Australian Academy of Science

Is Australian science ready for AI?

Infrastructure

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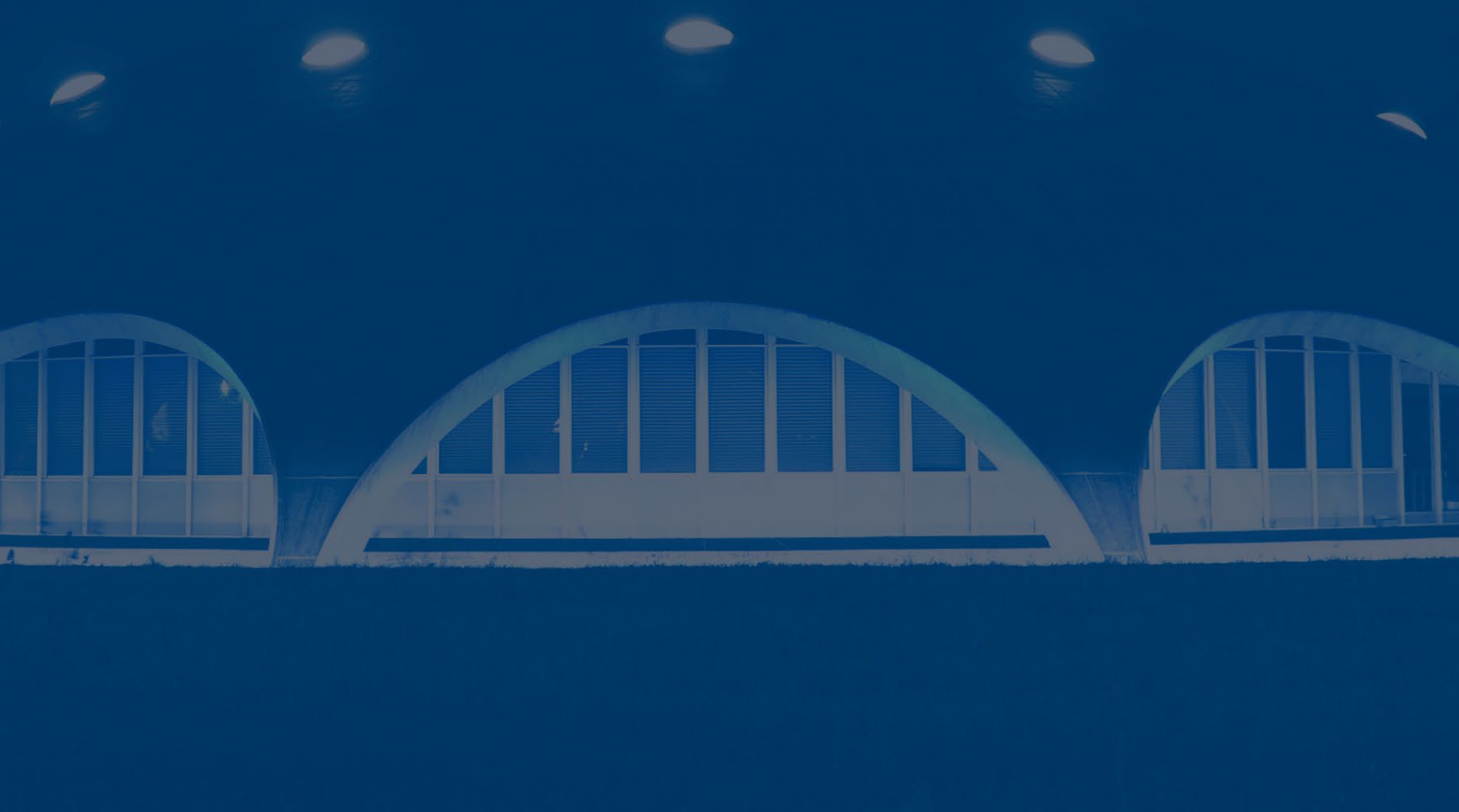

'Is Australian science ready for AI?' is a series of discussion papers that explore the preparedness of the Australian science sector for AI advances.

Does Australia have the infrastructure it needs to access AI opportunities?

AI demands serious computational muscle, but Australia's options are limited by access to hardware and data storage infrastructure. Gaps in Australia's semiconductor supply chain also pose a critical challenge.

While the US and EU are investing billions to secure their chip industries and introducing regulations to ensure access, Australia must decide whether to invest heavily on local supercomputing and data or remain reliant on foreign tech giants.

High-performance computing and data for AI

AI relies on powerful computing capabilities and extensive data storage to process and access the vast amounts of information needed for large-scale models in scientific research and science-based applications.

Scientific processes that can be augmented and/or automated by AI, such as complex climate and weather models, and drug discovery, demand high computing speeds and large data storage capacity. For instance, climate science models require high-resolution simulations that may need tens of thousands of Central Processing Unit (CPU) cores to run efficiently. Running century-scale simulations can span many months and use in the order of thousands of cores and generate terabytes of data, all of which require substantial computing power and data storage capacity.[1]

While cloud computing services from large companies (e.g. Amazon Web Services and Microsoft) can offer data storage, it is often insufficient to power the large-scale processes and calculations necessary, is costly for researchers to use, and when data and infrastructure is located offshore, comes with significant national security, research security and practical limitations around the handling of sensitive information.

