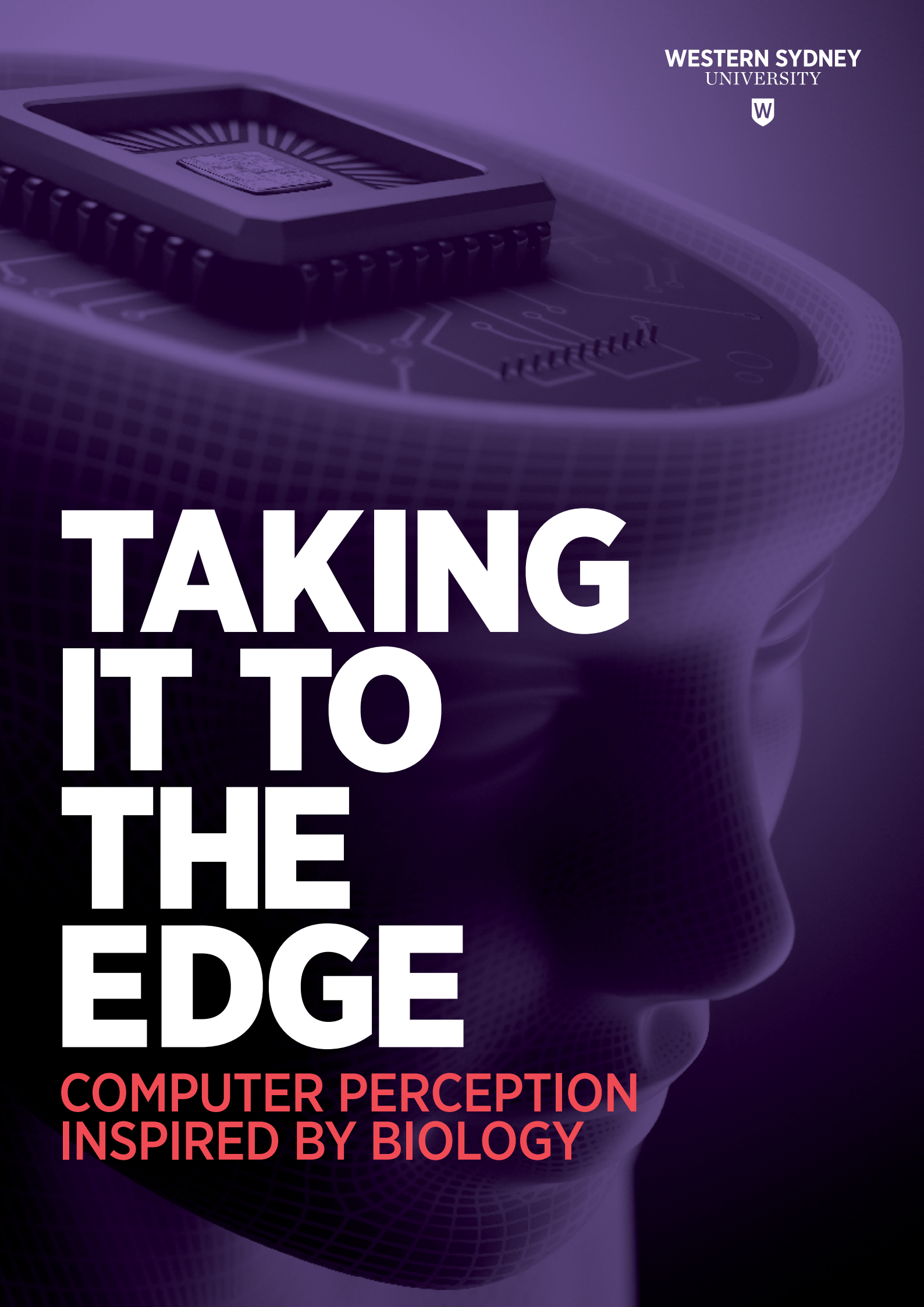


WESTERN SYDNEY
UNIVERSITY

TAKING IT TO THE EDGE

COMPUTER PERCEPTION INSPIRED BY BIOLOGY

INFORMATION MEMORANDUM

We are seeking commercial partners to realise the potential of our game-changing technology solutions. The range of opportunities outlined in this memorandum offer proven and sustainable ways of collecting and making sense of the modern world's ongoing data deluge.

