

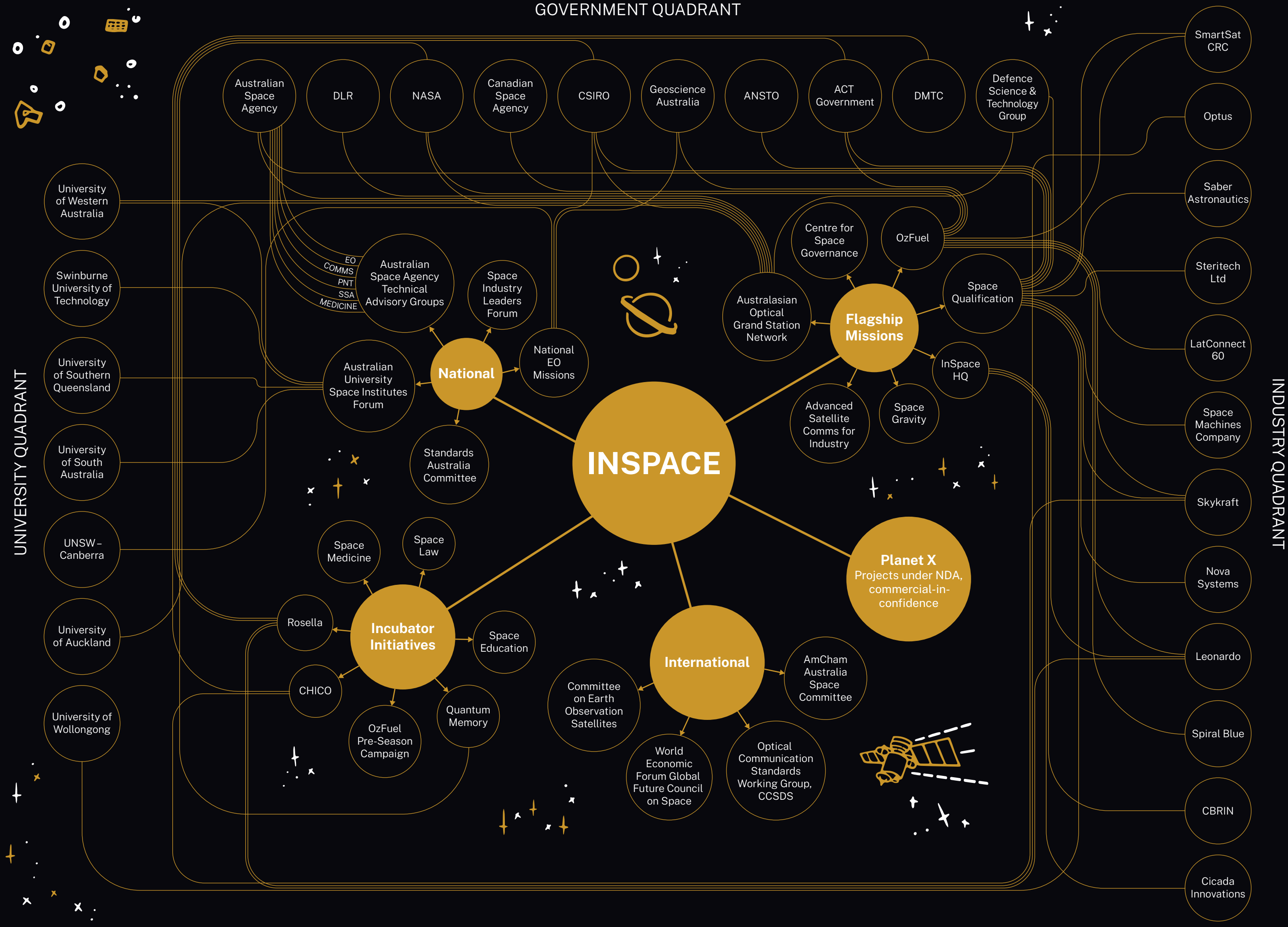


Australian
National
University

The Australian National University Institute for Space

ANNUAL REPORT 2020-21

Advancing Australia through Space



Learn more about the Australian National University Institute for Space



ANU Institute for Space

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The ANU Institute for Space (InSpace) is accelerating the growth and connectedness of our space industry at a time of huge opportunity and national priority for space research and development. InSpace is a strategic gateway for engagement between industry, government and the Australian National University's cross-disciplinary expertise and capability in space research.

