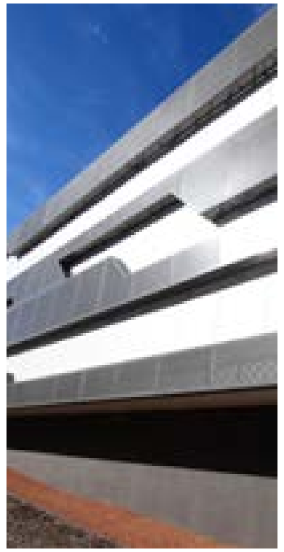
PAWSEY
supercomputing centre

EMPOWERING CUTTING EDGE RESEARCH FOR AUSTRALIA'S FUTURE

Cover images courtesy of Woodhead



The beginning of full operation by the Pawsey Supercomputing Centre is a signal achievement in the progression of Australia's scientific capacity. As one of the most significant national research infrastructure projects in our history, it represents a considerable coming together of talented people from many organisations. This has created a facility that places Australia amongst world leaders in the sphere of computational science and supports important keystone national science projects.

As Australia looks forward to building on its commitment to scientific research, the support of the Pawsey Supercomputing Centre will allow the best and brightest Australians to investigate new areas of research which have the potential to further enhance our way of life.

From enhanced mineral resource extraction to advanced analysis of staple foodstuffs, the state of the art equipment in the Pawsey Supercomputing Centre will be used by Australian scientists to conduct research that will generate an unimaginable range of social and economic benefits.

The Pawsey Supercomputing Centre is a remarkable testament to the spirit of collaboration across Australia and internationally and I am honoured to be a part of this landmark venture as it begins consolidating our place in the ranks of global innovation leaders.

John Langoulant
Chairman of iVEC
September 2014

OVERVIEW

The Pawsey Supercomputing Centre is an iconic landmark in the Western Australian scientific landscape, representing the next chapter in Australia's contribution to the advancement of international research.

A globally significant supercomputing facility named in honour of Dr Joseph Pawsey, the father of Australian radio astronomy, the Pawsey Supercomputing Centre stands at the forefront of two of Australia's most important scientific disciplines - radio astronomy and geoscience. Housing Magnus, the most powerful public research supercomputer in the Southern Hemisphere, the Pawsey Supercomputing Centre is a state of the art facility empowering cutting edge science for Australia's future.

With a new era of scientific activity beginning thanks to the power of high performance computing, Western Australian supercomputing organisation iVEC has chosen to realign itself with the Pawsey Supercomputing Centre brand to demonstrate its focus and dedication to making Western Australia one of the world's most significant hubs of expertise in the sector.

The Pawsey Supercomputing Centre maintains iVEC's track record as a successful joint venture between Federal and State-based organisations and continues its fourteen years of service to the research community, providing users with enhanced research outcomes through supercomputing, data, and visualisation services. The Pawsey Supercomputing Project is an initiative of the Australian Government, being conducted as part of the Super Science Initiative and financed from the Education Investment Fund. It represents a national commitment to supporting research that secures Australia's economic, social and environmental future using the power of supercomputing.

As one of two major national supercomputing centres, the Pawsey Supercomputing Centre works with its sister organisation, NCI (National Computational Infrastructure), to ensure that Australia remains internationally competitive in research that contributes to the nation's current and future wealth, happiness, security, and capacity for innovation. Supporting the needs of researchers across the country, the two centres work together to enable Australia's scientists to harness supercomputing resources to achieve world-leading outcomes.

The Pawsey Supercomputing Centre is configured to focus on the two priority research areas of radio astronomy and geosciences, supporting major projects such as Square Kilometre Array (SKA) pathfinder research, capitalising on Australia's unique wealth in terms of underground minerals and clear views of the skies above. The Pawsey Supercomputing Centre has the primary aim of hosting new supercomputing capabilities and expertise to support a variety of scientific research disciplines requiring high level computational, visual and data management resources, connected nationally by high-speed networks.

Pawsey Supercomputing Centre Photography courtesy of Woodhead

In establishing the Pawsey Supercomputing Centre, the Australian Government committed a 25% share of the supercomputer capability to both the radio astronomy and geosciences research domains in support of Australia's commitment to the SKA project and the development of significant research capacity in the geosciences for Western Australia. It also required that 15% of capacity be allocated through a national merit allocation scheme to ensure that researchers from across Australia can benefit from the world-class supercomputer resources. A further 30% and 5% were also committed to the Pawsey Supercomputing Centre partners and the Executive Director respectively in recognition of the partners' operational funding commitments.

Of major significance, the Government of Western Australia has committed approximately $20m over 5 years to enable the Centre to operate its facilities and assist the user community in harnessing the power of its systems, while developing Perth as one of the fastest-growing communities of supercomputing expertise in the world. The continuing long term investment by the Government recognises the vital role supercomputing will play in the future prosperity of the State through enabling high-powered resources research. It also reinforces the contribution of Western Australia to the SKA, with an ever-increasing supercomputing capacity required to manage the vast amounts of data that will be produced by the world's greatest science project.

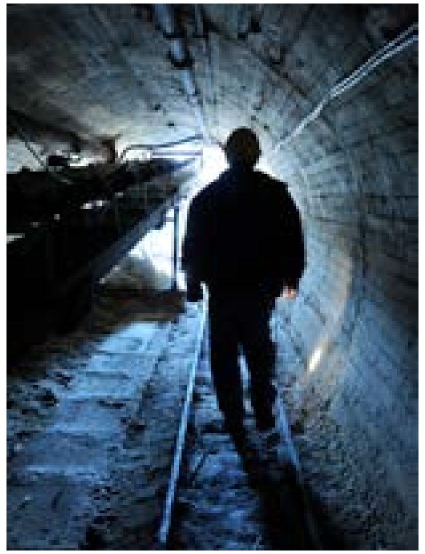
In addition to the Government of Western Australia, the Pawsey Supercomputing Centre's Partner organisations have all contributed significantly, both in terms of supporting its operations and by providing key expertise and guidance.

The Pawsey Supercomputing Centre comprises a purpose-built structure, housing supercomputers and associated works at Kensington, Western Australia. The facility is managed by staff with over fourteen years of expertise in the supercomputing and scientific research industries. The building is located on CSIRO-owned land adjacent to the Australian Resources Research Centre facility, which is approximately six kilometres from Perth's CBD. The facilities incorporate initiatives to minimise impact on the environment and best practice technologies to reduce energy usage.

The Pawsey Supercomputing Centre is currently playing an integral role in Australia's most important research activities and has made Western Australia a leading hub of supercomputing expertise. Now that it is fully operational, the Pawsey Supercomputing Centre will help deliver cutting edge research for Australia for years to come.

Night Sky at MWA Site Western Australia © John Goldsmith

Super Pit Kalgoorlie Western Australia (Imagestock)



Over the past 100 years, Australian researchers have been part of groundbreaking discoveries like the pacemaker, medical penicillin, Wi-Fi technology and the bionic ear. The Pawsey Supercomputing Centre is proud to be playing a pivotal role in continuing this legacy of scientific greatness into the 21st century.

The power of supercomputing will be increasingly vital in maintaining Australia's standing at the forefront of the global scientific community. As the Southern Hemisphere's most powerful facility of its type, the Pawsey Supercomputing Centre will be central to securing the nation's research future.

Researchers using the power of the Centre are already delivering results in key scientific disciplines such as geoscience, radio astronomy, nanotechnology and medicine. These results will only continue to accelerate moving into the future, as a critical base of knowledge is developed.

Geoscience

Australia's economic prosperity relies heavily on mineral and energy resources. However, over the past decade, global expenditure for resources exploration has declined sharply. Part of the reasoning behind this slump is the exhaustion of cheaply and easily accessed deposits. Improved imaging and extraction techniques are needed to maintain this vitally important sector of the Australian economy.

The Pawsey Supercomputing Centre is committed to enabling research into investigating and developing these new techniques, including enhanced identification, imaging and recovery methods.

Not only do these technologies hold direct economic benefits for Australia that can be measured in billions of dollars, but they also help to place Australia firmly at the forefront of the minerals and resource exploration in the global scientific community.

Resources and Engineering

The Pawsey Supercomputing Centre is also actively engaging in projects designed to solve potential engineering challenges and encourage new ways of thinking about the world. These solutions could produce tangible benefits for Australians across a diverse range of areas.

NCI PROVIDING AUSTRALIAN RESEARCHERS WITH WORLD-CLASS HIGH-END COMPUTING SERVICES

PAWSEY supercomputing centre

The range of these projects is diverse: including nanotechnology, modeling of improved food production processes and revolutionary energy generation technologies.

By encouraging and enabling research into projects such as these, the Pawsey Supercomputing Centre is helping to ensure Australia is behind many of the future's most important scientific breakthroughs.

Medicine

Developing methods and technologies for medicine is critically important – not only for improving the quality of life of millions of Australians, but also for the economic benefits that can be produced through having a healthier population.

These projects are developing new methods and technologies for studying and treating diseases ranging from asthma to Alzheimer's.

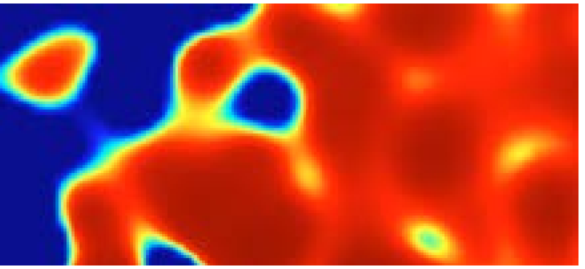
The Pawsey Supercomputing Centre is actively engaging in advanced health research through a number of projects, and will continue to engage in this vital scientific field moving into the future.