OUR VISION

To commercialise our range of neuromorphic computer perception solutions to help solve problems currently impeding technological innovation. By harnessing the potential of our world-leading research on neuromorphic sensors, algorithms, and processing hardware, we can help shape the future.

WHAT IS NEUROMORPHIC ENGINEERING?

Inspired by biology, Neuromorphic Engineering is a cutting-edge approach to collecting data from sensors and extracting meaning from it.

The human brain is remarkable. It processes information more efficiently and faster than even the most advanced technology, using very little energy. Neuromorphic Engineering applies similar principles to electronic devices to achieve the same level of robustness and effectiveness.

Crucially, the energy efficiency of the neuromorphic approach enables processing at the sensor ('at the edge') to extract meaning from data and only communicate what is needed to central servers. This, in turn, saves even more energy, reduces the required communication bandwidth and preserves privacy.

The result is that rather than simply producing massive amounts of irrelevant data, neuromorphic solutions provide sensors and algorithms that efficiently alert us to important environmental changes, both on Earth and in Space, so we can take action.

Australian Defence:

"Neuromorphic sensors are a huge game changer for how we will do Space situational awareness in the future."

Jerome Reid, GPCAPT, Director RAAF Plan Jericho, 2019

Google:

"We recognise the urgent need for more research and education in Neuromorphic Engineering and solutions come at the right time."

Richard F. Lyon, Principal Scientist, Google

Intel:

"Over the past decade we have made tremendous progress in machine learning and AI, but arguably we are not much closer to understanding how brains achieve their remarkable data processing capabilities. Understanding biological brains will allow us to build better artificial brains. The next evolutionary step is neuromorphic computing."

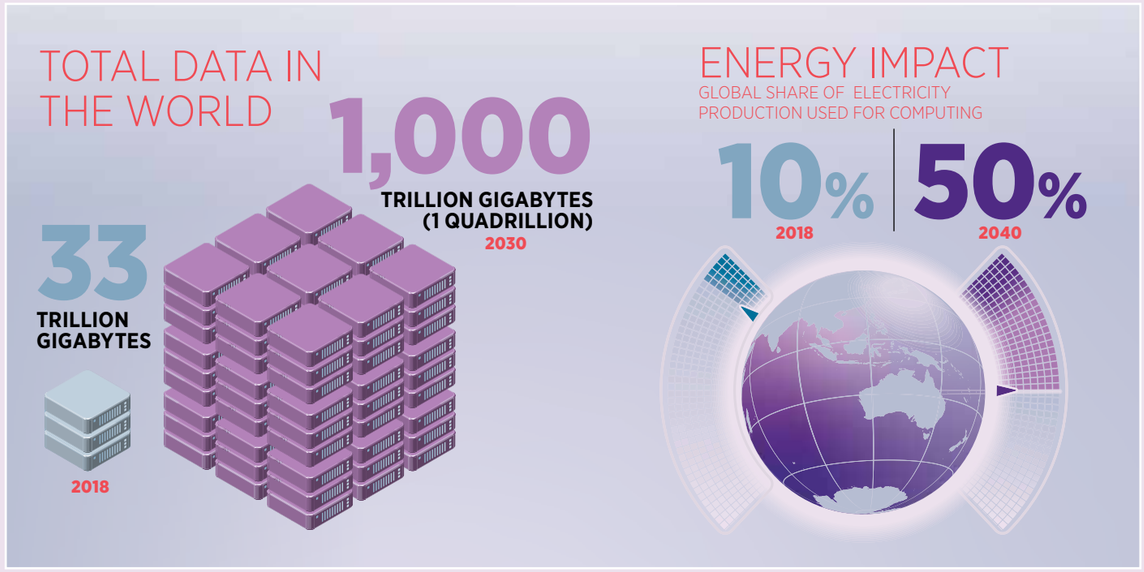
Christian Karl, Senior Staff Implementation Lead, Intel.

