becoming increasingly important in the face of growing environmental and social pressures.

Fossil fuels, which have been the backbone of the energy industry for decades, have substantial negative impacts on both the environment and human health.

Accelerating the shift towards renewable energy sources, such as wind and solar, is crucial for mitigating the effects of climate change, reducing greenhouse gas emissions, and ensuring a healthier planet for future generations. Policy, innovation, and investment in clean energy technologies must drive this energy transition. It presents a significant opportunity for companies to make a positive impact while securing their long-term business viability.

Emerging Opportunities

- **Renewable Energy:** As countries look to transition away from fossil fuels, there is a growing demand for renewable energy sources such as wind and solar power, providing opportunities in these industries.
- **Energy Storage:** As renewable energy sources become more prevalent; there is a growing need for energy storage solutions to ensure a stable power supply. This need has led to investment and development in battery technologies and other forms of energy storage.
- **Smart Grids:** Technology and data analytics are being employed to create smart grids, which can better manage the distribution and consumption of energy. This presents opportunities for companies working on these solutions.
- **Hydrogen:** There is growing interest in hydrogen fuel cell technology as a sustainable energy source, and investments are being made to develop cost-effective and efficient hydrogen production methods.

Australian Government Focus

The Australian government has made significant investments in clean energy and energy transition, with a commitment of $10 billion towards a Clean Energy Finance Corporation (CEFC) fund, and a further investment of $24.9 billion over the next decade to deliver on climate change and energy transformation priorities.

They have also signed a Letter of Intent with the US Special Presidential Envoy for Climate to advance cooperation in emissions reduction, clean energy, and developing and deploying emerging energy technologies. Additionally, many private companies are investing in energy transition in Australia, with investments in wind, solar, and battery storage technologies, among others.

The Australian Government's Digital Economy Strategy identifies critical sustainable technologies which are well aligned to Deakin's impact theme of "Enabling a Sustainable World":

- Hydrogen and ammonia for power
- Nuclear energy
- Nuclear waste management & recycling
- Directed energy technologies
- Photovoltaics
- Supercapacitors
- Biofuels
- Electric batteries

Things to Watch

- **Government Policies:** Government policies and regulations can significantly impact the transition to clean energy. Keeping up to date with changes in policies and regulations can help businesses and investors anticipate future opportunities and challenges.
- **Technology advancements:** Changes in technology and the development of new, more efficient, and effective solutions can transform the energy sector. It is essential to stay informed about emerging technologies and their potential impact on the industry.
- **Investment and financing:** Financing and investment are crucial for the development and implementation of clean energy projects. Changes in investment trends, funding availability, and financing structures can impact the energy transition.
- **Public Acceptance:** The energy transition's success also depends on public acceptance and support. Therefore, it is vital to track public sentiment towards clean energy solutions and identify any challenges or concerns.

Mobility

Smart Mobility is shaping the business model of the future. The global smart mobility market is valued at $76.9 Billion in 2022 and is expected to reach $203.5 billion by 2028.

Automation, connectivity, electrification, and shared mobility (ACES) are the four defining trends shaping smart mobility.

In the future, connected vehicles and road infrastructure will be in two-way conversations, coordinating for a cooperative intelligent transport system (C-ITS), resulting in increased flow, safety, and road capacity. Connected cooperative automated mobility (CCAM) will be more affordable, accessible, and inclusive. Mobility as a Service (MaaS) will enable frictionless door-to-door journeys through integrated, on-demand, shared and mass mobility services. Mobility ecosystem data will be the new oil-powering multimodal transport network.