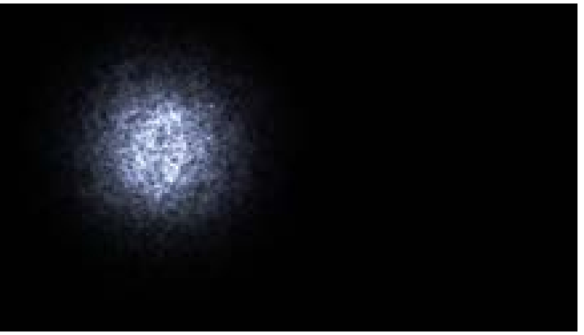
NCI and the Pawsey Supercomputing Centre: Australia's commitment to the 21st century

A partnership between the National Computational Infrastructure (NCI) in Canberra and the Pawsey Supercomputing Centre is at the heart of the Australian government's commitment to ensuring the nation has a consistent world-class supercomputing capability. This commitment represents a significant investment on the part of the Australian government to scientific research in the 21st century.

Working together, these two world-class facilities will allow Australia to produce internationally competitive results in all fields of scientific research, developing solutions that will benefit the nation for decades to come.

SUPERCOMPUTING - SCIENTIFIC SUPPORT FOR AUSTRALIA'S FINEST

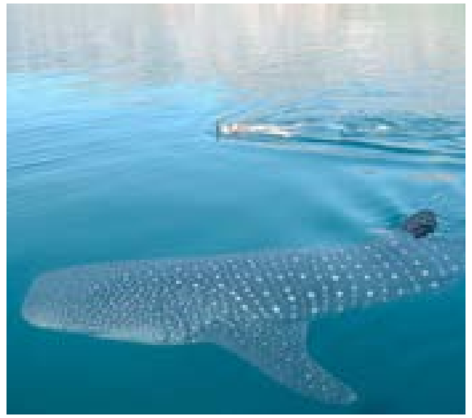


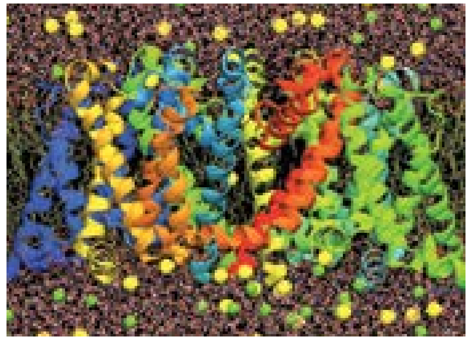


The Australian Government's commitment to ongoing national supercomputing resources is a key aspect of Australia's ability to remain at the technological and social forefront of developed nations. The commitment is based on an understanding that high end science is not an end in itself but the means of providing a base of knowledge that can power a wider range of endeavours than less intensive research.

The work undertaken by Australia's scientific leaders flows down through their community, enabling new avenues of research and inspiring other scientists to expand their existing activities. It is refined through a range of collaborative initiatives into knowledge and practices that drive industry forwards, and a nation's ability to self-source this research capacity as opposed to obtaining it from other nations at cost is a significant marker of global competitiveness.

These areas of elite scientific endeavour require specific computational resources that can only be supported through supercomputing. While Australia hosts a general research infrastructure network amongst its research institutions that is able to serve the needs of most scientists through tools such as cloud computing or in-house compute clusters, the capacity for top-end science is only allowed by the power of supercomputing resources.





Through an ongoing commitment to the provision of world-class supercomputing facilities the Australian Government has recognised a national need to remain competitive with neighbouring nations who have begun to take advantage of the research benefits it provides. By building a base of both physical hardware and human expertise, the Pawsey Supercomputing Centre and NCI are ensuring that elite science can support Australia in key areas of national importance.

CASE STUDY - SEISMIC IMAGING AND MODELLING FOR MINERAL AND HYDROCARBON EXPLORATION AND PRODUCTION

The Problem

Australia's current and future economic prosperity relies heavily on mineral and energy resources.

However, over the past decade, global expenditure for resources exploration in Australia has declined sharply.

Part of the cause behind this slump is the exhaustion of cheaply and easily accessed deposits. Improved imaging and exploration techniques are needed to enhance the processes used to identify and target new mineral deposits and hydrocarbon reservoirs.

The Solution

3D and 2D seismic modelling and imaging is being investigated by a team of researchers from Curtin University using resources and expertise supplied by the Pawsey Supercomputing Centre.

Improved methods for resource identification and imaging can bring great economic benefits in terms of efficiency and production.

This research breaks new ground in developing new imaging methods, new modelling algorithms and other computational geoscience techniques.

By being able to better detect and image mineral deposits and hydrocarbon reservoirs, new resources, which until now may not have been feasibly accessible, can be utilised. The economic benefits of this for Australia can be measured in billions of dollars.

Piping system in industrial plant (imagestock)/ Below: Streamlines highlighting structural attributes for both magnetotelluric derived conductivities and polar dip derived from a seismic reflectivity volume. Image courtesy of Andrew Pethick

How the Pawsey Supercomputing Centre Helped

When applied to methods of mineral exploration, 3D seismic modelling and imaging is extremely time and resource intensive.

However, using the Pawsey Supercomputing Centre's considerable supercomputing resources and expertise, these processes can be performed exponentially faster and more efficiently than traditional methods.

Using these capabilities, researchers were able to develop complex seismic modelling algorithms and novel imaging approaches that would have otherwise been impossible.

"The ability to visualise these massive datasets enables a new era in Australia's ability to benefit from its natural resources. These new processes would not have been possible without the use of iVEC's world-class facilities."

Dr Andrew Squelch, Curtin University, Project Initiator

This was made possible by the Centre's focus on providing tailored solutions that embrace a range of different technical disciplines.

Whiteflies feeding on the underside of cassava leaves

A/Prof Laura Boykin of The University of Western Australia's Plant Energy Biology ARC Centre of Excellence is using the Pawsey Supercomputing Centre's resources and expertise to assist farmers in poverty-stricken Eastern Africa by building more accurate identification systems for highly invasive pest species, including *Bemisia tabaci*, the silverleaf whitefly. These systems could potentially bring great benefits to researchers and farmers all over the world, including in Australia.

The Problem

Species of whitefly are one of the most pervasive pests on Earth, being found on every continent except Antarctica. While some species of whitefly are harmless native populations, many are highly invasive pests. These invasive species feeds on valuable crops and spread viruses, leaving many smallholder farmers without enough food to feed their families.

A/Prof Boykin's project is concerned with the silverleaf whitefly, *Bemisia tabaci*. This species is spread throughout the world, including populations in the United States, Australia and Eastern Africa.

A key problem for researchers and farmers is the visual similarity between various species of whiteflies. This makes differentiating between harmless and invasive species almost impossible, as well as hindering management strategies. Different species of whiteflies respond differently to varying strategies, such as pesticides or biological controls.

"It's a pest which is found all around the world affecting agriculture wherever they go, and the techniques that we're developing with the East African whiteflies can be applied with researchers and farmers all around the world," says A/Prof Boykin.

The Solution

A/Prof Boykin is using phylogenetic techniques to better understand the relationships between whiteflies around the world. Running a program on 'Magnus' using the Markov chain Monte Carlo method, the project is able to genetically distinguish between *Bemisia tabaci* and other harmless species that look identical.

"This project is all about "knowing the enemy". To a farmer, these species all look the same. This project could help develop diagnostic tests that will tell farmers if they have a harmless species or one they have to get rid of ASAP, which is invaluable," says A/Prof Boykin.

How the Pawsey Supercomputing Centre Helped

The genetic data sets involved in this project involved upwards of thousands of base pairs. Even with only 500 whiteflies in a dataset, the possible relationships between these flies would be an almost impossible calculation using a desktop computer.

"There's not enough computing power to do it using normal methods," says A/Prof Boykin.

As well as the size of the data sets, the sophisticated techniques used in this project are also extremely computationally intensive, necessitating world-class supercomputing power.

Using 'Magnus' and the Pawsey Supercomputing Centre's resources and expertise, these calculations can be performed in a practical timeframe.

"The Pawsey Supercomputing Centre has really helped," says A/Prof Boykin.

"The beauty of this particular project is it really is a true engagement. It's not just me using the resources, I'm interacting with the scientists and staff there as well. It's made a huge difference in pushing this research forward."

Bemisia tabaci

Image courtesy A/Prof Laura Boykin

Aerosol science plays a developing role in research areas in the health sector. Professor Ben Mullins from Curtin University's School of Public Health is a chemical and environmental engineer who applies aerosol science to his biomedical research projects. In collaboration with colleague and mechanical engineer Dr. Andrew King, Prof. Mullins is conducting research that compares airway penetration between liquid and powdered medications.

The Problem

"Chronic Obstructive Pulmonary Disease (COPD) and pneumonia are two of the top five killers of the elderly, with COPD claiming one patient every 10 seconds," Prof. Mullins says.

"Asthma affects approximately 15 percent of the Australian population and $358 million is spent on asthma medication alone per year, yet more than 95 per cent of it is wasted."

No other WA research groups have had prior experience of stimulating an expanding and contracting lung that reflects on realistic breathing. In order to attain comparison results, a 3-D model had to be created. The model was developed to simulate respiratory airflow and particle deposition during realistic lung expansion and contraction.

The Solution

The solution to attaining results was to couple a 'moving mesh' algorithm with custom airflow and particle models.

"We developed the most advanced and physiologically realistic lung model to simulate airflow, which will revolutionise aerosol drug delivery (such as Ventolin inhalers) and also assess exposure to airborne pollutants." Prof. Mullins says.