WHAT IS THE PROBLEM?

The world is drowning in data. The amount of data we collect is expected to double every two years, yet we are still able to process and analyse only a fraction.

We can no longer rely on the techniques that have driven advances in electronics over the past 50 years. Moore's law is coming to an end and we are reaching the physical limits of how small we can make devices on a chip.

The other major challenge is power. All data processing needs electricity. Computer processing is already creating more carbon emissions than aviation or shipping. On the current trajectory, in 20 years storage and manipulation of data will consume as much power as everything else in the world combined.



This trajectory is not sustainable. We are quickly running out of capacity, which risks slowing our digital innovation, impacting the economic development of Australia and the Asia-Pacific region.

"Brute force is currently being used to leverage the power of AI, but this approach is not scalable. It will hit a heat wall, a data wall, and a cost wall related to the ability of the semiconductor industry to deliver at a certain pace, Moore's law, the incremental cost to performance improvements. Current AI computing will not deliver, so what AI technology would be necessary? Neuromorphic computing and sensing solutions, drawing inspiration from what happens in the brain, have key specificities to compete within the existing AI landscape and constraints. These technologies will address most of the current challenges and could represent 20 per cent of all AI computing and sensing by 2035."

Adrien Sanchez, Technology & Market Analyst, Computing & Software division at Yole Développement

With the continued growth of our digital economies under threat from the limits of existing technology, Neuromorphic Engineering offers a sustainable solution, allowing us to better harness the power of data and turn it into insights we can use to drive action. To do this, we need to be nimble, adapt and implement a fresh approach that utilises the two core facets of Neuromorphic Engineering: neuromorphic or Event-Based (EB) sensing and neuromorphic computing. The former allows us to collect smarter, more useful data. The latter enables us to process that data using energy efficient, brain-inspired, neuromorphic computers.

WHAT IS THE OPPORTUNITY?

To co-invest with us to exploit a range of commercial opportunities in the defence and/or industrial domains. We have a window of opportunity to lead the world in the next wave of digital infrastructure design and development.

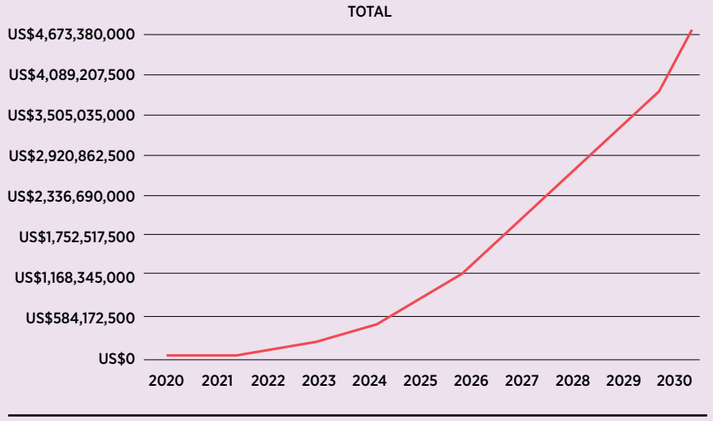
The two main contending technologies for next-generation computing are Quantum computing and Neuromorphic computing. Quantum computing will continue to rely on energy-hungry supercomputers for the foreseeable future, while Neuromorphic computing promises brain-inspired AI at much reduced energy consumption. Quantum sensors, however, can be combined with Neuromorphic Engineering to create smarter sensors.

Neuromorphic Engineering can offer energy efficient solutions now. It repurposes existing, tried and trusted microelectronics technology to develop novel solutions – without massive infrastructure investment.