Emerging Opportunities

- **Innovative Business Models:** The growing popularity of electric vehicles is finding unusual allies among major players in the hospitality, food, and retail industries. The rapid disruptions happening in the way people or goods are moved from point to point will fundamentally transform the way these industries operate and innovate.
- **Boosting Revenue with Shared Autonomous Vehicles:** A fleet of shared autonomous vehicles (SAVs) can offer travellers a low-cost, efficient, and safe mobility option.
- **Connected Vehicle Commerce:** Connected vehicle commerce is estimated to be worth upwards of $828 Billion over the next decade. However, getting customers to purchase goods and services on the move effectively requires a well-oiled collaboration with providers in retail, travel and tourism, hospitality, logistics and healthcare, implemented through partnerships with fintech and delivered through hyper-personalised engagements.
- **Growing Battery Market:** Batteries are one of the most critical components that Automotive OEMs are looking at for launching powerful and efficient electric vehicles. Adequate supply of lithium-ion batteries and battery recycling are also important areas for consideration. This is emerging as an important area of research and innovation for industry and academia.
- **Data Management:** Analytics can be used to generate powerful insights on data generated by vehicles on vehicle parameters, driving behaviour, road conditions, traffic patterns and environmental factors.
- **Safety:** As demonstrated in the electric vehicles (EVs) on the market today, digital technology enables advancement in safety through artificial intelligence (AI), energy efficiency, and integration with homes to manage electricity and the digitalisation of vehicle maintenance procedures.
- **Charging Stations:** As the digital ecosystem evolves, technology and automation enable more possibilities for charging solutions in the urban environment that defy the conventional format of designated fuelling areas.

Australian Government Focus

The Australian Government budget for 2023 earmarked significant funding to improve network connectivity across Australia. This included $2.4 billion for the National Broadband Network (NBN), expanding full-fibre access to 1.5 million premises by 2025. This will deliver a faster, more reliable network to advance Australia's digital economy, businesses, and communities.

Australian Government also invested $1.2 billion for the Better Connectivity for Regional and Rural Australia Plan. It includes $400 million for mobile base stations and $200 million for the Regional Connectivity Program.

Things to Watch

- **Security concerns:** With the growth of smart mobility services and applications, the risks of cyber incidents are also on the rise. The world of smart mobility has significantly increased the risk of data leakage.
- **Evolving business models:** Mobility can lead to alternate revenue models for automotive companies for which business and operating models need revisiting.

Space Technology

Space Technology has witnessed favourable changes over the last few years, making space more accessible and cost-effective.

Digital forces coupled with advancements in power systems positively impact the space economy, thereby necessitating the need for research and innovation. The global SpaceTech economy is valued at $570 billion in 2020. It is expected to grow to $15 Trillion by 2030.