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FOREWORD BY THE CHAIR OF THE BOARD

The Australian National University has a strong heritage in space research. InSpace was established to harness the disciplinary expertise across the University's 42 separate research schools. Recognising the importance for the Institute to tap into the strengths in every school, the Institute is an organisational unit within the Research and Innovation Portfolio.

InSpace brings together technology, law, science, economics, and social science research to grow Australia's commercial and scientific interests in the space industry.

Despite the challenges presented by COVID restrictions in 2021, the InSpace team has curated and delivered a significant portfolio of opportunities, together with its industry partners.

This year, the Board saw the introduction of InSpace Flagship Missions, representing the very best of what ANU offers the national space ecosystem. This year's Flagship Missions impact defence capability, disaster management and prevention, increase supply chain access and trade, and improve how we curate and translate space research.

The Board is also keen to note the number of InSpace Mission Specialists who serve in a national space advisory capacity, including the Australian Space Agency Technical Advisory Groups, the Space Industry Leaders Forum and the World Economic Forum.

In recognition of these achievements and more, InSpace Director, Professor Anna Moore, was awarded Female Leader of the Year at the Australian Space Awards. This award celebrates the efforts of the InSpace team of Mission Control and Mission Specialists representing our diverse research community.

A special thanks to our board members who have guided InSpace this year:

- Professor Kiaran Kirk, Dean, ANU College of Science
- Professor Nick Birbilis, Interim Dean, ANU College of Engineering & Computer Science
- Professor Sharon Bell, Dean, ANU College of Asia & the Pacific
- Helen Sullivan, Dean, ANU College of Asia & the Pacific

As Chair of the InSpace board, I am delighted to endorse the ANU Institute for Space 2021 Annual Report.

KEITH NUGENT

Deputy-Vice Chancellor for Research and Innovation

Chair of the Board



I am delighted to present our 2021 annual report. This report provides a snapshot of the impact of the Institute's Mission Control and Mission Specialist teams.



ANNA MOORE
Vice-Chancellor's
Entrepreneurial Professor
Director, ANU Institute
for Space

As an organisational unit with the University's Research and Innovation portfolio, InSpace ensures the University invests its funding towards the creation of sovereign space capability, totalling \$3.1M so far for Incubator Initiatives.

FY21 provided many funding opportunities for ANU across the Australian space ecosystem, such as the Australian Space Agency's Space Infrastructure Fund - Payload Qualification Facilities Grant, multiple Defence initiatives in quantum communications and space situational awareness, and the industry-only Modern Manufacturing Initiative.

The InSpace team has capitalised on our ANU capability establishing more than 20 new research/industry linkages to support this research, including NASA, Skykraft, Nova Systems, Saber Astronautics and CEA Technologies. The team has curated a pipeline of opportunities totalling more than \$55M in FY21, resulting in a lifetime total of more than \$110M, well in advance of our target.



INSPACE CREATES OPPORTUNITIES FOR ANU INNOVATORS

**7 FLAGSHIP MISSIONS
CREATED FOR
NATIONAL IMPACT**

**\$5M FUNDING
FOR FLAGSHIP
MISSIONS**

A YEAR IN



In FY21, InSpace catalysed opportunities through its inaugural four Flagship Missions. InSpace Flagship Missions are significant space endeavours with national and international reach. Our InSpace team generated almost \$5M of funding for joint research and industry space missions in FY21.

InSpace has embraced its space advocacy role through a joint project with the World Economic Forum and in hundreds of media interviews in the last year. We have also advocated for diversity in STEM careers through multiple events.

The InSpace team transitioned from its temporary accommodation at Mount Stromlo to InSpace HQ at Level 1, 121 Marcus Clarke St. Our dedicated HQ brings together researchers and industry to catalyse the translation and adoption of space research for commercial benefit and showcases our ground-breaking research through space-related events, outreach and training.