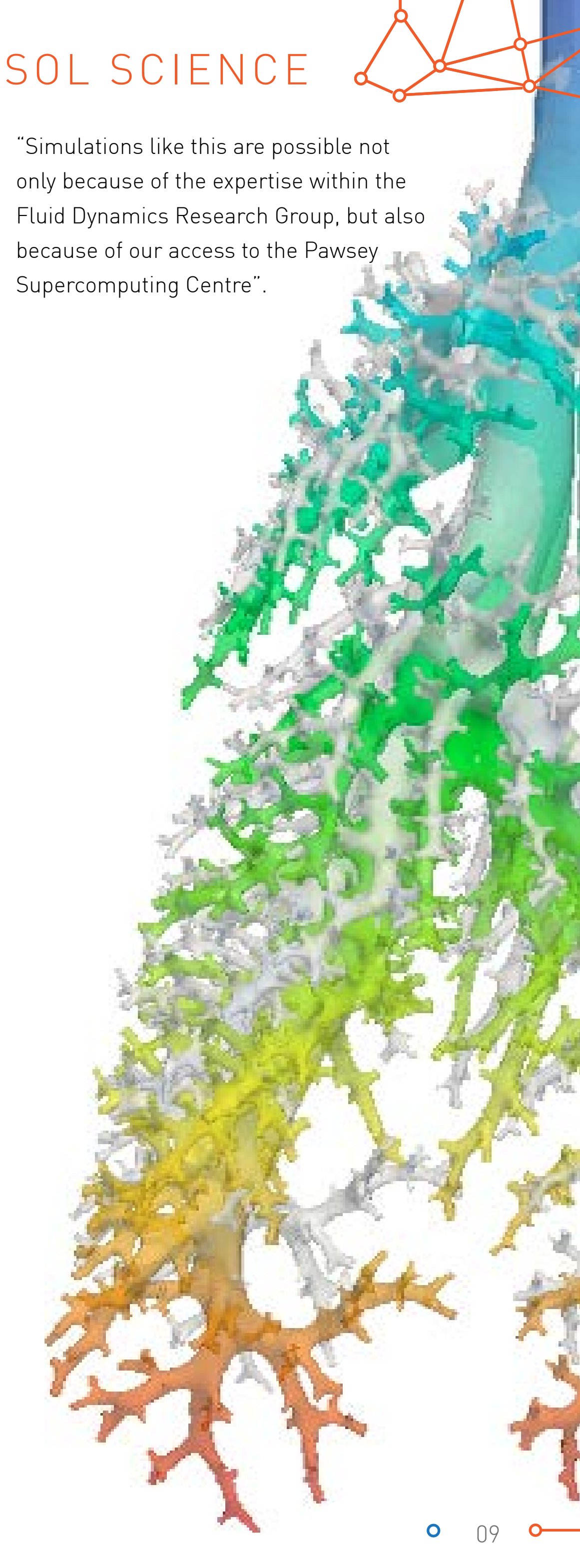
"This research is the first of its kind and allows us to get better information on what is happening at highly localised regions in the lung. This will, in turn, allow us to better target drug delivery to where it is needed most."

How the Pawsey Supercomputing Centre Helped

Supercomputing is considered an essential element of the research project as it makes the process function a thousand times quicker. The Pawsey Supercomputing Centre's solutions were extremely helpful to this research project as it is impossible to effectively conduct complex computational fluid dynamics (CFD) simulations without high powered computers. Both the particle code and the moving mesh algorithm are highly computationally-intensive to resolve, and require a huge data transfer between cores in order to reach a solution within a reasonable time.

"HPC means our experiments are a thousand times faster," says Prof. Mullins.

"Simulations like this are possible not only because of the expertise within the Fluid Dynamics Research Group, but also because of our access to the Pawsey Supercomputing Centre".



Simulation of airflow and expansion (breathing) of a lung

3D MINERAL MAP OF THE ROCKLEA DOME CHANNEL IRON DEPOSIT

The Problem

The Hamersley iron ore province is a major source for Australia's iron ore resources. Channel Iron Deposits (CIDs) are economically significant formations, providing a major percentage of the iron mined in Western Australia. Location of deposits carries a significant cost in terms of resources and time, with traditional, physical methods having significant margins of error.

The Solution

3D mineral maps can be generated from multi- and hyper-spectral data for a variety of mineral deposit types, providing unprecedented mineralogical information for the Australian resources sector, necessary for advanced mineral exploration and mining. Supercomputing facilities, such as the Pawsey Centre, enable the processing and visualisation of these computationally intensive data.

How the Pawsey Supercomputing Centre Helped

The Pawsey Supercomputing Centre's resources helped to produce and visualise a 3D model of the Rocklea Dome CID in the Hamersley Basin, showing key mineralogical parameters derived from hyper-spectral remote and proximal sensing data. The surface mineral map and subsurface mineral logs display the relative crystallinity of kaolin group minerals (rainbow colour stretch from blue = poorly crystalline to red = well crystalline kaolinite), which are used to model the extent of a CID (white surface). The red surface, enveloped by the white channel surface, represents the actual iron ore resource, and was modelled from hyperspectral drill core logging data, using CSIRO's HyLoggingTM system.

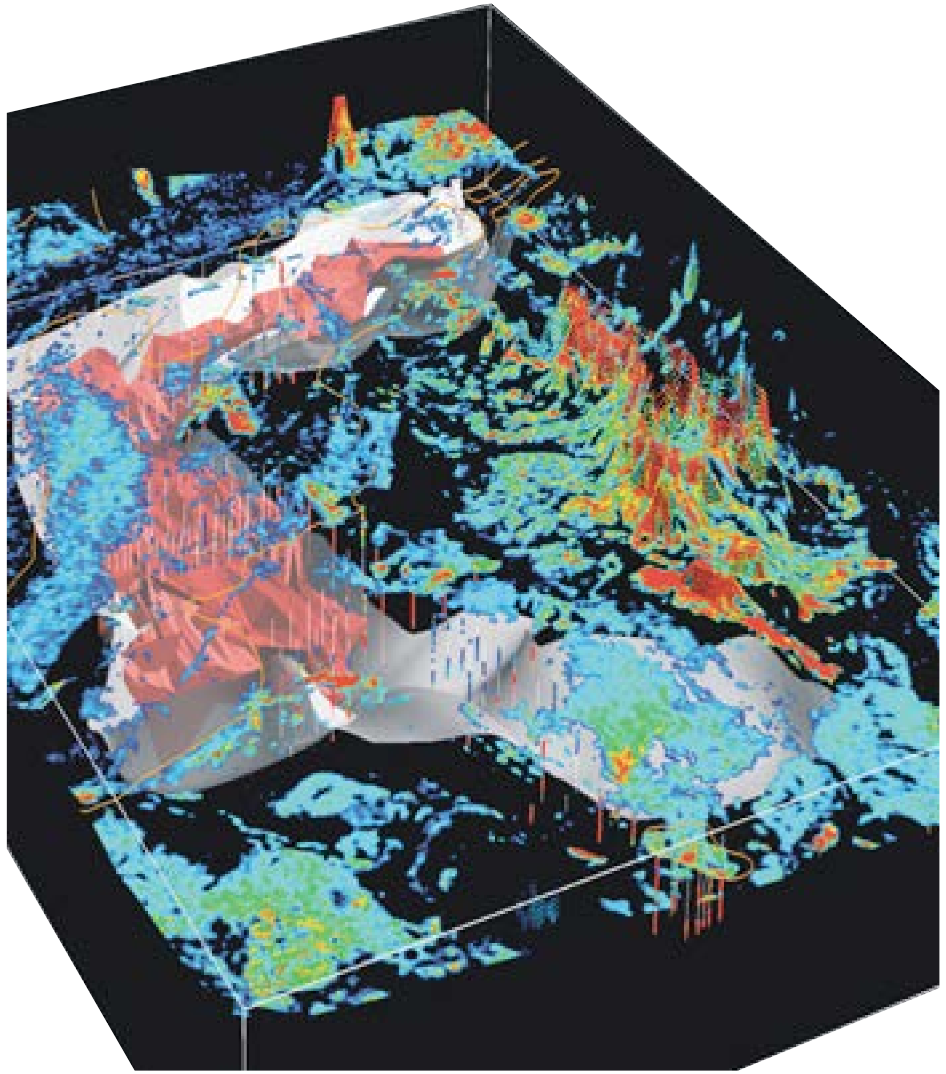


Image displays the relative crystallinity of kaolin group minerals (rainbow colour stretch from blue = poorly crystalline to red = well crystalline kaolinite), used to model the extent of a Channel Iron Deposit (white surface) and iron ore resource (red surface).

THE PAWSEY SUPERCOMPUTING CENTRE AND THE SKA

The Square Kilometre Array (SKA) is an international project to build a next-generation radio telescope, which will be 50 times more sensitive and able to survey 10,000 times faster than today's most advanced telescopes.

The SKA will help scientists answer fundamental questions about the origins of the universe, such as how the first stars and galaxies were formed.

A $2.3 billion joint effort between institutions from over 20 countries, the SKA will be co-hosted by southern Africa and Australia.

The Australian component of the project will be located at the CSIRO's Murchison Radio-astronomy Observatory (MRO), the centre of a radio-quiet zone, near Boolardy in Western Australia, 315km northeast of Geraldton.

In addition to delivering groundbreaking scientific results, the SKA also brings many other benefits to Australia.

As one of the two co-hosts, Australia's central involvement in the SKA will help to cement the nation's place at the forefront of the global scientific community.