Emerging Opportunities

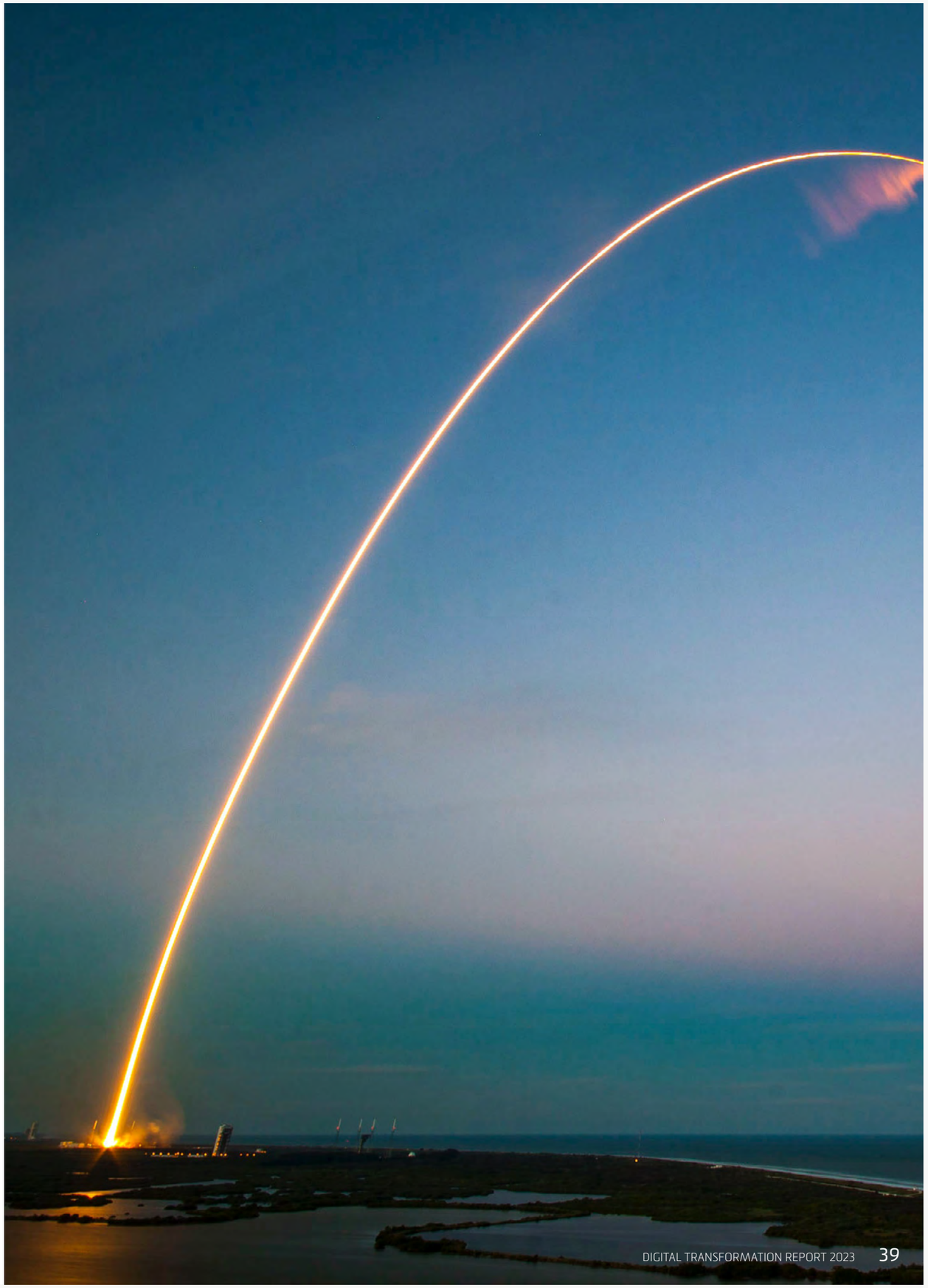
- **Small Satellites:** Small satellites are one of the most important developments in space technology. Remote sensing small satellite systems have been developed for infrastructure monitoring.
- **Propulsion Solutions:** Cost-effective and environment-friendly propulsion solutions are being developed, which in the future, should make space more accessible.
- **Space Communication:** Space communication is becoming more advanced. Data transmission between satellites can happen through contact using laser links.
- **Edge Computing:** Using AI, blockchain, and big data to gather insights from the large amount of data generated from the satellites can aid in future development.
- **Space Mining:** New generation of space cameras and satellites can aid in mining asteroids and space objects, eventually leading to the extraction of minerals.
- **Space Manufacturing:** Manufacturing processes of space products and services are undergoing innovative changes by digital forces like automation, robotics, 3D printing and sensors.
- **Space Traffic Management:** Collisions and explosions in space create debris and junk, obstructing space exploration and travel. For proper space traffic management, debris retrieval is necessary. AI can be used to locate space junk or debris in orbit and take necessary corrective actions.

Australian Government Focus

The Australian Government has committed an investment of more than $65 million to the nation's space industry. The funding will support Australia becoming a launch destination of choice, driving jobs in this sector and technology investments. Initiatives such as the Space Infrastructure Fund (SIF) invested $19.5 million into the growth of the space sector. It increased Australia's space infrastructure and capabilities. The International Space Investment Initiative expansion will provide $25 million to support collaborative projects between Australia and India.

Things to Watch

- **Regulatory risks:** There are regulatory risks associated with technology implementation in space and associated research.
- **Environmental hazards:** Space exploration may lead to a generation of debris and space junk that can lead to environmental hazards.



Sustainability

Sustainability heralds a fundamental shift in how society thinks about and approaches economic, social, and environmental challenges.

It requires a change from the traditional linear economic model of "take, make, and dispose" to a circular model that promotes resource conservation, waste reduction, and closed-loop systems. This shift requires a new way of thinking about production, consumption, and waste – and digital plays a crucial role to enable this shift.

Digital and sustainability are becoming increasingly intertwined and dependent upon each other. The digital transformation of industries and society can help drive sustainability through a more efficient and effective use of resources, reduced carbon emissions, and better data-driven decision-making. At the same time, sustainability is necessary to ensure the long-term viability and impact of digital technologies.

The rise of digital platforms and technologies has also enabled collaborative and decentralised models of production and consumption, emphasising the idea of co-creation and community ownership. In moving toward a more sustainable future, digital solutions will continue to play a key role in driving innovation and progress. There will be an increasing focus on designing and implementing solutions that benefit both digital progress and sustainability.

