Queensland University of Technology
response to the
2022 List of Critical Technologies in the National Interest

QUT welcomes the opportunity to comment on the 2022 List of Critical Technologies in the National Interest. We thank the Critical Technologies Hub within the Department of Industry, Science and Resources for the helpful consultation process.

We address below the specific questions asked in the consultation paper, but have a few general observations that may assist at the outset.

The List is too enamoured of currently fashionable technologies and immediate contexts, while it could easily be made more open to innovations still working on the margins or just over the horizon, without loss of meaning. The result is a List whose terms are too prescriptive, relying too narrowly on currently prominent examples, which not only makes them less forward-looking but may actively dissuade investment or research in viable alternatives to the current major preoccupations of industry and research. We have suggested various means of addressing this problem below, within the present architecture, but overall we argue that the List's utility and conceptual integrity would be improved by a minor architectural revision on a model that headlines the broad issue being solved and remains to the extent feasible more agnostic as to the means. An obvious example is **Electric batteries** which could be rendered **Energy storage** to improve flexibility without loss of meaning.

The List also consistently takes insufficient account of human factors – for example, advanced analytics is silent on social and behavioural data analytics. More generally the social, cultural and political work needed for technologies to achieve social licence, regulatory approval, widespread uptake and broad public benefit can be overlooked if the descriptions are too narrowly focused on technical aspects or at most economic/business considerations.

Relatedly, we would recommend that the List makes an explicit and prominent statement that confirms that each critical technology requires not only STEM research and industry expertise but also HASS research and practitioner expertise to work on identifying, understanding and anticipating the social, cultural, environmental and policy implications of the critical technologies' development, deployment, and use.

1 Are there technologies that should be considered for inclusion or removal from the original List? What are your reasons for the suggestion?

We propose the addition to AI, Computing and Communications of:

> **Data Governance Solutions**
> Systems, processes and algorithms to support strong data governance practices in organisations to increase organisational performance. Having near real-time access to high-

quality data is critical for data-driven decision-making. Applications for data governance solutions include evidence-based healthcare, real-time risk monitoring, better compliance management, and reliable data-driven insights for policymakers.

Advanced Automation Technologies
Systems, frameworks and solutions to support smart automation of organisational processes. These technologies could cover robotic process automation (RPA), flexible and dynamic workflows, process intelligence, digital twins, enterprise systems that connect with the industrial Internet of things etc. Applications for advanced automation technologies include digital health, digital government, and digital mining where smart automation of technologies in these sectors can benefit the digital transformation of organisations.

Digital Twins
Digital models of physical assets and processes that facilitate human interaction with real-world data and knowledge. Digital Twins enable the capture, visualisation and optimisation of business, manufacturing and industrial performance for the purpose of system simulation, prototyping, planning, integration, testing, monitoring, and maintenance.

Computer visualization techniques
Computer graphics, animation and virtual reality to model complex events and visualize phenomena that cannot be observed directly.

We propose the addition to Energy and Environment of:

Printed and Flexible Electronics for Next Generation Devices
Including displays, sensors, wearable electronics, smart living technologies.

Non-battery energy storage
The exclusive reliance in the List for macro-scale energy storage on electric batteries neglects viable, evolving and emerging critical technologies.

Renewable energy export
The criticality of hydrogen/ammonia as a heat and power source is debatable (perhaps their inclusion is driven more by sectional interest than objective criticality) but where these technologies certainly are critical is in their ability to export renewable energy. This new category could cite hydrogen and ammonia as leading examples. This suggestion twins with our call below to merge the **Biofuels** and **Hydrogen and ammonia for power** definitions under the title **Renewable fuels**.

We propose the addition to Sensing, timing and Navigation of:

GPS-independent navigation
Knowing where you are in the world is a key navigational capability need for people, animals, and both autonomous and human-operated platforms ranging from self-driving cards to aircraft, but accurate and trustworthy positional knowledge has widespread implications beyond navigation: it can, for example, allow life-and-death decisions in defence and in tracking the spread of global pandemics.
With better positioning information, robotics, autonomous vehicle, and AI technologies of the future could transform and improve the competitiveness of current strategic industries like mining and agriculture. It could bring new capabilities in manufacturing and medical technologies and re-invigorate sectors under pressure like aged care and transport.

