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Submission to the Department of Industry, Science and Resources

# ATSE SUBMISSION TO THE CRITICAL TECHNOLOGIES LIST – 2022 UPDATE CONSULTATION

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# ATSE SUBMISSION TO THE CRITICAL TECHNOLOGIES LIST – 2022 UPDATE CONSULTATION

The Australian Academy of Technological Sciences and Engineering (ATSE) is a Learned Academy of independent, non-political experts helping Australians understand and use technology to solve complex problems. Bringing together Australia's leading thinkers in applied science, technology and engineering, ATSE provides impartial, practical and evidence-based advice on how to achieve sustainable solutions and advance prosperity.

ATSE welcomes the opportunity to provide input to the 2022 review of the List of Critical Technologies in the National Interest ("the List"). We make the following recommendations for amendments to the 2022 List:

**Recommendation 1:** Allow technologies to be assigned to multiple categories.

**Recommendation 2:** Split *Advanced Materials and Manufacturing* into two separate categories.

**Recommendation 3:** Create a new category for *Critical Minerals Extraction and Processing*.

**Recommendation 4:** Include 'organ-on-a-chip' technologies in the category of *Biotechnology, Gene Technology, and Vaccines*.

**Recommendation 5**: Include 'medical device manufacture' as a technology in the category of *Biotechnology, Gene Technology, and Vaccines*.

**Recommendation 6:** Amend the critical technology 'quantum computing' to include healthcare as an application.

**Recommendation 7:** Add a technology 'digital twinning' under the category of *AI, Computing and Communications*.

**Recommendation 8:** Include 'warm sea aquaculture' as a technology under *Biotechnology, Gene Technology, and Vaccines*.

**Recommendation 9:** Add 'carbon capture and storage' as a technology under *Energy and Environment*.

**Recommendation 10:** Create a critical technology profile on nuclear energy and nuclear waste management, with regulation, submarines, and skills requirements being key issues to include.

**Recommendation 11:** Create a critical technology profile on quantum computing.

### An approach to critical technologies for a human-driven, technology-powered future

Future List updates should be generated using an outcome-driven process. Presently, the List provides a catalogue of technologies with the potential to be of national importance. Instead, an approach of defining desired outcomes – such as social cohesion, quality-of-life improvements, economic growth, sovereign capability, and carbon emissions reduction – would enable identification of critical technologies. As the List is intended to inform government, industry, and academia to assist in the identification of investment and policy development, the absence of an outcome-driven approach runs the risk of driving investment in technologies that are not fit for end-users or do not lead to desired outcomes.

The approach to risk in the critical technology profiles should also be amended to capture and emphasise those with the most severe potential consequences, particularly regarding national

security, biosecurity, biodiversity, and human health. For example, new materials may be persistent in the environment and have adverse impacts on human and animal health. These risks are qualitatively different to, for example, expense and difficulty of manufacture (as captured in the risks in the advanced composite materials profile).

ATSE is aware that the List is used to inform Government on issues of sovereign capability and national security. While it is important to protect Australian research from misuse, it is essential that international research collaboration with aligned countries remains a cornerstone of Australia's research efforts. As a small country with a strong research program, international collaboration is a net benefit to Australia and should always be considered before restricting international engagement due to national security concerns.

Finally, it is important that the List is not used to divert resources away from, or create administrative friction against, other basic or translational research. There are many technologies and areas of research that are not in the List but that are in the national interest.

**Revising technology categories to influence technology development**

The seven technology categories provide a framework to understand technologies of national interest. Many technologies, particularly in health, are interdisciplinary and require combinations across the seven technology categories. Outcomes such as mitigating climate change are important to highlight, and similarly would cut across multiple categories. The ability to tag technologies into multiple categories, or assign secondary categories, would assist in demonstrating cross-topic messaging.

**Recommendation 1:** Allow technologies to be assigned to multiple categories.

Elevation of technologies into their own category can act as a signal of the anticipated importance of that technology, with the potential to guide investment and further development. To emphasise technologies of significance, ATSE suggested the following revisions to the technology categories:

*Advanced materials and manufacturing*

*Advanced Materials and Manufacturing* is a single category in the 2021 List. Treating these as one area would suggest that only high-tech manufacturing, rather than modern manufacturing more broadly, is considered. The COVID-19 pandemic and related supply chain issues have demonstrated the importance of improving local manufacturing capacity of critical goods. Delineation into two distinct categories would enable greater focus on advances in modern manufacturing. If separated, most technologies in the current combined category would be placed in an *Advanced Materials* category.

**Recommendation 2:** Split *Advanced Materials and Manufacturing* into two separate categories.

*Critical minerals extraction and processing*

In the 2021 List, the technology "Critical Minerals Extraction and Processing" is categorised under *Advanced Materials and Manufacturing*. Critical minerals are an enabler for net zero emissions and will underpin national prosperity in the years ahead. Australia is well-placed to innovate in critical minerals due to our natural resources and research strength in this area. To drive future progress, further developments are needed to improve extraction and separation rather than rely on outdated technologies. Innovations are required in re-processing of mining and processing waste to increase critical mineral supply and to develop a circular economy approach (Whitworth, Forbes, Verster, Jokovic, Awatey & Parbhakar-Fox, 2022). Elevating "Critical Minerals Extraction and Processing" to its own category would underscore its importance. Individual technologies within this category could include emerging extraction and processing technologies (such as new floatation cells), waste

minimisation and management, remote area power supplies, electrification including of excavators and large-haul trucks, and techniques for controlling fugitive gases.