Emerging Opportunities

- **Renewable energy:** The growth in renewable energy sources such as solar, wind, and hydropower presents opportunities for investment, job creation, and reducing greenhouse gas emissions.
- **Circular economy:** This aims to eliminate waste and create a closed-loop system where resources are reused and recycled. This presents opportunities for businesses to reduce costs, increase efficiency, and promote sustainability.
- **Sustainable agriculture:** Sustainable agriculture practices such as organic farming, crop rotation, and agroforestry can promote soil health, reduce pesticide use, and increase food security.
- **Sustainable transportation:** The growth of electric vehicles, public transportation, and cycling infrastructure presents opportunities to reduce greenhouse gas emissions, improve air quality, and promote sustainable transport options.
- **Sustainable fashion:** Presents opportunities for reducing waste, promoting ethical production practices, and creating more sustainable fashion options.
- **Sustainable finance:** Sustainable finance presents opportunities for investors to support sustainable businesses and initiatives while promoting environmental and social responsibility.

Australian Government Focus

The Australian government has invested in various sustainability aspects, ranging from climate change to ocean science and aquaculture, and education and health programs.

- Reducing climate change risks through partnerships and initiatives.
- National assessment of the country's environment.
- Ocean science and aquaculture innovation through initiatives such as the Blue Economy Aquaculture Challenge.
- Education and health.

The Australian Government's Digital Economy Strategy identifies critical sustainable technologies aligned with Deakin's impact theme of 'Enabling a Sustainable World':

- Hydrogen and ammonia for power
- Nuclear energy
- Nuclear waste management and recycling
- Directed energy technologies
- Photovoltaics
- Supercapacitors
- Biofuels
- Electric batteries

Things to Watch

- **Greenwashing:** The practice of making misleading or false claims about the environmental benefits of a product or service. It is essential that sustainability claims are supported by evidence.
- **Lack of regulation:** The lack of regulation and standards for sustainability can make it difficult to determine which products and services are truly sustainable. There is a need for transparency and standards to promote transparency and accountability.
- **Unintended consequences:** These are caused by increased use of resources in other areas or unintended social impacts. It is important to consider the entire lifecycle of sustainability initiatives to avoid unintended consequences.

Looking Ahead

The Digital Futures report has summarised the digital technologies and emergent areas that feature prominently on the radar of industry as they institutionalise their digital initiatives. The Australian Government is also backing majority of these critical and emerging technologies to strengthen Australia's future.

Deakin University's Impact Themes are well aligned with the technologies identified through this report. Deakin can expand its capabilities further to emerge as a leading research and innovation institution for digital futures. We have noticed common philosophies around organisations in their journeys to digital maturity and full-blown capabilities. They endeavour to create exponential value, leverage ecosystems, embrace risk and capitalise on the age of abundance.

Creating Exponential Value

Digital technologies have deconstructed traditional value-creation concepts to unveil new opportunities for delivering value to society.

Leveraging Ecosystems

Digital technologies are redefining industry boundaries and the competitive landscape. As a result, organisations across industries are collaborating in the search to deliver greater value.

Embracing Risk

Digital technologies have enabled new levels of agility and flexibility, allowing organisations to embrace risk. They have created a landscape promising high returns on risks taken, with no growth for 'safe' options.

Capitalising in the Age of Abundance

Digital has redrawn traditional concepts of static resources. Instead of making the best of scarce resources, organisations are harnessing the abundance that can be mapped across three basic building blocks of talent, capital, and capabilities.

- **Talent:** Mobility, scale, social, global access, and most importantly, the platform economy powered by digital makes it possible to tap into almost infinite resources. This availability helps organisations to produce innovative business models.
- **Capital:** Innovation is at a premium in the digital world and developing it commercially has become easier. Venture capital spawns an ecosystem of capital support; governments and big companies are actively supporting start-ups and university incubators.
- **Capabilities:** Organisations are no longer thinking only within their in-house capabilities. Instead, they are developing a partnership ecosystem with start-ups, suppliers, service providers, big and small companies, and sometimes even competitors.

The digital trends and technologies examined in this report will continue to shape the way we live, work, and connect with one another. The rise of new technologies is driving significant disruption and change across a range of industries.