Current positioning technologies are fundamentally incapable of meeting current and future positioning demands because they do not (and will never) meet the required performance, reliability, and trustworthiness targets.
One of the primary positioning systems in use today is GPS. This satellite-based navigation system gives location information to GPS receivers with an unobstructed view of at least four satellites in orbit. The US operates the original GPS system, but Russia, China, India, and the EU have their own systems. Positioning information is generally accurate to five metres, with new systems capable of accuracy down to 10 cm, depending on what additional infrastructure is available (e.g. real-time kinematic positioning (RTK)).
But GPS has major limitations:

- Australia has no sovereign satellite-based positioning capability. In an increasingly volatile geopolitical climate, we instead rely on GPS provision by external actors such as the US or EU.
- GPS positioning, whether provided by an ally or Australia's own hypothetical satellite network, is increasingly vulnerable to physical and cyber-attacks, and will likely degrade or disappear at the onset of any major conflict, rendering Australia's armed forces largely blind as to their location. GPS signals are also susceptible to jamming and spoofing (tricking the system into thinking it is somewhere it is not).
- GPS is not available indoors, underground, underwater, in thick vegetation, or even in city centres, where so many commercial and consumer use cases abound.

Consequently, there is a clear and present critical demand for non-GPS-based positioning solutions that are performant, ubiquitous, and trusted.

We propose the addition to Transportation, Robotics and Space of:

Complex autonomous environments safety systems
Critical technologies required to manage large scale simultaneous operations for transport and logistics (e.g. Unmanned Traffic Management (UTM) for Airspace) to ensure collision avoidance, separation management, efficient queueing, etc. This is an entirely separate technology to individual autonomous systems.

Surgical Robots
This is going to be a critical technology for the delivery of healthcare globally by the end of the decade. It will be especially important in Australia as access to high care (such as surgery) in rural, remote and regional communities is a major impediment to health equity and closing the gap.

We propose the addition to Advanced Materials and Manufacturing of:

Circular advanced materials and manufacturing
The combination of the additive manufacturing, advanced composite materials and continuous flow synthesis from sustainable resources in a zero waste / re-use paradigm. This might be the use of agricultural and forestry waste, or the conversion of existing waste streams into a reprocessing plant to create materials such as biocrude, biochar, polymers or fine chemicals. This not only aids the decarbonisation of the economy, but also improves efficiency by converting industrial liabilities into beneficial (and very low-cost) feedstock.

2 Do you have any comments on the individual technology definitions?

We propose amendments to the following definitions:

AI, Computing and Communications

Advanced data analytics
Human intervention is critical across all parts of this from coding new methods, interpreting results, refining approaches, understanding and ensuring appropriate rigour.
This technology also hinges on **high performance computing** (data storage/handling, computer power) and **advanced optical communications**.
This description should also include techniques to support **responsible data science practices**, supply chain analytics and social data analytics.
This definition currently omits mention of **statistics**. Both these new fields of artificial intelligence and machine learning were built on statistics and are underpinned by statistics. To achieve real advances in these new fields, we need continued investment in the statistics and mathematics.
The definition needs to explicitly include **social and behavioural data analytics**, critical for supporting policy, legislation, regulation, infrastructure investment, primary health interventions, education, justice system, etc. – wherever a decision interacts with the community.

Biotechnology, gene technology and vaccines

Biological manufacturing
This definition should also include reference to advanced synthetic foods, which is likely to surpass the manufacture of biologic medicines in the medium term. It is partially covered in synthetic biology in terms of the production of in vitro meat and dairy, but extends well beyond that domain.

Energy and Environment

Biofuels and **Hydrogen and ammonia for power**
These definitions should be merged under the title **Renewable fuels**, which is actually the critical technology category, and which permits scope for the inclusion of other energy technologies harnessing natural processes, either existing (wind, wave) or novel. Consideration could be given to folding in Photovoltaics as well. This suggestion twins with our call above for the addition of a **Renewable energy export** definition.'

Advanced Materials and Manufacturing

Additive manufacturing
This definition is too narrow (and arguably dated): there are many other emerging advanced manufacturing technologies that are also critical, e.g. emerging extrusion and injection moulding capabilities. These related technologies should be added as examples and the capability renamed **Decentralised and scalable manufacturing**.

3 Do you have a view on the frequency of updates to the List?

The list should be updated biennially to keep pace with advancements in STEM and social licence.

4 Do you have any feedback on the content of the Critical Technology Profiles?

The Critical Technology Profiles are a useful snapshot of how relevant each critical technology is to Australia. Venture capital investment is listed but it would also be interesting to include Government investment figures (and as a percentage of GDP).

5 Has the List influenced decisions in your organisation about technology investment or adoption?

Overall, the List of Critical Technologies in the National Interest is very well thought out, and more or less reflects QUT's current and prospective technology research portfolio. The List is informative about nationally desired research investments and QUT is likely to consider the List in the future, particularly in the translation and adoption of our research discoveries by our industry collaborators, which can lead to significant benefit to Australia's national interest.