Requirements for high-performance computing and data capability

High-performance computing and data (HPCD) allow for parallel processing of large datasets, providing far greater speeds than desktop machines. HPC infrastructure is centralised and is often more economical to develop at scale on a national level. Planning for future capability must also account for the high energy requirements and water use of supercomputing facilities, which shape decisions about siting, sustainability and long-term operational resilience.

Graphics processing units are more efficient than CPUs in handling AI tasks, as they are engineered for concurrent applications. However, CPUs will remain preferred for many areas of research for the foreseeable future, including climate and weather. Science will continue to require both types of processing units. Maintaining computing capacity and advanced architectures appropriate for these different types of tasks will be essential.

Maintaining this infrastructure requires significant investment in both not only physical facilities, software and ongoing user support, including technicians and help-desk services.

HPCD depends as much on software as on hardware. Software platforms and workflow tools enable scientists to use advanced architectures efficiently and at scale, and need to be considered alongside investments in physical infrastructure.

Sovereign capability in computing and data is an asset and necessity

Sovereign computing and data storage are vital in securing Australia's strategic interests. They ensure that local regulations oversee sensitive information and guard against unauthorised access, especially from foreign entities. Australia's data protection framework highlights the necessity of keeping data within the country to uphold control and compliance. This strategy is essential not only for national security but also for protecting citizens' sensitive data in the public sector and ensuring a safe digital future for future generations.

Additionally, hosting data centres onshore mitigates vulnerabilities associated with reliance on undersea cables – recently demonstrated to be susceptible to disruption – and addresses latency concerns, as offshore centres cannot adequately support high-volume, real-time services.

Should onshore data storage and computing capabilities prove insufficient to handle Australia's increasing demands, the country will face a key juncture: either risking its data sovereignty by transferring sensitive data abroad or suffering from infrastructure limitations that impede global competitiveness.

Supply chains for computing and data infrastructure

Role of semiconductors in AI infrastructure

A range of raw materials and manufactured goods, such as semiconductors and the materials required for their fabrication, underpin the computing infrastructure required for AI. Semiconductors are materials with specific electrical properties that make them ideal for use in electrical components such as chips, which power the memory and processing units of computers.

AI is intrinsically linked to the global semiconductor supply chain, and the rapid development of AI is driving increased investment in HPC systems. Additionally, application-specific integrated chips are being developed for specific purposes, including AI.

However, the semiconductor supply chain is complex, requiring high levels of technical precision, and is fraught with geopolitical tensions. Aspects of the supply chain are often highly concentrated in single countries or even individual companies.

For example, the Taiwan Semiconductor Manufacturing Company currently produces almost all cutting-edge semiconductors, including AI chips.[2] Therefore, developing, securing and/or diversifying the semiconductor supply chain is crucial to ensuring the continued development of AI infrastructure in Australia.

International responses to global supply chain pressures

In the context of supply chain challenges emerging from the pandemic and international conflicts, and increasing geopolitical competition, the US passed the *Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act 2022*.[3] The CHIPS and Science Act represents an investment of US$53 billion in semiconductor manufacturing, R&D, and the workforce in the US, as well as tax incentives for capital investments in semiconductor manufacturing infrastructure. The US has also placed increasing restrictions on the supply of semiconductors and access to key elements of their supply chain to China.[4]

Similarly, In September 2023, the European Chips Act entered into force to strengthen the EU's technological leadership in semiconductors and address semiconductor shortages. The Act mobilises more than €43 billion of public and private investment for technological capacity building, innovation, manufacturing and coordination across the region.

Australia's position in the global supply chain

In the context of these broader developments, Australia is a small player in the global supply chain for semiconductors. This has been identified as a potential weakness in Australia's innovation, economy and security. For example, there could be instances where the Australian Government and partners look to fund a new HPC facility, but Australia is unable to access the necessary components to build it.

In recent years, the NSW Government has taken an interest in the development of Australia's semiconductor sector, for example, by commissioning the Australian Semiconductor Sector Study[5] and establishing the Semiconductor Sector Service Bureau.[6] The Australian Semiconductor Study found that "Australia's semiconductor sector is relatively small compared to some other economies, but Australia is not without areas of strength and strategic significance."[5]

These strengths include:

- basic research expertise in many disciplines related to semiconductors, including, but not limited to, materials science, quantum computing, communications (especially photonics) and nanotechnology
- world-class semiconductor design capabilities in radio frequency, millimetre wave photonics and radar
- natural mineral endowments alongside mining capability and world-class material science R&D capabilities
- some existing participation in the semiconductor value chain more generally.

While semiconductors have dominated supply chain concerns in recent times, other AI-related infrastructure shortages, such as electrical transformers, may also be on the horizon.[7]

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