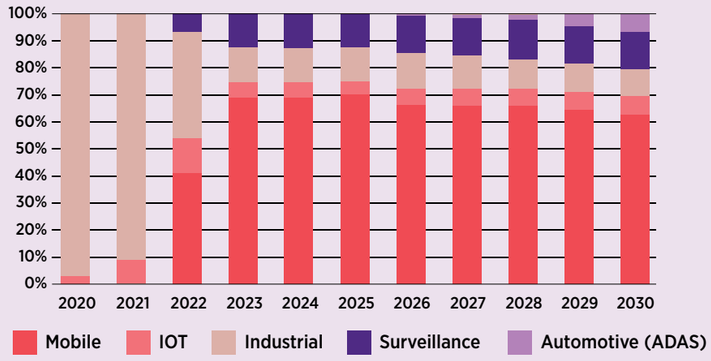
"Neuromorphic Engineering is not going to replace general purpose hardware, but it could be hugely important for solving special or specific technology challenges, such as effectively implementing artificial intelligence at the edge," says Emre Neftci, assistant professor in cognitive sciences at the University of California, Irvine, and head of the university's Neuromorphic Machine Intelligence Lab.

The field has exploded internationally in the last decade, with interest from industries and governments looking to find alternatives to conventional computational technology.

THE NEUROMORPHIC SENSING MARKET IS PROJECTED TO REACH US$5 BILLION BY 2030, WITH A COMPOUND ANNUAL GROWTH RATE (CAGR) OF 116 PER CENT BETWEEN 2025 AND 2030.



EVENT-BASED (EB) SENSOR REVENUE SHARE BY MARKET



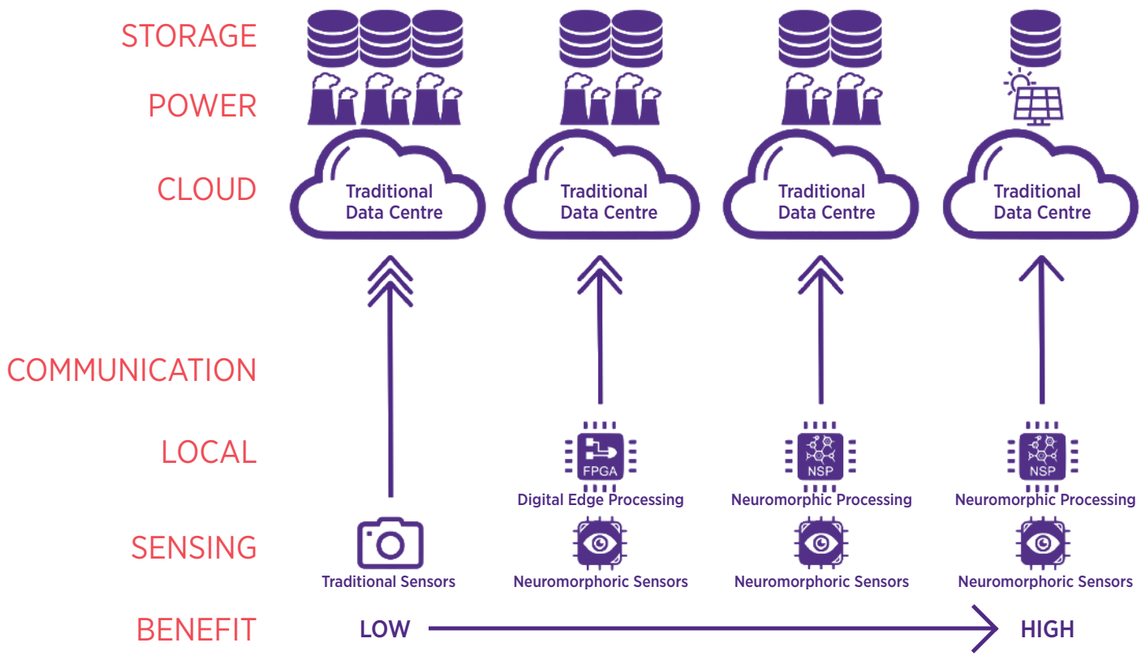
THE THREE MAIN SEGMENTS

- **CONSUMER**
- **INDUSTRIAL**
- **AUTOMOTIVE**

- Until 2025, Neuromorphic Engineering for industrial applications will remain a niche market, reaching US$2 billion in 2030 for computing and sensing combined.
- Industrial is forecast to be the first segment to adopt EB technologies, followed by Surveillance, Robotics, Mobile and Internet of Things.
- Yole Développement (Yole) estimates that mobile and other consumer applications will reach US$2.8 billion in 2030.
- After a maturation period (2024-25) EB Vision technology is expected to penetrate the automotive market as well.
- Neuromorphic computing for the automotive industry will reach US$2 billion in 2030.