By raising Australia's international profile as a scientific leader, the SKA will bring greatly increased international investment to the North West region of Western Australia as well as the entire nation.

The Pawsey Supercomputing Centre's cutting-edge resources and expertise will be crucial in processing the immense amount of data produced by this world-leading astronomy project.

Outrigger tile at night - Credit, Pete Wheeler, ICRAR

Antennas of CSIRO's Australian SKA Pathfinder (ASKAP) telescope, at the Murchison Radio-Astronomy Observatory in Western Australia

The Pawsey Supercomputing Centre is one of around 20 members of the SKA Science Data Processing Consortium (SDPC). The consortium is responsible for designing the infrastructure, hardware and software necessary to analyse, process and visualise the data produced by the SKA.

The data from the Australian component of the SKA is under consideration to primarily be processed and stored using the world-class resources and expertise at the Pawsey Supercomputing Centre.

When the SKA is completed, it will collect more data than is contained in the entire Internet today, representing a significant computing challenge.

The amount of data produced is too large to store for any reasonable period of time. This means the data must be processed in real-time, necessitating an immense amount of processing power.

Two precursor projects to the SKA, the CSIRO's Australian Square Kilometre Array Pathfinder (ASKAP) and the Murchison Widefield Array (MWA) were launched in late 2012 and are serving as important technological demonstrators for SKA.

The 'Galaxy' real time supercomputer is the central science processor for the ASKAP project.

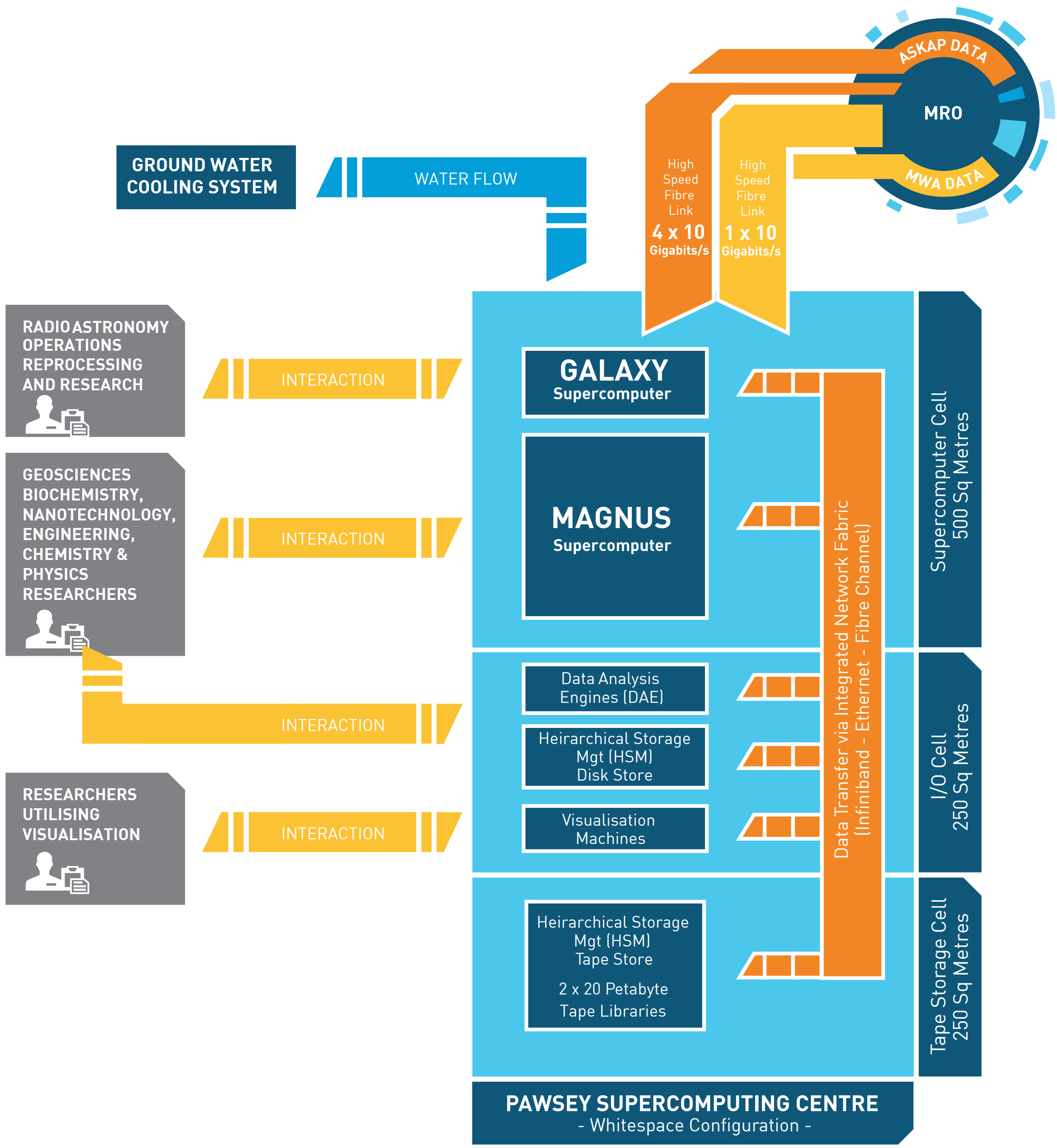
Both ASKAP and the MWA already make use of the Pawsey Supercomputing Centre's facilities, which represents a near unique advantage.

With its experience processing data from the pathfinders, the Centre has vital experience testing the technologies and potential problems the SKA may face.

As a member of the SKA consortium, the Pawsey Supercomputing Centre can comment and advise on its experience in a way that many other supercomputing centres that are involved cannot.

The Pawsey Supercomputing Centre also holds key skills in the area of visualisation, which will allow the raw data from the SKA to be explored in new dimensions by the international community.

PAWSEY CENTRE SUPERCOMPUTER: KEY COMPONENTS



TECHNICAL SPECIFICATIONS

Magnus

Magnus, from the Latin 'Great', is a latest-generation Cray XC30 system that will be used for supercomputing projects across the entire range of scientific fields serviced by the Pawsey Supercomputing Centre, including geoscience and general research. Following the recent installation of its second stage upgrade, Magnus delivers peak compute performance in excess of one PetaFLOP (one quadrillion floating point operations per second). This makes the Pawsey Supercomputing Centre the most advanced supercomputing facility in the Southern Hemisphere.

This system provides users with over 35,000 cores, using the cutting edge Intel® Xeon® processor E5-2600 v3 product family (former codename Haswell). Magnus is one of the first supercomputers in the world to make use of these latest generation processors.

The compute nodes communicate amongst themselves over Cray's high-speed, low-latency Aries interconnect. Storage consists of three petabytes of working storage, provided by Cray's Sonexion Lustre appliances, and is connected via 56 Gbit/s FDR Infiniband.

Galaxy

Galaxy is a Cray XC30 system that supports radio-astronomy activities within the iVEC community. It fulfils the real-time processing requirements of the Australian Square Kilometre Array Pathfinder (ASKAP) telescope, as well as providing for the reprocessing and research needs of the wider Australian radio-astronomy community, including those of the Murchison Widefield Array (MWA) telescope. In the context of ASKAP, Galaxy runs the Central Science Processor, allowing pseudo-real-time processing of data delivered, to the Pawsey Supercomputing Centre, from the Murchison Radio-astronomy Observatory (MRO).

Galaxy consists of three cabinets, containing 118 compute blades, each of which has four nodes. Each node supports two, 10-core Intel Xeon E5-2960 'Ivy Bridge' processors operating at 3.00 GHz, for a total of 9,440 cores delivering around 200 TeraFLOPS of compute power. Communication between the nodes occurs via Cray's high-speed, low-latency Aries interconnect. Galaxy local storage is provided by a Cray Sonnexion 1600 appliance, providing 1.3 Petabyte of capacity, via an FDR Infiniband network.

Zythos

Zythos is a latest generation SGI UV2000 system housed in the Input/Output cell at the Pawsey Supercomputing Centre. It is a large shared-memory machine used for data-intensive jobs such as visualisation.

Zythos contains 24 UV blades. Twenty of the blades each contain two hex-core Intel Xeon E5-4610 'Sandy Bridge' processors and 128GB RAM, and the remaining four each contain a single hex-core Intel processor, an NVIDIA Tesla 'Kepler' K20 GPU, and 256GB RAM. Altogether the machine boasts 264 CPU-cores, four GPUs, and a total of 6TB RAM.

Pawsey Supercomputing Centre Building Features

The special features of the Pawsey Supercomputing Centre building include;

- A 'dual skin' building construction to ensure the most effective insulation of the supercomputing environment from external temperature extremes.
- Fibre optic high speed networks linking researchers from Australia and overseas to the facility. This includes a specific purpose high speed link to the Murchison Radio Astronomy Observatory, some 800km north of Perth.
- Scalable cooling and electrical services which will enable flexible supercomputer expansion within the 1,000 square metre computer hall.
- A unique groundwater cooling system for removing heat from the supercomputer and reinjecting and dissipating this heat into the aquifer, 140m below the Pawsey Supercomputing Centre, with no net loss of groundwater.
- A Photo Voltaic system has been incorporated into the building's shaded facade plus an extensive PV array on the roof of the building. This PV installation generates 140kWs of electricity onsite, which acts to offset the electrical and CO_2 footprint of the Supercomputing Centre.
- The Pawsey Supercomputing Centre is an automated, secure, 'intelligent' building with real-time monitoring to facilitate efficient operation and support fine tuning of operations to reduce overall power costs.