Minerals considered "critical" – defined as essential to the economy or national security and that are vulnerable to supply chain disruptions – can change due to market forces and new innovations. In this context, critical minerals should refer to those listed on the Department of Industry, Science and Resources' register, which is subject to regular review. The critical technology profile should be updated to reflect this.

**Recommendation 3:** Create a new category for *Critical Minerals Extraction and Processing*.

**Strengthening the List with emerging technologies**

In addition to the higher-level feedback presented above, ATSE would also like to suggest additions of emerging technologies to the 2022 List update.

*Health and medical research*

The organ-on-a-chip is a microfluidic cell culture device that can be used to model organ functions. This represents an alternative to animal studies for drug development. Organ-on-a-chip technologies are an emerging area with anticipated future applications in physiological and pharmaceutical research (Leung et al, 2022). Nano- and micro-fluidics, and lab-on-a-chip technologies more broadly could also be considered for addition to the List.

**Recommendation 4:** Include 'organ-on-a-chip technologies' in the category of *Biotechnology, Gene Technology, and Vaccines*.

Medical device manufacture (which includes prosthetics, electronic implants, mechanical devices, and sensors) should be included in the list. The medical device industry requires high-end manufacturing capability which includes a skilled workforce and suitable facilities. It is a potential growth area to achieve Australian technology manufacturing independence and further wealth generation with less dependence on importation and overseas manufacture.

**Recommendation 5:** Include 'medical device manufacture' as a technology in the category of *Biotechnology, Gene Technology, and Vaccines*.

Quantum health is another emerging area to be captured in the List. It is anticipated that quantum computing, in combination with artificial intelligence and machine learning, will be applied to process health data and model health outcomes for personalised patient care (Mallow et al, 2022).

**Recommendation 6:** Amend the critical technology 'quantum computing' to include healthcare as an application.

*Digital twinning*

A digital twin is a virtual representation of a physical object, usually with data fed in through sensors on the object to assist with simulations. Digital twinning goes beyond current simulation software (which is used in the design phase) by providing real-time data for maintenance and optimisation of the objects. This is an emerging area enabled by the emergence of artificial intelligence, big data, and the Internet of Things (Rathore et al, 2021).

This adds to existing well-known simulation software packages, including Finite Element Analysis (FEA) software that can be used to simulate strength, stiffness, and endurance under different conditions. Simulation software for energy analysis will become more important to understand the energy efficiency of new buildings in efforts to reduce carbon emissions, as well as to build infrastructure to withstand more extreme environmental conditions.

**Recommendation 7:** Add a technology 'digital twinning' under the category of *AI, Computing and Communications*.

*Foods – warm sea aquaculture*

There is considerable innovation and new technology being developed to secure better food supply. Warm sea aquaculture with genetic solutions is a key research area to improve fish farming yield, with an Australian research strength in this area through the ARC Research Hub for Supercharging Topical Aquaculture through Genetic Solutions.

**Recommendation 8:** Include 'warm sea aquaculture' as a technology under *Biotechnology, Gene Technology, and Vaccines*.

*Carbon capture and storage*

Developing viable carbon capture technologies, including direct air capture, capture from industrial processes, and capture from oil and gas fields and injection into depleted fields, is of increased importance and urgency with the Australian Government's recent commitment to net zero carbon emissions by 2050. This also represents an area of risk as failing to develop viable and economical technologies would adversely impact the Government's plans to reach net zero emissions.

**Recommendation 9:** Add 'carbon capture and storage' as a technology under *Energy and Environment*.

*Nuclear energy and waste management*

The current list has nuclear energy, and nuclear waste management and recycling under the *Energy and Environment* category. Nuclear issues are also picked up in the *Biotechnology, Gene Technologies and Vaccines* category under vaccines and medical countermeasures, which explicitly includes treatments for exposure to radiation exposure. However, nuclear energy and waste management do not appear in the critical technology profiles. Due to the increasing importance of nuclear power, particularly given the planned nuclear-powered submarines, a critical technology profile would be useful for stakeholders to summarise Australian Government actions, risks, opportunities, and underpinning science needs.

**Recommendation 10:** Create a critical technology profile on nuclear energy and nuclear waste management, with regulation, submarines, and skills requirements being key issues to include.

*Quantum computing*

Quantum computing represents a leading area of quantum research and economic opportunity in Australia. While there are critical technology profiles on quantum communications, quantum sensors, and post-quantum cryptography, there is not currently a critical technology profile on quantum computing. This should be addressed in the updated critical technology profiles.

**Recommendation 11:** Create a critical technology profile on quantum computing.

**References**

Leung, CM, de Haan, P, Ronaldson-Bouchard, K, Kim, G, Ko, J, Rho, HS, Chen, Z, Habibovic, P, Jeon, NL, Takayama, S, Shuler, ML, Vunjak-Novakovic, G, Frey, O, Verpoorte, E, & Toh, Y 2022, 'A guide to the organ-on-a-chip', *Nature Reviews Methods Primers*, vol. 2, no. 33

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Rathore, MM, Shah, SA, Shukla, D, Bentafat, E, & Bakiras, S 2021, 'The role of AI, machine learning, and big data in digital twinning: A systematic literature review, challenges, and opportunities', *IEEE Access*, vol. 9, pp. 32030 – 32052

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