The possibilities for research and innovation on these technologies can be numerous and this will present both opportunities and challenges. It is important for organisations to keep a pulse on the latest digital developments and adapt their strategies accordingly. Research, collaboration, digital capability, data-driven decision-making, and an agile approach to innovation are key to success in this fast-moving digital landscape.

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Appendices

Appendix 1: Mapping Critical Technologies to Deakin's Impact Themes

Critical Technologies identified by Australian Government are technologies of national interest. The objective here is to map these technologies to the five overarching impact themes by Deakin University.

IMPROVING HEALTH AND WELLBEING	CREATING SMARTER TECHNOLOGIES	BUILDING SAFE AND SECURE COMMUNITIES	ADVANCING SOCIETY, CULTURE, AND THE ECONOMY	ENABLING A SUSTAINABLE WORLD
Biological manufacturing	Advanced data analytics	Advanced protection	Additive manufacturing	Biofuels
Biomaterials	Advanced integrated circuit design and fabrication	Protective Cyber Security Technologies	Advanced composite materials	Directed energy technologies
Genetic engineering	Advanced optical communications		Advanced explosives and energetic materials	Electric batteries
Genome and genetic sequencing and analysis	Advanced radiofrequency communications		Advanced magnets and superconductors	Hydrogen and ammonia for power
Nanobiotechnology	Artificial intelligence (AI) algorithms and hardware accelerators		Continuous flow chemical synthesis	Nuclear energy
Nanoscale robotics	Distributed ledger		Coatings	Nuclear waste management and recycling
Neural engineering	High performance computing		Critical minerals extraction and processing	Photovoltaics
Novel antibiotics and antivirals	Machine learning (incl. neural networks and deep learning)		High-specification machining processes	Supercapacitors
Nuclear medicine and radiotherapy	Natural language processing (incl. speech and text recognition and analysis)		Nanoscale materials and manufacturing	
Synthetic biology	Post-quantum cryptography		Novel metamaterials	
Vaccines and medical countermeasures	Quantum communications		Smart materials	
	Quantum computing		Advanced imaging systems	
	Quantum sensors		Atomic clocks	
	Advanced aircraft engines		Gravitational-force sensors	
	Advanced robotics		Inertial navigation systems	
	Autonomous systems operation technology		Magnetic field sensors	
	Drones, swarming and collaborative robots		Miniature sensors	
	Small satellites		Multispectral and hyperspectral imaging sensors	
	Space launch systems (incl. launch vehicles and supporting infrastructure)		Photonic sensors	
			Radar	
			Satellite positioning and navigation	
			Scalable and sustainable sensor networks	
			Sonar and acoustic sensors	

Appendix 2: Summary of 2021-22 Budget Measures in Digital Economy Strategy

The investments are categorised in three major areas such as:

1. Developing right foundation to grow digital economy.
2. Building capabilities in emerging technologies.
3. Digital growth priorities.

MEASURES	INVESTMENT
Right foundations to grow the digital economy	
Peri-Urban Mobile Program to fund new mobile solutions	$16.4 million
Continuing Measuring Broadband Australia	$7.7 million
Securing Australia's future mobile networks	$31.7 million
Delivery of a National Data Security Action Plan	$1.8 million
Expanding the Cyber Security Skills Partnership	Distributed ledger
Innovation Fund	$43.8 million
Strengthening Australia's national system of identity settings	$2.8 million
Cyber Hubs pilot	$18.8 million
Digital Skills Cadetship Trial	$10.7 million
Accelerating the adoption of electronic invoicing	$15.3 million
Accelerated rollout of the Consumer Data Right	$111.3 million
Delivering a Digital Atlas	$40.2 million
Enhanced management of Government data assets	$16.5 million
Total	**$317 million**
Building capabilities in emerging technologies	
Establishing a National AI Centre and AI and Digital Capability Centres	$53.8 million
AI-based solutions to solve national challenges grants	$33.7 million
Catalysing AI in our regions grants	$12.0 million
Next Generation AI Graduates Program	$24.7 million
Next Generation Emerging Technology Graduates Program	$22.6 million
Emerging Aviation Technology Partnerships grants	$32.6 million
New Drone Rule Management System	$1.6 million
Developing a National Drone Detection Network	$1.5 million
Total	**$182.5 million**
Lifting our ambition – Digital Growth Priorities	
Allowing taxpayers to self-assess the effective life of depreciating intangible assets	$170.0 million
Expanding and enhancing the Digital Solutions -Australian Small Business Advisory Services program	$12.7 million
Introducing a digital games tax offset	$18.8 million
Enhancing myGo	$200.1 million
Enabling next-wave My Health Record	$301.8 million
Total	**$703.4 million**

Appendix 3: Digital Technology Funding in the Federal Budget 2023-24

In the Budget 2023-24, the expected government spending on ICT and digital project is forecasted to be nearly $3.7 billion for the next four years (of which nearly $2 billion planned for the next financial year).