In general terms the facility has been designed to anticipate and accommodate the high power, cooling and physical requirements of the next generation of supercomputers.

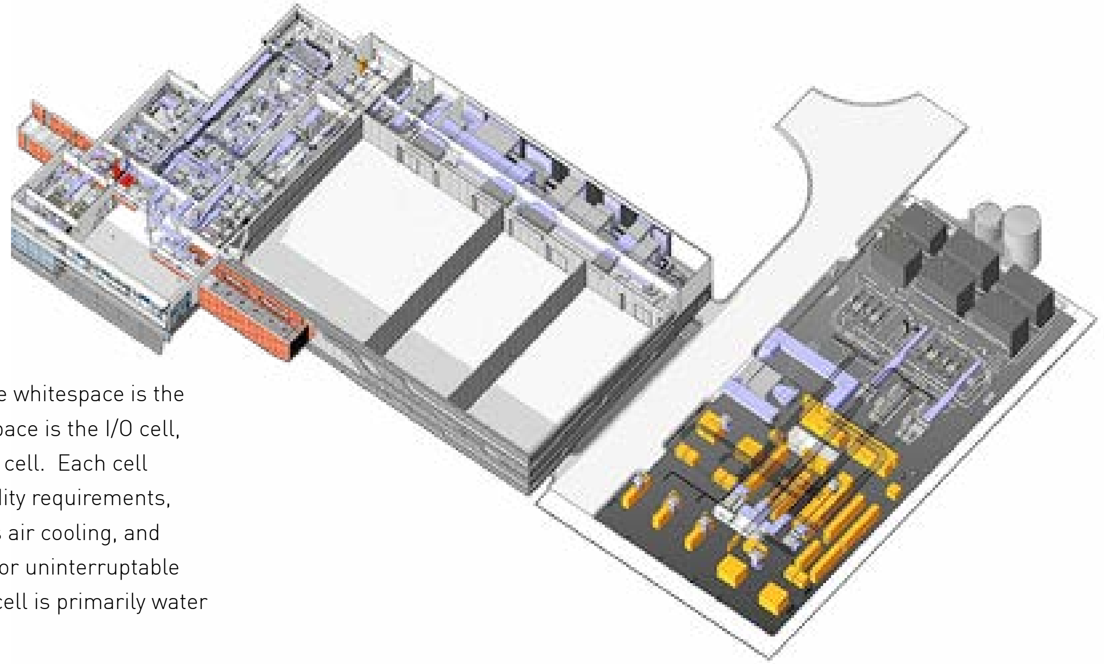
Geothermal Cooling System

CSIRO has developed an innovative geothermal solution for cooling the Centre's supercomputing systems. The system is known as groundwater cooling and was funded by the Australian Government as part of the CSIRO Geothermal Project.

The process involves pumping water with an ambient temperature of around 21°C from the Mullaloo aquifer through an above-ground heat exchanger to provide the necessary cooling effect for the supercomputer, then reinjecting the water back into the aquifer. CSIRO estimates that using groundwater cooling to cool the supercomputer will save approximately 14.5 million litres of water in the first two years of operation every year, compared with using conventional cooling towers. The system is designed to have the capacity to scale with additions to the supercomputing hardware.

Photo courtesy PS Structures © Brian Smyth Photography

The Pawsey Centre comprises two buildings. These are the data centre and plant area. The data centre comprises a 1000 square metre whitespace that is partitioned into three areas, a visualisation room, and office space. The plant building contains most of the equipment associated with power, cooling, and the uninterruptable power supply (UPS).



Pawsey Centre Internal Layout

In the building layout above, the large whitespace is the supercomputer cell, the next whitespace is the I/O cell, and the lower whitespace is the tape cell. Each cell has different temperature and humidity requirements, differences between water cooling vs air cooling, and differences in whether mains power or uninterruptable power is used. The supercomputer cell is primarily water cooled and on mains power.

Being a leading, national supercomputing centre is about much more than just providing access to state-of-the-art facilities. To realise the benefits of petascale computing, researchers need guidance and support from experts who can help them to achieve a step-change in their research.

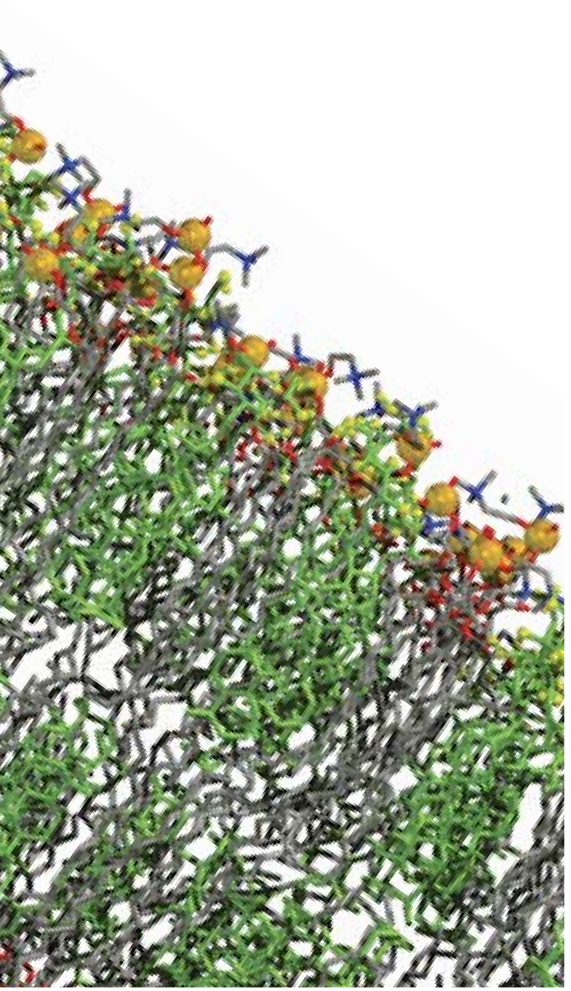


Image courtesy of Dr David Poger - The University of Queensland

The Pawsey Supercomputing Centre aims to provide an end-to-end solution that covers supercomputing, data services and visualisation, offering great flexibility in the level and type of engagement, to meet the needs of each individual case.

Supercomputing

The Pawsey Supercomputing Centre's Supercomputing team is drawn from the international community and has a combined, scientific-computing experience in excess of 50 years. The team's activities are focused on growing the uptake of supercomputing within the Australian science community. This is about more than just porting a researcher's work flow: it is about helping researchers to understand how a petascale system allows them to consider a new class of problem. The supercomputing team is about upscaling researchers' ambitions as well as their applications.

The supercomputing team engages with the Pawsey Supercomputing Centre community in a range of ways, developing and delivering training materials to grow the base of understanding, providing one-on-one consultations to tackle specific problems, and being embedded into research groups for longer term projects.

The Pawsey Supercomputing Centre supercomputing resources are mostly allocated via several merit-based assessment processes. Alongside national (15%) and the Pawsey Supercomputing Centre Partner (30%) allocations, the Centre provisions thematic allocations in geosciences (25%) and radio astronomy (25%). Further, small amounts of compute time are available for more speculative or experimental projects through the Director's Share scheme (5%).

Data Services

Scientific computing places new demands on a researcher to curate and share their data, to ensure the value, accuracy and longevity of their results. Data is everywhere – for example, the output of a computer simulation, the readings from a sensor network, or the output of a piece of apparatus. The volume, diversity, and variability of data that is being generated translates to both opportunities and challenges for the Pawsey Supercomputing Centre community.

The Data team provides hardware, services and expertise to help researchers improve their management of research data. Managing data involves storing the physical data sets, managing or adding metadata to make datasets discoverable and controlling access to the data.

The team is responsible for developing the award-winning Collaborative and Annotation Tools for Analysis of Marine Imagery and Video (CATAMI) project, a federally funded initiative designed to assist marine ecology and habitat monitoring processes.

The Data team is also the Pawsey Supercomputing Centre's interface to the Research Data Storage Infrastructure (RDSI) project and the National eResearch Collaboration Tools and Resources (NeCTAR) Project Cloud service.

Visualisation

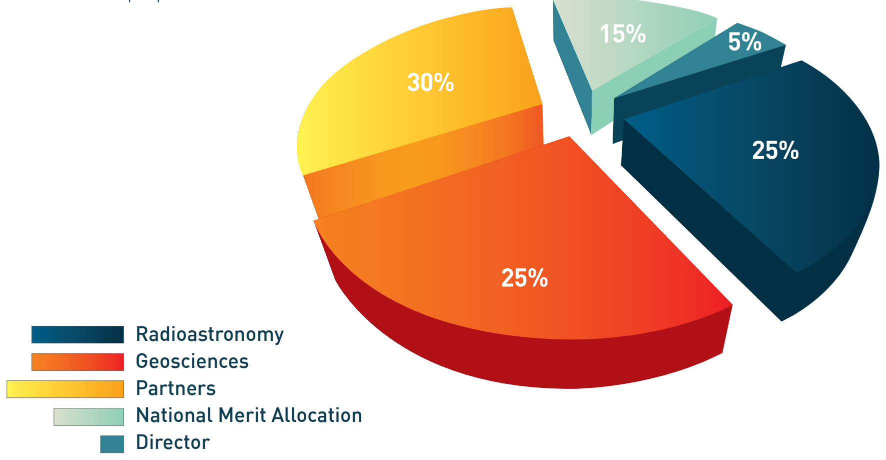
Visualisation is the process of applying advanced algorithms and computer graphics to data to provide research insights. Data visualisation has a number of outcomes that include allowing researchers to learn something new, to work faster than using simpler techniques to more rapidly identify problems, and to communicate with peers or with a wider audience using visual displays. A petascale supercomputer enables a researcher to generate and subsequently analyse data of unprecedented size and complexity, so visualization plays a key role in understanding this data.