Until April 2021, I was Director of the Advanced Instrumentation and Technology Centre, Australia's premier astronomical and space instrumentation centre hosted within the Research School of Astronomy and Astrophysics (RSAA). I stepped down to focus on InSpace. It was an honour to lead the AITC, as much as it is to now lead the ANU Institute for Space.

TO SUPERCHARGE AUSTRALIA'S SPACE CAPABILITY.

\$51M PIPELINE
CREATED
IN 2021

WORKING WITH
75 GLOBAL
PARTNERS

SUMMARY

It's a new space age.

Space is no longer just about astronauts exploring our solar system or astronomers looking into space. It is about innovation, technological advancement and making life better for people on Earth. It is about satellites and their valuable space data, space medicine advances that translate to your local hospital, and rovers and robotics that work off-world and in places on Earth humans cannot reach.

That is where InSpace shines.

The ANU Institute for Space is here to create opportunities for ANU researchers to supercharge Australia's space capability and advance our nation for all Australians.

WHO WE ARE

Today, collaboration is critical. Here is how we do it.

Across the Australian National University, researchers from many disciplines are applying their world-class expertise to space-related research. These are our Missions that make life better and advance Australia. Our researchers are called Mission Specialists. Mission Specialists are supported by our Mission Control team, who are world-class space industry professionals. This team works to increase external funding for missions and other space-related work, creates strategic national initiatives through strong partnerships, builds commercial connections with international and national space agencies and companies, and helps to advocate research capabilities to government and Defence. They also help communicate the importance of this ground-breaking space research and activity to all Australians.

It is for the space generation.

Space research at ANU is not just creating game-changing innovation that will accelerate our future space industry. It is shaping the next generation of Australians who will think nothing of working off-world, using robotics to reach their goals, and innovating to save our planet while sustainably exploring the next.



HOW ANU INSPACE ADVANCES AUSTRALIA



ASSOC. PROF. FRANCIS BENNET

is an ADAPTIVE OPTICS EXPERT TAKING WORLD-LEADING ANU QUANTUM COMMUNICATIONS EXPERIMENTS FROM LAB TO SPACE, ENABLING A GLOBAL QUANTUM ENCRYPTED COMMUNICATIONS NETWORK



DR. CAITLIN BYRT

is a BIOLOGIST WHO STUDIES TYPES OF MEMBRANE PROTEINS THAT ARE USED TO FILTER ASTRONAUT PEE BACK INTO DRINKING WATER, AND HOW THEY CAN BE USED ON EARTH TO FILTER DIRTY WATER INTO DRINKING WATER AND HELP US IN EMERGENCIES AND DROUGHTS



PROF. P.K. LAM

is a WORLD-LEADING EXPERT IN QUANTUM OPTICS AND QUANTUM INFORMATION. HE IS WORKING TO BUILD THE NEXT GENERATION OF COMMUNICATION AND SECURE IT WITH QUANTUM KEY DISTRIBUTION TO CREATE VIRTUALLY UNHACKABLE COMMUNICATION VIA LASERS.



ASSOC. PROF. KIRK MCKENZIE

and HIS TEAM ARE DEVELOPING LASERS FOR PRECISE MEASUREMENTS THAT WILL MAP EARTH'S GRAVITATIONAL FIELD FROM SPACE TO UNDERSTAND IMPORTANT PROCESSES LIKE WATER MOVEMENT AND CLIMATE CHANGE



DR. CASSANDRA STEER

of the ANU COLLEGE OF LAW RESEARCHES AND TEACHES SPACE LAW AND GOVERNANCE TO ENSURE SPACE REMAINS SAFE, SECURE AND SUSTAINABLE



ASSOC. PROF. MARTA YEBRA

USES SATELLITE DATA TO SUPPORT FIRE MANAGERS WITH IMPORTANT INFORMATION TO MAKE DECISIONS TO PREVENT, RESPOND AND RECOVER FROM BUSHFIRES