PROJECT NAME	INVESTMENT
National Disability Insurance Agency systems for processes and planning decisions	$429.5 million
Modernisation of My Health Record	$429 million
Australian Digital Health Agency	$325.7 million
Department of Veterans' Affairs' new and at-risk legacy ICT systems	$254.1 million
ICT infrastructure investments for aged care	$214.5 million
Modernisation and replacement of legacy ICT systems for Australian Bureau of Statistics	$197 million
IT Infrastructure for National Library of Australia	$146.1 million
Department of Agriculture, Fisheries and Forestry digital systems in cargo pathways	$145.2 million
Sustain the myGov platform (one year program)	$134.5 million
Office of the eSafety Commissioner	$134.1 million
Provision of electronic-prescription delivery infrastructure and services	$111.8 million
Support and uplift of cyber security in Australia	$101.6 million
Support businesses to integrate quantum and artificial intelligence (AI) technologies into their operations	$101.2 million
Transformation of technology platform for administration for schools and higher education providers	$91.7 million
Consumer Data Right in the banking, energy and non-bank lending sectors, progress the design of action initiation and [to] uplift cyber security for Treasury	$88.8 million
Administration of student loans and security and privacy of data holdings	$87.8 million
Combat scams and online fraud	$86.5 million
Infrastructure and ICT upgrades at Questacon, and to continue its STEM education and engagement programs	$59.7 million
Critical ICT and equipment upgrade at the National Measurement Institute	$51.2 million
Management of fraud and non-compliant payments for NDIA	$48.3 million
Office of the Australian Information Commissioner's data privacy and analytics capability	$44.3 million
ICT infrastructure to prepare for future pandemic events and extend existing COVID-19 programs	$43 million
Improve monitoring and data analysis for Australian Institute of Marine Science	$40.4 million
Support agricultural statistics, climate analysis and upgrades to data and information systems for the Australian Bureau of Agricultural and Resource Economics and Sciences.	$38.3 million
IT systems to support infrastructure investment and road vehicle safety regulation for the Department of Infrastructure, Transport, Regional Development, Communications, and the Arts	$35.6 million
Single digital platform for national water data management for Bureau of Meteorology	$32.7 million

PROJECT NAME	INVESTMENT
ICT system upgrade for Treasury	$32.7 million
Department of Finance and the Digital Transformation Agency (DTA)'s current Digital ID system and design the policy and legislative foundations to transition to an economy-wide Digital ID ecosystem with an independent regulator	$24.7 million
Department of Foreign Affairs and Trade (DFAT) for modernising the simplified trade system and operating the trade information service	$23.8 million
Data insights to inform long term policy responses for Australian Bureau of Statistics	$16.4 million
Australian National Audit Office (ANAO)'s audit program and data upgrade	$14.4 million
GPs telehealth consultations for COVID-positive patients	$14.2 million
Essential technology and communication upgrades for the Director of National Parks	$10.6 million
Broadband and mobile services upgrades for First Nations people in Central Australia	$10 million
Australian Communications and Media Authority's plan to combat online misinformation and disinformation on global digital platforms	$7.9 million
Australian Sports Foundation to enhance its IT network to address emerging cyber security risks	$3.8 million
Australian Institute of Aboriginal and Torres Strait Islander Studies to digitise and store at-risk audio-visual material	$3.8 million
ICT services for Department of Parliamentary Services	$1.6 million
Privacy assurance for the Digital ID program for Office of the Australian Information Commissioner	$1.1 million
Australian Taxation Office communications research associated with the myGovID brand	$1.1 million
Attorney-General's Department to progress the government's response to the recent review of the Privacy Act	$900,000
Mobile and internet for wi-fi connectivity in Alice Springs Town Camps through the digital connectivity project	$300,000
Total	**$3,639.9 million**

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