The Pawsey Supercomputing Centre Visualisation team provides a package of hardware, software and expertise, to tackle the whole range of visualisation activities that are relevant to the Pawsey Supercomputing Centre user community. As with supercomputing, a crucial contribution of the program team is to inform researchers of new ways to present and interpret their results.

PAWSEY supercomputing centre IN NUMBERS

2014 ACCESSING Pawsey's SERVICES

Pawsey supercomputing resources are accessed through national and local merit allocation schemes. Pawsey infrastructure is committed in the following proportions:



286 million

CPU core hours were available on 2013, 12 months of Epic, Fornax, and Galaxy, plus six months of Magnus Phase1 and 4 months of Magnus Phase2.

During 2014 projects on Pawsey systems were supported by grant funding of more than

$49 million

+500 people

were trained during the past five years alone

The Pawsey Supercomputing Centre maintains offices in each of its partner organisations in order to host infrastructure and deliver the Centre's expertise directly to members of its partner organisations and the wider scientific community. Although located at specific venues, these resources are made accessible to staff at all partner organisations.

The Pawsey Supercomputing Centre facilities are connected via a dedicated research network. This maintains a high quality of service for applications such as moving large datasets or streaming of remotely rendered content.

The Pawsey Supercomputing Centre network is organised in a star topology with the hub located at the ARRC facility. Currently, the Pawsey Supercomputing Centre branches at The University of Western Australia, Murdoch University and Curtin University are connected at 10 Gbps whilst Edith Cowan University is connected at 1 Gbps. The network also links the nodes to AARNet at 10 Gbps and subsequently the eastern coast of Australia and overseas.

CSIRO

The CSIRO branch of the Pawsey Supercomputing Centre is located within CSIRO's Australian Resources Research Centre (ARRC) in Kensington, Western Australia. It is the Pawsey Supercomputing Centre's longest running facility, having been set up when ARRC was first opened in 2001. Currently, the CSIRO branch of the Centre hosts the Office of the Executive Director, along with Supercomputing and Technical team staff. It also supports two 3D visualisation environments and room-based videoconferencing services. The Pawsey Supercomputing Centre CSIRO branch is the hub of the Pawsey Supercomputing Centre's high-speed dark fibre Metropolitan Area Network (MAN) connecting the Pawsey Supercomputing Centre partners, and provides access to AARNet and the internet at large through CSIRO and AARNet's Point-of-Presence (PoP) at ARRC.

Curtin University

The Pawsey Supercomputing Centre branch at Curtin University was established as a directorate within Curtin IT Services (CITS) in early 2013. It brings together the research support and engagement activities of CITS with those of the Pawsey Supercomputing Centre to provide researchers with a single point of contact for all questions regarding the use of advanced ICT in the research workflow.

Through its location on Curtin University's Bentley Campus, it enables Curtin's research community to conveniently have access to a wide range the Pawsey Supercomputing Centre's expert staff.

The staff at the facility is compromised of the Director, three CITS staff and 15 staff associated with the Pawsey Supercomputing Centre Programs and Resources, affiliated with a number of projects developing ICT tools and services to support research workflows.

The Curtin office is focused on providing the research community with fit-for-purpose ICT tools and services and is in particular involved in supporting the uptake of cloud computing resources.

Curtin University's researchers are heavy users of the Pawsey Supercomputing Centre's infrastructure and the branch directly manages this uptake and engagement.

ECU

The Pawsey Supercomputing Centre office at ECU is the most recent facility established and will work on promoting scientific simulation services as well as access to sport and environmental visualisation tools, to promote the use of

Photos courtesy of Curtin University, Edith Cowan University, Murdoch University and The University of Western Australia

innovative technology by WA researchers.

The Edith Cowan University branch was officially launched on the 18th September 2012. The facility provides a link to the Pawsey Supercomputing Centre supercomputing resources, visualisation equipment, video conferencing facility and a training space for small groups. Two ECU staff members are associated with this facility, the Facility Director and the ECU Data Advisor.

Since the inception of the facility there has been excellent uptake from researchers and to ensure continuity of this, a local database of contacts has been established. To facilitate the uptake and further increase awareness, a series of Pawsey Supercomputing Centre roadshows have been instigated.

Working in collaboration with the Pawsey Supercomputing Centre UWA branch Director and the Head of the Data Team, there are now ECU researchers involved with visualisation and eResearch. The Data Team Leader has also been assisting the facility in developing data management guidelines.

It is anticipated that 2014 will be an exciting year for the Pawsey Supercomputing Centre facility at ECU with a range of new opportunities becoming available for the research community. The main challenge for this facility is to materialise the full potential at ECU into quality activities and outputs. To assist with the dissemination of information to all research teams at ECU, a Pawsey Supercomputing Centre ECU User Group has been established.

Murdoch University

The Pawsey Supercomputing Centre's office at Murdoch University is co-located with the Centre for Comparative Genomics (CCG). The CCG is an established Western Australian State Government Centre of Excellence. The Centre draws together biomedical and agricultural research and development, bioinformatics activities and expertise in comparative genomics, in such a way as to promote shared understanding within and across fields of study.

Staff expertise at the Centre has been developed over many years in order to meet the demands of a diverse user base ranging from highly technical users to more novice users looking to harness supercomputing for their research. This expertise includes: commodity Linux cluster architecture and design with particular expertise developed in the Lustre high performance network file system; Maintaining eResearch and Grid Infrastructure; Contemporary software development processes and practices, particularly in relation to maximising use of the Internet to deliver research outcomes; Strategic and Technical delivery of information technology projects.

The University of Western Australia

The Pawsey Supercomputing Centre's branch at The University of Western Australia acts as an interface between UWA users and the Pawsey Supercomputing Centre, assisting UWA staff and students in accessing resources. The office hosts high-performance computing, visualisation, collaboration, and image/video capture infrastructure. Staff expertise includes eResearch, supercomputing technologies, and visualisation.

Collaborative tools are provided through a dedicated room configured for video conferencing.

The Pawsey Supercomputing Centre UWA office is located within the Faculty of Engineering, Computing, and Mathematics. It is physically located on the ground floor of the Physics building and houses the Fornax supercomputer.

PAWSEY CENTRE NETWORK

Aside from the Aries network, which is used for inter-processor communication, and the FDR InfiniBand network, used for storage traffic, the Pawsey Centre has two ethernet networks: a 1 Gbit/s network for management and monitoring and a 10 Gbit/s network for data transfers between systems and to and from the outside world.

The 10 Gbit/s network is based on Cisco's Nexus range of products and is fully non-blocking, with all ports capable of running simultaneously at full line-rate. The 1 Gbit/s management and monitoring network is also Cisco Nexus-based, and makes use of their remote line-card fabric extender (FEX) technology to minimise the amount of copper cabling required in the Centre and also reduce the number of switches requiring management.

The Pawsey Supercomputing Centre connects its various facilities via a pair of 20 Gbit/s-capable Palo Alto firewalls, and to Australia's R&E network, AARNet, via a 10 Gbits/s link.

The Murchison Radio-astronomy Observatory (MRO) is currently connected into Pawsey over a single 10 Gbits/s link, but this will be expanded up to five 10 Gbit/s links in the near future. The fibre links from Pawsey to the MRO are capable of running up to 80 channels of 100 Gbits/s per channel over a single pair of fibres using Dense Wave Division Multiplexing (DWDM) technology, with the interfaces at Pawsey and the MRO presenting as multiples of 10 Gb ethernet.

The AARNet link between Perth and Adelaide has been upgraded from a single 10 Gbit/s bearer link to also support up to 80 channels of 100 Gbit/s per channel, providing compatibility with the existing optical networks in the eastern states.

HELPING AUSTRALIA WORK TOGETHER

As a world-class facility, the Pawsey Supercomputing Centre is proud to be playing an active role at the centre of Australia's scientific community. This is achieved through the Centre's strong commitment to its relationships with several other significant Australian scientific and ICT organisations.

These collaborative relationships are forged thanks to the Australian Government's funding of the Pawsey Supercomputing Centre and other national facilities and organisations. This funding represents an ongoing commitment by the Government to ensuring Australia is a major contributor to the global scientific community.

Partner Organisations

The Pawsey Supercomputing Centre is a joint venture between CSIRO and the four public WA universities. Being founded in 2000, the Centre is the longest running and most successful organisation of this type in Australia.

This long-lasting success is a tribute to the exceptional possibilities that can be achieved thanks to these organisations' dedication to enhancing collaboration in Australian science.

National Computational Infrastructure (NCI)

The Pawsey Supercomputing Centre actively cooperates with its sister facility, NCI in Canberra, in order to provide Australia with consistent, globally competitive supercomputing power across all areas of science.

Together, the Pawsey Supercomputing Centre and NCI are the two most powerful scientific supercomputing facilities in the Southern Hemisphere. Moving forward, this relationship will only continue to strengthen, allowing the Pawsey Supercomputing Centre and NCI to evolve and meet Australia's future scientific needs.

Research Data Storage Infrastructure (RDSI)

The RDSI is a $50 million Australian Government project, designed to create a national system to collect and preserve historic Australian research for future generations. The Pawsey Supercomputing Centre was chosen in a competitive process to serve as one of the eight RDSI facilities around Australia.

Representing the only Western Australian facility chosen to serve as an RDSI node, the Pawsey Supercomputing Centre is proud to be playing a major role in helping to connect past, present and future researchers across Australia.