Western Sydney University (WSU) has made a commitment to continue to invest in this game-changing technology via the International Centre for Neuromorphic Systems (ICNS), the largest research group of its kind and the only dedicated neuromorphic research laboratory in Australia. This support will deliver a strong and reliable pipeline of next-generation commercial opportunities.

The diagram below provides a high-level overview of the potential areas of impact for neuromorphic solutions. They exist right across the digital value chain. The more integrated your organisation's neuromorphic implementation, the greater the benefit in terms of power savings, decreased data production and storage, and faster decision making due to more precise perception of changes in your systems.



NEUROMORPHIC ENGINEERING IN ACTION

At ICNS, we conduct world-leading research to develop neuromorphic sensors, algorithms, and processing hardware, applying these unique tools to solve problems other forms of technology can't fix.

ICNS is implementing novel solutions in areas such as Space and aviation, smart manufacturing, built environment, agriculture, and medical technology – all of which are demanding new and integrated smart sensing and data analytics.

Neuromorphic Engineering solutions can be applied to:

- Space data and technologies
- Defence
- The automotive industry (including driverless and electric cars)
- Mining
- Agriculture
- Intelligence
- Internet Of Things including quantum sensors
- Speech and image recognition
- Other machine-learning applications

Neuromorphic Engineering solutions have the capacity to transform your organisation's process, product and/or service. A number of multinational companies have recognised this potential already and we are actively working with them on the real-world application of our solutions.

"Investment in this research will help drive Australia's ability to innovate, boost our productivity and competitiveness, promote economic growth through international collaboration, and increase our contribution to science and research globally."

Barney Glover,
Vice Chancellor and President
Western Sydney University

Further opportunities exist to collaborate on this breakthrough technology. Outlined on the following pages are some examples of the types of solutions we are seeking investment partners to work with to develop commercial capabilities. We encourage you to study our range of solutions to see how Neuromorphic Engineering might benefit your organisation.