National eResearch Collaboration Tools and Resources (NeCTAR) Project

A $47 million Australian Government initiative, NeCTAR connects researchers around Australia, helping them work together to discover groundbreaking new possibilities. This is achieved by providing cutting-edge technologies like Virtual Laboratories, national servers and research clouds.

The Pawsey Supercomputing Centre Research Cloud is the only Western Australian NeCTAR facility. By providing over 30,000 cores, the Pawsey Supercomputing Centre is allowing Australian researchers to unlock new avenues of research.

International Centre for Radio Astronomy Research (ICRAR)

ICRAR is an Australian collaboration that achieves world-class research in astronomical science and engineering. It also plays a key role in the Square Kilometre Array (SKA), the largest scientific project in human history.

These research achievements would not be possible without the sizeable contributions of the Pawsey Supercomputing Centre, which provides state-of-the-art resources and expertise to ICRAR and the SKA precursor projects.

Australian Academic Research Network (AARNet)

AARNet is a national resource, providing researchers and institutions across Australia with a world-class high-speed communications network infrastructure.

As part of its relationship with AARNet, the Pawsey Supercomputing Centre is connected nationally to other users and facilities across Australia. This allows research excellence produced at the Pawsey Supercomputing Centre to be shared quickly with all of Australia.

PROJECT LIST

PRINCIPAL INVESTIGATOR	INSTITUTION	PROJECT TITLE
Sebastien Allgeyer	Australian National University	Development of a better physics behind the tsunami modelling and coastal infrastructure behaviour.
Yuan Mei	Australian National University	Gold transport in geofluids during phase separation: insights from molecular dynamics simulation
Ben Corry	Australian National University	Simulation studies of biological and synthetic channels
Lynn Reid	CDM Smith Australia	Parallelizing MODFLOW-based flow and water resources optimisation codes
Ben Humphreys	CSIRO	Australian Square Kilometre Array Pathfinder
Robert Bell	CSIRO	CSIRO Advanced Scientific Computing
Dave Morrison	CSIRO	CSIRO Australian Square Kilometre Array Data Archive
Yuqing Feng	CSIRO	Discrete particle simulation of particulate multiphase flow
Florian Wellmann	CSIRO	Efficient estimation of information correlation in 3-D
Aaron Davis	CSIRO	Electromagnetic modelling for geophysical earth structure
Ravichandar Babarao	CSIRO	Enhancing storage and delivery of small molecules in porous materials from molecular perspective
James Hane	CSIRO	Genome analysis of plants, pathogen and pests relevant to wheat, lupin and other legumes
Chris Green	CSIRO	High resolution density-driven convection in 3D porous media using MOOSE
Jim Gunson	CSIRO	Littoral-zone modelling of morphodynamic changes on bathymetry and shorelines
Junfang Zhang	CSIRO	Molecular dynamic study of gas adsorption on coal
Neil Francis	CSIRO	Molecular Modelling of Hydrometallurgical Reagents
Thomas Poulet	CSIRO	Multiphysics simulations using MOOSE
Dirk Slawinski	CSIRO	Offline particle track modelling for connectivity analysis in Northwest WA
David Annetts	CSIRO	Probabilistic inversions for lithological units
Jess Robertson	CSIRO	Scale-sensitive algorithms for data-driven resource discovery
Chandana Jayasundara	CSIRO	Simulation of Underground Coal Mines and Mineral processing
Jesse Robertson	CSIRO	Sloshing silicates and sulfides - the fluid dynamics of magmatic sulfide deposits
Tristan Salles	CSIRO	Stratigraphic & Geomorphic Forward Modelling Infrastructure (SGFM)
Florian Wellmann	CSIRO	Uncertainty quantification in subsurface flow fields
Xiaoliang Wu	CSIRO	Urban Monitor

PRINCIPAL INVESTIGATOR	INSTITUTION	PROJECT TITLE
Amanda Barnard	CSIRO	Virtual Nanoscience
Cathryn Trott	Curtin / ICRAR / University of Melbourne / CSIRO	Detection of the Epoch of Reionisation using the Murchison Widefield Array
Cathryn Trott	Curtin / The University of Western Australia / MWA	Estimation of the Epoch of Reionisation with the Murchison Widefield Array
Neha Gandhi	Curtin / The University of Western Australia / MWA	Molecular dynamics simulations of tau protein folding and aggregation
Randall Wayth	Curtin / The University of Western Australia / MWA	MWA GLEAM: The GaLactic/Extragalactic All-sky MWA survey
Randall Wayth	Curtin / The University of Western Australia / MWA	MWA Operations
Piotr Kowalczyk	Curtin University	Thermodynamics and Kinetics of Multi-Component Greenhouse Gas Mixtures in Nanoconfinement
James Haile	Curtin University	Analysis of Trace and Environmental DNA
Andrew Rohl	Curtin University	Curtin - Chemical Research Methods 362
Mahyar Madadi	Curtin University	Finite Difference/Finite Element modeling of elastic waves
Igor Bray	Curtin University	GPU implementation for solving large-scale linear equation systems will be investigated.
Gary Madden	Curtin University	Hedonic Pricing Model for the Finnish Mobile Handset Market
Ryan Mead-Hunter	Curtin University	Modelling of particle deposition in the upper airways and lungs
Wei Hu	Curtin University	Reload option pricing
Andrew King	Curtin University	Wave Energy Characterisation
Christian Hirt	Curtin University	100 m-resolution model of Earth's global gravity field
Hongwei Wu	Curtin University	1-Modelling of LNG dispersion 2-Modelling of bio-oil/char slurry in a fluidized bed reactor
Jonathan Kirby	Curtin University	3D Christmas Trees: Anisotropic Rheology of the Lithosphere
Chi Minh Phan	Curtin University	Adsorption Layer Properties of CnTAB at the oil-water Interface
Igor Bray	Curtin University	Atomic Collision Theory
Julian Gale	Curtin University	Atomistic simulation of minerals and geochemistry
Peter Fearns	Curtin University	Australian Regional Environmental Remote Sensing

PRINCIPAL INVESTIGATOR	INSTITUTION	PROJECT TITLE
Andrew King	Curtin University	Flow Induced vibrations
Milinkumar Shah	Curtin University	Gas-Solid Flow Modelling in FCC Riser
Jeffrey Dick	Curtin University	Gold-organic sulfur interactions at high temperature
Chunyan Fan	Curtin University	Mechanisms of Adsorption in Novel Nanoporous Materials and the Characterization
Dr. Biao Sun	Curtin University	Modeling and optimization of LNG regasification technologies
Julien Cisonni	Curtin University	Modelling and prediction for tailored treatment of sleep-related breathing disorders
Nigel Marks	Curtin University	Modelling of Nuclear Materials and Carbon Nanostructures
Chunsheng Lu	Curtin University	Molecular dynamics simulations of the novel mechanical behaviour of nano-structured ceramics
Randall Wayth	Curtin University	MWA survey data processing
James Jewkes	Curtin University	OpenFOAM 4th year mechanical engineering student projects
Andrew Rohl	Curtin University	Realistic Modelling of the Effects of Solvent and Additives on Crystal Growth
Marco Marinelli	Curtin University	Statistical modelling of relationship between winter storms and storm surge.
James Jewkes	Curtin University	The Phenomenology of Unsteady Impinging Jets: Fluid Dynamics and Heat Transfer
Jason Park	Curtin University	Valuation of Collateralized Debt Obligations: An equilibrium model
Chunyan Fan	Curtin University,	Fundamental Study of Adsorption Processes in Novel Nanoporous Materials and Characterization
Ricardo Mancera	Curtin University,	Large scale molecular dynamics simulations of macrobiomolecular complexes
Kym Ottewell	Dept Parks & Wildlife	Genomics of West Australian flora
Daniel Grimwood	DMP (dmp.wa.gov.au)	DMP / iVEC pilot
Steven Hinckley	Edith Cowan University	Biomedical imaging in optical coherence tomography using a genetic algorithm model.
Shane Henderson	Edith Cowan University	ECU 3D Animation renderfarm 2014
Meghan Thomas	Edith Cowan University	Epigenetic regulation of alternative splicing
Mohamed Ismail	Edith Cowan University	Flume Open Channel
Mahmudul Raz	Edith Cowan University	Rendering project

PRINCIPAL INVESTIGATOR	INSTITUTION	PROJECT TITLE
Mehdi Khiadani	Edith Cowan University	ECU - CFD Concrete Mattress, Jet in Cross Flow, Flash Evaporation, Spatially Valid Flow
Michael Black	Edith Cowan University	Genomic and glycomic risk factors of chronic disease in Australia and PR China
Ute Mueller	Edith Cowan University	Geostatistical simulation and estimation of material types
Chris Harris	ICRAR	SKA Science Data Processor Workpackage
Natasha Hurley-Walker	ICRAR / ANU	New Calibration and Imaging Algorithms for the Murchison Widefield Array
Cormac Reynolds	ICRAR / Curtin	High Angular Resolution Radio Astronomy with the Long Baseline Array.
Andrew Squelch	iVEC	Seismic imaging and modelling for mineral and hydrocarbon exploration and production monitoring
David Wilson	La Trobe University	Quantum Chemical Molecular Properties
Kerry Hourigan	Monash University	Advanced Modelling of Biological Fluid Flows
Nikhil Medhekar	Monash University	Atomistic simulations for electronic, chemical amd mechanical properties of nanoscale materials
Chenghua Sun	Monash University	Computer-aided Design of Dye/TiO2 Interface for High Performance Solar Cells
Ekaterina Pas	Monash University	Fragment molecular orbital approach for liquid electrolytes
Julio Soria	Monash University	Investigations of transitional and turbulent shear flows
Michael Dentith	Moombarriga Geoscience	3D Inverse Modelling of Magnetotelluric Data:A Useful Regional Mineral Exploration Targeting Tool?
Mohammednoor Altarawneh	Murdoch University	Fundamental Understanding of the Role of Singlet Molecular Oxygen in Spontaneous fires
Matthew Bellgard	Murdoch University	Barley genome assembly
Matthew Bellgard	Murdoch University	Large genome activities
Carlo Pacioni	Murdoch University	Applying coalescent-based genetic simulations to the conservation of endangered species
Rudi Appels	Murdoch University	BPA wheat activities - Assembly of chromosome 7A and SNP analysis for 16 varieties
Brad Norman	Murdoch University	ECOCEAN Whale Shark Photo-identification Library
Matthew Bellgard	Murdoch University	High performance computing for bioinformatics analysis across 'omics platforms
Tom Lyons	Murdoch University	Past and Future Temperature Extremes and Vegetation in Western Australia
David Henry	Murdoch University	Theoretical Design of Nanocatalysts and Materials
Michael Meuleners	Ocean Systems Engineering	Hydrodynamic modelling of ocean currents for use in operational forecasting and oil spill response.