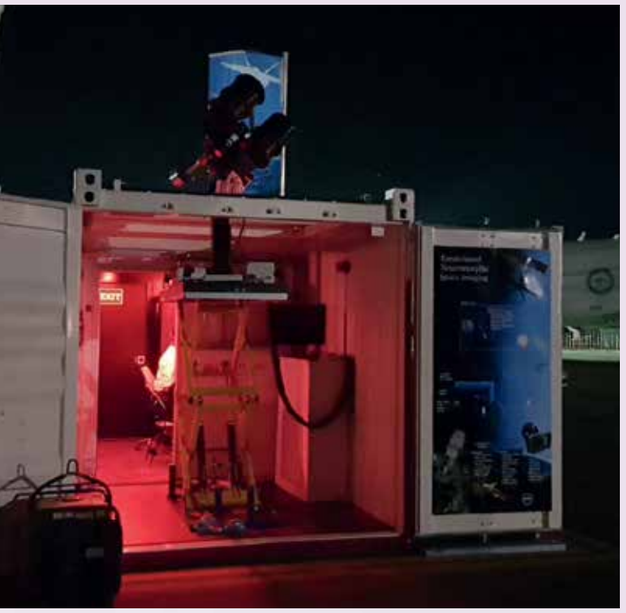
SPACE DOMAIN AWARENESS

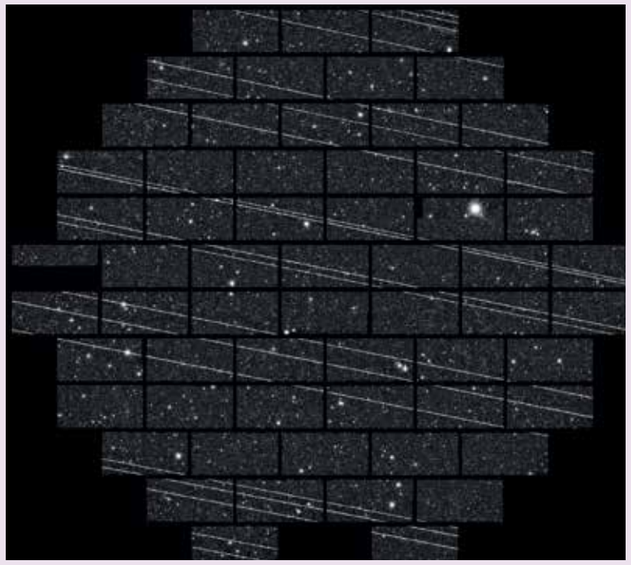
The global Space Domain Awareness (SDA) market is set to undergo considerable growth in the next three to five years, as over 60 countries and corporations will soon be capable of launching into Space. As a result, the SDA market is projected to be worth $1.44B by 2023.

The Astrosite™, a mobile SDA module, is a mature solution and a revolutionary, world-first approach to Space imaging. SDA is a critical service for the continued development of Space for defence and commercial purposes.

The image below is a recent attempt to track an object from Earth using traditional astronomy techniques. The streaks in the image are transiting CubeSats. Using silicon retinas, the Astrosite™ can detect and track objects in Space with unprecedented temporal resolution without suffering from motion blur, in real time. By analysing the orbiting object data at the source, the system can operate with low bandwidth and low power, maximising the agility of the mobile platform. By more effectively detecting Space junk, other satellites and debris, we can keep our Space assets safe and also better understand the activities of our allies and adversaries in Space.

Our sensors and algorithms are mature and operational in Space on the M2 CubeSat and will be installed on the International Space Station. Space is a high contrast and demanding environment and our solutions have been proven to meet many of the operational needs of this rapidly expanding market.





The time-lapse image on the right shows the passage of a Starlink satellite cluster (bright streaks) through a telescope's field of view at the Cerro Tololo Inter-American Observatory in Chile in November 2019.
Credit: CTIO, NOIRLab, NSF, AURA and DECam DELVE Survey

OPTICAL SOLUTIONS

Human and animal eyes are remarkably efficient, robust, and capable of operating over an incredible range of light intensities. Neuromorphic event-based cameras, or silicon retinas, seek to replicate these advantages.
At ICNS we focus on the development and use of silicon retinas for dynamic, real world, low-power, bandwidth-constrained applications, where neuromorphic sensing has in-built natural advantages over other more established imaging technologies.

ROCKET LAUNCH DETECTION

Rocket launches, especially for Space missions, involve fast moving and sometimes unpredictable trajectories (e.g. when rockets eject CubeSats). Detecting and tracking rocket launches is critical to maintaining safety, anticipating actions and deploying countermeasures as required.
The approach we have developed for SDA can also be applied to tracking rockets. We have undertaken a range of development activities in this field by leveraging our mature solution for SDA.

DRONE DETECTION AND TRAFFIC MANAGEMENT

Drone traffic management is a significant and emerging issue, with up to 1 million drones expected to be in commercial service by 2050 – Drones Go to Work (*bcg.com*). It is inevitable that traffic management and good operator standards are going to be increasingly regulated, which will require better systems for detection and tracking to enforce. Our sensors and analytics have been proven to be able to monitor and observe drones in flight. With sufficient resolution, we can predict their next move and alert traffic managers to unsafe or suspicious behaviour.

EYE TRACKING IN VR HEADSETS

Virtual Reality (VR) headsets are rapidly moving out of the gamer space into industrial applications, offering an immersive virtual presence for simulations, training, design etc, particularly in travel-restricted times. At present VR headsets are constrained by power consumption issues as they are rendering high-definition screens for both eyes at a high-update rate – currently advanced headsets only have a battery life of two to three hours.
By using EB vision systems, which are low power and extremely fast, we can track the location of users' eyes to determine where they are looking in a virtual scene. Using associated AI, we can then render the peripheral vision with much less detail, achieving savings of at least 50 per cent in headset power, effectively doubling its battery life. There are commercial versions of this approach in market today.

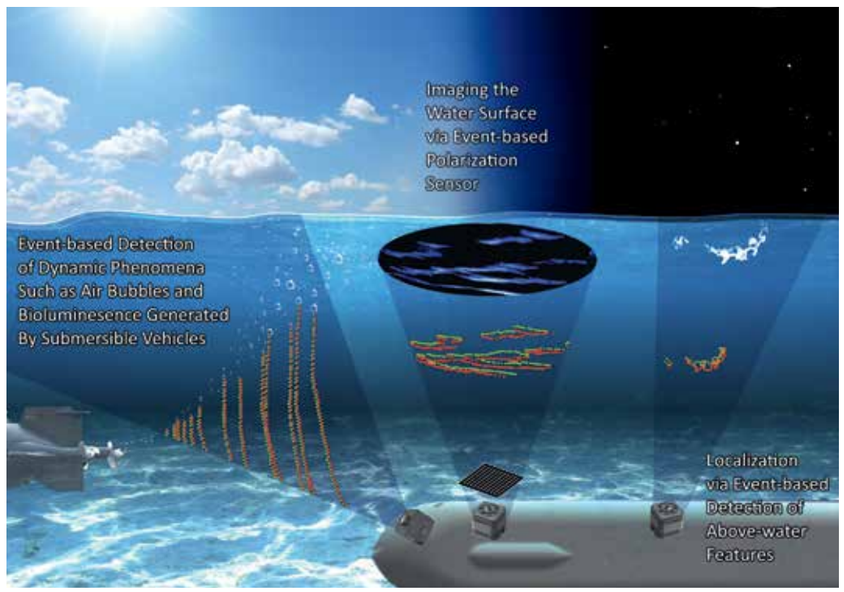
HONEY BEE HIVE HEALTH MANAGEMENT

We are using neuromorphic optical and audio sensors to constantly observe worker-bee behaviour in the hive. Our low-power and low-data rate systems allow us to monitor the orientation and frequency of returning worker-bee "waggle", known to communicate food sources to other bees in the hive. We are actively collecting the training data for this application. With sufficient data on the frequency of waggles, we expect we can begin to predict beehive health and make more informed decisions about hive location.

AUDITORY SOLUTIONS

Humans and other mammals process sound using the cochlea in their inner ear. The human hearing system is not only able to identify the location of individual sound sources but is also able to interpret them within complex auditory environments, like, for example, a cocktail party situation. This ability has proven extremely difficult to achieve for current state-of-the-art conventional audio processing algorithms.

We have developed and matured an artificial cochlea, inspired by biology, which allows us to replicate the remarkable performance and efficiency of the human ear. By operating in the same event-based domain and preserving timing information, our neuromorphic auditory system allows the development of superior processing techniques used in the brain, such as recognition, localisation and auditory-scene analysis, that have so far remained in the technological too-hard basket.



UNDERWATER AND SURFACE SITUATIONAL AWARENESS SURVEILLANCE

Underwater zones can be cluttered and chaotic environments. By using our sensors and algorithms to pierce the surface water and locate stars, we are exploring ways in which we can deliver accurate location data in GPS-denied environments, reducing the need for submersibles to breach. Additionally, there is the potential to observe and characterise objects in the water, or to provide enhanced situational awareness to underwater drones as they breach, to avoid collisions with boats and other surface objects.

BATTLEFIELD SITUATIONAL AWARENESS

Whether it's on land or at sea, battlefield commanders can use our optical and auditory sensors and edge processing, to identify friends, threats and incoming projectiles. It could be a soldier using our sensors and algorithms to quickly determine the origin of enemy fire or to survey surrounding bush terrain to determine the nature of a threat and take appropriate action. Or a ship captain seeking to identify and neutralise incoming missile threats. Our ongoing projects in this area are demonstrating our ability to manage platform movement and accurately characterise situational events to greatly enhance our combatants' battlefield awareness.