PROJECT LIST

PRINCIPAL INVESTIGATOR	INSTITUTION	PROJECT TITLE
Ramin Rahmani	refricenter.com.au	Hydrogen storage
Toby Allen	Royal Melbourne Institute of Technology	Mechanisms of charge-membrane interactions and transport
Michelle Spencer	Royal Melbourne Institute of Technology	Modelling Nanoscale Materials for Sensing and Device Applications
Irene Yarovsky	Royal Melbourne Institute of Technology	Theoretical Investigation of surfaces and interfaces for industrial and biomedical applications
Alan Duffy	Swinburne University / University of Melbourne	Smaug - The First Galaxies Simulation Series
Munish Mehta	The The University of Western Australia	Cane Toad Genome Sequencing
Feifei Tong	The The University of Western Australia	Classification of wake flow patterns around four cylinders in square arrangement in steady flow
Dilusha Silva	The University of Western Australia	Agata Guzek
Jeffrey Shragge	The University of Western Australia	Computational modelling, imaging and inversion of 3D/4D seismic wavefields
Dino Spagnoli	The University of Western Australia	Density Functional Theory Study of Semiconductors and their Surfaces
David Huang	The University of Western Australia	Design of High-Speed Underwater Acoustic Communication Systems Using Block-by-Block Turbo Processing
Chris Power	The University of Western Australia	Detecting Missing Baryons in the Cosmic Web
Chris Power	The University of Western Australia	Developing & incorporating models of AGN feedback in cosmological simulations
Greg Ivey	The University of Western Australia	Developing a water quality forecast system for the Sohar industrial port, oman
Hong Hao	The University of Western Australia	Development of Fuel Storage Tank with Frangible Roof to Resist Accidental Explosion Load
Alan Duffy	The University of Western Australia	DRAGONS Dark-ages Reionization and Galaxy Formation Simulation
Keith Godfrey	The University of Western Australia	Empirical investigation of pairs trading in financial securities
Ryan Lowe	The University of Western Australia	Highly-resolved ocean simulations of the northwest Australian coast
Mariusz Martyniuk	The University of Western Australia	Integrated on-chip force and displacement sensors for high-speed AFM of ultimate sensitivity
Karl-Heinz Wyrwoll	The University of Western Australia	Modelling of the climatology of the northwest Australian summer monsoon over the last 22,000 years
Dino Spagnoli	The University of Western Australia	Molecular dynamics simulations of the aggregation of polyaromatic hydrocarbons
Weronika Gorczyk	The University of Western Australia	Multiscale Dynamics of Orebody Formation
Hongwei An	The University of Western Australia	Numerical simulations of wave boundary layer effect on the stability of small diameter pipeline
Marco Ghisalberti	The University of Western Australia	Numerical study of particle capture in aquatic ecosystems
Andy Fourie	The University of Western Australia	Paste tailings beach slope prediction with CFD simulation
Dylan Jayatilaka	The University of Western Australia	Quantum crystallography on large systems
Jason Wang	The University of Western Australia	Radio Astronomy Data Intensive and HPC Research Projects from ICRAR ICT Team
Kenji Bekki	The University of Western Australia	Simulating dust and molecular cloud formation in dwarf galaxies
Phillip Melton	The University of Western Australia	Statistical Genetic and Epidemiological Analyses for Complex Diseases
Agata Guzek	The University of Western Australia	Topological interlocking as a novel design concept for the development of hybrid materials
Scott Wilson	The University of Western Australia	Understanding complex human genetic diseases through whole genome sequencing
Tongming Zhou	The University of Western Australia	Vortex and force characteristics of inclined offshore cylindrical structures in oscillatory flows
Carol Wang	The University of Western Australia	Western Australian Pregnancy (Raine) Cohort and the Preterm Birth Genome Project
Berwin Turlach	The University of Western Australia	Alternative Spatiotemporal Imputation Methods for Catch Rate Standardisation.
Ali Karrech	The University of Western Australia	Computational Multi-physics for Fault Reactivation in Resource Reservoirs
Huaiyu Yuan	The University of Western Australia	Full waveform inversion for the seismic anisotropy in the global and regional upper mantle
Rie Kamei	The University of Western Australia	Full Waveform Inversion of 3D seismic data on GPU arrays
Geun Jang	The University of Western Australia	Full Waveform Inversion of 3D seismic data on HPC x86 clusters
Dong Wang	The University of Western Australia	GPU parallelisation of Material Point Method oriented to submarine landslide
Jeffrey Shragge	The University of Western Australia	GPU-based imaging/inversion of complex 3D/4D seismic wavefields

PRINCIPAL INVESTIGATOR	INSTITUTION	PROJECT TITLE
Linqing Wen	The University of Western Australia	Gravitational Wave Search with Application of GPUs
Nader Issa	The University of Western Australia	HPC simulation, imaging and inversion of passive seismology data
Marco Ghisalberti	The University of Western Australia	Influence of turbulence in particle capture in aquatic systems
Amir Karton	The University of Western Australia	Mimicking nature computational design of better antioxidants
Matthew Hipsey	The University of Western Australia	Modelling estuary health
Martin Ebert	The University of Western Australia	Monte Carlo Simulations in Medical Physics
Laura Boykin	The University of Western Australia	MrBayes and BEAST analyses of agriculturally important organisms (Magnus)
Liang Cheng	The University of Western Australia	Numerical modeling of scour below an offshore pipeline
Jie Liu	The University of Western Australia	Quantitative analysis of microtomography and pore-scale hydrodynamic simulations
Dylan Jayatilaka	The University of Western Australia	Quantum crystallography on vitamin B12 coenzyme
Jingbo Wang	The University of Western Australia	Quantum walk based simulation of electron trasport
Peter Munro	The University of Western Australia	Reaching new frontiers in optical imaging through the use of rigorous models
Peter Metaxas	The University of Western Australia	Strongly coupled nanomagnets: applications to reconfigurable spintronic devices
Feifei Tong	The University of Western Australia	The effects of wave breaking on cylindrical structures
Nilimesh Halder	The University of Western Australia	UWA Dengue Spread Model
Randall Wayth	The University of Western Australia / CURTIN / ICRAR	MWA data preprocessing: flags and compression
Kenji Bekki	The University of Western Australia / ICRAR	Simulating the two-stage formation process of the Galactic globular clusters
Mike Ford	Univeristy of Technology Sydney	Electron beam induced etching and deposition
Michael Cortie	Univeristy of Technology Sydney	Investigation of High Entropy Alloys for advanced nuclear applications
Derek Leinweber	University of Adelaide	Electromagnetic Structure of Matter
Joel Brugger	University of Adelaide	Mobility of platinum group elements in hydrothermal system: insights from molecular dynamics
Greg Poole	University of Melbourne	Tiamat and DRAGONS - the Dark-ages Reionisation and Galaxy Formation Simulation Program
Evatt Hawkes	University of New South Wales	Direct Numerical Simulations and Large Eddy Simulations of Turbulent Combustion
Aibing Yu	University of New South Wales	Simulation and Modelling of Particulate Systems
Robert Wittenmyer	University of New South Wales	Studying the Dynamics of Multiple Planetary Systems
David Edwards	University of Queensland	Crop genome informatics
Evelyne Deplazes	University of Queensland	Developing computational methods to improve the accuracy of structural data obtained from DEER
Alan Mark	University of Queensland	From molecules to cells
Alan Aitken	University of Queensland	Methodologies of large-scale multi-method geophysical inversion
Dietmar Muller	University of Sydney	Towards dynamic tectonic reconstructions
Sanjib Sharma	University of Sydney	Understanding Galaxy Formation
Peter Jones	University of Technology, Sydney	Plasmodium falciparum neutral aminopeptidases structure-function analysis
Willy Susilo	University of Wollongong	Quantum Simulator

Acknowledgements

The Pawsey Supercomputing Centre is supported by $90 million funding as part of the Australian Government's measures to support national research infrastructure under the National Collaborative Research Infrastructure Strategy and related programs through the Department of Education. The Centre would also like to acknowledge the support provided by the Western Australian Government and its partner organisations.

Government of **Western Australia**
Department of **the Premier and Cabinet**
Office of Science

Australian Government

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

CSIRO

Curtin University

AUSTRALIA ECU EDITH COWAN UNIVERSITY

Murdoch UNIVERSITY

THE UNIVERSITY OF WESTERN AUSTRALIA