NEUROMORPHIC COMPUTING

DATA CENTRES

We are using our world-leading expertise in Neuromorphic Engineering to create machine-learning hardware, inspired by the brain. This neuromorphic computer will process data to provide actionable insights faster and with more relevance than traditional computing systems, while being up to a thousand times more energy efficient.

Additionally, by processing data at the edge of any network and only reporting relevant events for further analysis, these digital nerve centres will foster the next wave of digital transformation in our cities, agriculture and advanced manufacturing.

Building on our proof-of-concept systems, we are working with global IT companies like Intel and Microsoft. With Intel we are working together to design and build a next-generation neuromorphic computing data centre, which will help to redefine the place of data centres within the evolving global digital infrastructure.

CYBERSECURITY ANOMALY DETECTION

All systems operate at a given tempo and activity level. It is when the system changes that we want to be alerted. We are providing hardware solutions to the problem of security at the edge via the use of Neuromorphic Engineering. We have implemented a suite of low power, high-speed Spiking Neural Networks (SNNs) for anomaly detection, which learn the normal operating states of an edge device and detect and report changes.

WESTERN SYDNEY PARKLANDS CITY / AEROTROPOLIS

The Western Sydney Aerotropolis will be Australia's next global gateway focused on the Western Sydney International (Nancy-Bird Walton) Airport. It represents a once-in-a-lifetime chance to drive transformational change in the emerging Western Parkland City, a vision for Western Sydney that will improve opportunity, amenity and sustainability for workers and residents.

As it evolves, the Aerotropolis will become home to global industries that will provide jobs of the future in defence and aerospace, advanced manufacturing, technology, agribusiness, health, education, research and tourism, all within a cool, green and connected Western Parkland City.

The success of the Aerotropolis requires strategic, integrated planning across different levels of government and collaboration with business and the community.

Western Sydney University is committed to driving the region forward through our world-leading research centre in Neuromorphic Engineering (ICNS) and as a cornerstone participant in the regional innovation precinct. We will contribute to providing the critical smart infrastructure required, as well as research and education, to build human capital and knowledge to support the region's ambition.

If we are to build the world's smartest city, Neuromorphic Engineering will be integral to the process.

JOIN US IN SHAPING THE FUTURE AND DELIVERING SOLUTIONS

We are seeking Expressions of Interest in how you wish to partner with us, so together we can fully realise the potential of these innovations and create globally significant commercial outcomes.

ABOUT WESTERN SYDNEY UNIVERSITY

Western Sydney University (WSU) is a modern, forward-thinking, research-led university, located in the heart of Western Sydney, Australia's fastest growing and economically significant region. Boasting 11 campuses – many in CBD locations – and more than 180,000 alumni, 49,000 students and 3500 staff, the University has 12 Schools with an array of well-designed programs and courses carefully structured to meet the demands of future industry. The University is ranked in the top two per cent of universities worldwide and, as a research leader, 80 per cent of the University's assessed research is rated at "World Standard" or above.

WSU is an academic institution driven by impact, with research making a difference regionally, nationally and globally. Our partners are invested in our outcomes and they do more than simply support the work of our researchers. They design and perform research and their link to our teams ensures we deliver a tangible impact to industry and communities, both close to home and around the world.

ABOUT THE INTERNATIONAL CENTRE FOR NEUROMORPHIC SYSTEMS

The International Centre for Neuromorphic Systems (ICNS) at WSU is the only dedicated neuromorphic laboratory in Australia and one of the largest in the world.

We are distinguished from other Neuromorphic Engineering research groups through our core focus on applications of neuromorphic technology – for example, finding real-world solutions for industry and defence.

We are well positioned to develop applications that outperform existing technology and establish Australia as the international leader in Neuromorphic Engineering.

westernsydney.edu.au/icns

WESTERN SYDNEY
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For more information or to partner with us, please contact:

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