DR. DORIS GROSSE

INVESTIGATES AND GATHERS INFORMATION THAT HELPS REDUCE THE ACCUMULATION OF SPACE DEBRIS, MAKING THE SPACE ENVIRONMENT A SAFER AND SUSTAINABLE PLACE FOR MANY CENTURIES TO COME



DR. EMMA TUCKER

is an EMERGENCY MEDICINE DOCTOR AND EXPERT IN SPACE MEDICINE WHO DOES RESEARCH ON THE HEALTH EFFECTS OF SPACEFLIGHT



PROF. PAUL TREGONING

is a GEOPHYSICIST WHO STUDIES HOW THE EARTH SURFACE CHANGES THROUGH GEOPHYSICAL PROCESSES SUCH AS TECTONIC DEFORMATION, CLIMATE-DRIVEN VARIATIONS IN SEA LEVEL AND MELTING OF POLAR ICE CAPS



ASSOC. PROF. MARIA RACIONERO LLORENTE

IS AN EXPERT IN PUBLIC ECONOMIC THEORY, INCLUDING OPTIMAL TAXATION THEORY, AND METHODS TO IMPROVE GENDER EQUITY IN PUBLIC POLICY



PROF. PENNY KING

EXAMINES SURFACE AND INTERIOR PROCESSES ON PLANETARY BODIES TO IMPROVE OUR UNDERSTANDING OF HOW MATERIALS IN THE SOLAR SYSTEM BEHAVE



PROF. ROBERT MAHONY

PROF. ROBERT MAHONY'S RESEARCH INTERESTS ARE IN NON-LINEAR CONTROL THEORY WITH APPLICATIONS IN ROBOTICS, GEOMETRIC OPTIMISATION TECHNIQUES AND SYSTEMS THEORY



PROF. JOHN CLOSE

PROF. JOHN CLOSE'S RESEARCH FOCUSSES ON HARNESSING THE PROPERTIES OF ULTRA-COLD ATOMS TO DEVELOP QUANTUM SENSORS TO MEASURE GRAVITATIONAL FIELDS AND MAGNETIC FIELDS, WITH APPLICATIONS IN UNDERGROUND STRUCTURE MAPPING AND NAVIGATION ON EARTH AND IN SPACE.



PROF. AIR VICE-MARSHAL (RET) TRACY SMART AO

is a PROFESSOR OF MILITARY AND AEROSPACE MEDICINE, PUBLIC HEALTH LEAD OF THE COVID RESPONSE OFFICE AT ANU, A PHYSICIAN, AEROSPACE MEDICINE SPECIALIST, HEALTH LEADER, AND RETIRED ROYAL AUSTRALIAN AIR FORCE (RAAF) SENIOR OFFICER. SHE IS DEVELOPING THE SPACE MEDICINE PROGRAM.

VALUE WE BRING TO ANU

At InSpace, we create pathways to commercialise promising space research across the University. Government investment and commercial partnerships make up a large proportion of funds we bring in.

PROPOSALS
SUBMITTED **\$5.31M / 2021**
41 / 2021 **\$11.13M / LIFETIME**
103 / LIFETIME

AMOUNT OF FUNDING INSPACE BROUGHT
INTO THE AUSTRALIAN NATIONAL UNIVERSITY

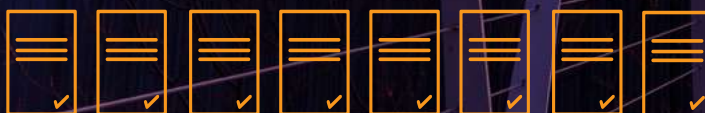
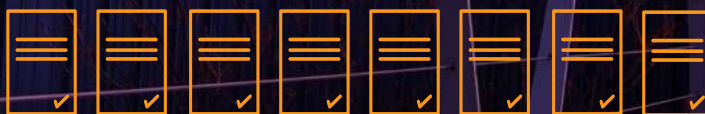
\$110 MILLION

PIPELINE LINKED TO 7 FLAGSHIP MISSIONS

InSpace signed:



MEMORANDUMS OF
UNDERSTANDING



23 NON-DISCLOSURE AGREEMENTS

**InSpace
supports:**



**4 ANU
INSTITUTES**



7 COLLEGES

**InSpace
connects with:**



**47
COMPANIES**



**6
SPACE
AGENCIES**

**The InSpace
community contributes to:**



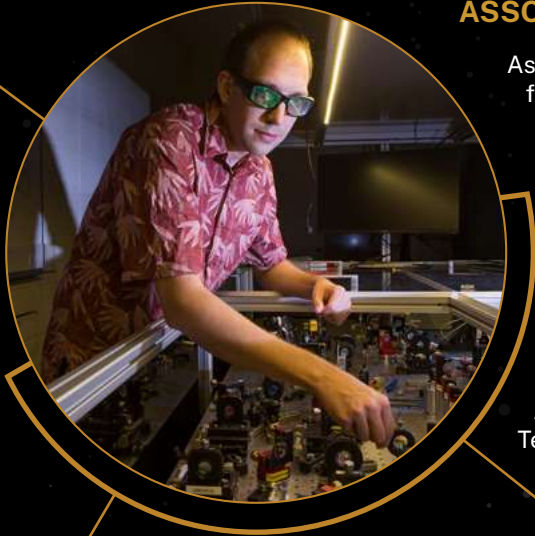
5 national, 10-year Australian Space Agency space technology roadmaps that will shape our future in the global space industry.

\$200M OF ANU
INFRASTRUCTURE
SUPPORTS SPACE
INDUSTRY GROWTH

INSPACE MISSION SPECIALISTS

Meet the researchers working to support space initiatives across the ANU and develop new opportunities for cross-disciplinary collaboration with the global space industry.

ASSOCIATE PROFESSOR FRANCIS BENNET



Associate Professor Francis Bennet is an expert in adaptive optics for astronomical instrumentation, space situational awareness, and laser communication. He takes quantum communications experiments from the lab to space, enabling a global quantum encrypted communications network. This includes working on the development of a satellite to test quantum communication between space and the ground and creating a prototype to demonstrate high-speed optical communications between Earth and Lunar spacecraft equipped for optical communication. Francis also leads the ACT Node of the Australasian Optical Ground Station Network, is an Associate Professor at the Research School of Astronomy and Astrophysics and is a member of the Australian Space Agency's Technical Advisory Group on Advanced Communications.

DR CAITLIN BYRT

Dr Caitlin Byrt is a biologist who studies proteins found in cell membranes throughout many organisms. These proteins can help plants survive droughts, as well as life in space. They can be used to filter valuable nutrients from wastewater or filter drinking water and can even be used in soft robotics. Caitlin is co-founder and director of Membrane Transporter Engineers, a company working on advancing the function of membrane separation technologies to enable the harvest of valuable resources from liquid wastes. Caitlin is an ARC Future Fellow at the Research School of Biology.



PROFESSOR JOHN CLOSE

Prof John Close is an experimental and theoretical physics researcher whose research focusses on harnessing the properties of ultra-cold atoms to develop quantum sensors to measure gravitational fields and magnetic fields with applications in underground structure mapping and navigation on Earth and in space. His work is multidisciplinary, and he has broad collaborations with Earth Science, Biology and Industry. He is a professor in the Department of Quantum Science and Technology at ANU, a Senior Fellow of the Higher Education Academy, former Head of the Department of Quantum Science, former elected member of ANU Council, and current Head of ANU Defence Engagement. John was awarded the Australian Defence Industry Prize for Academic of the Year and the Australian Defence Industry Prize for Excellence in 2020.



DR DORIS GROSSE

Dr Doris Grosse is an optical instrument scientist specialising in adaptive optics and the space environment. She investigates the characteristics and whereabouts of space debris to reduce its threat, making space safer and more sustainable so humans can rely on and benefit from satellites for centuries to come. Doris is also expanding her expertise in optical communications by working on space to ground laser communications. Doris serves as a member of the World Economic Forum's Global Future Council on Space and is a research fellow at the Research School of Astronomy and Astrophysics.



PROFESSOR PENNY KING

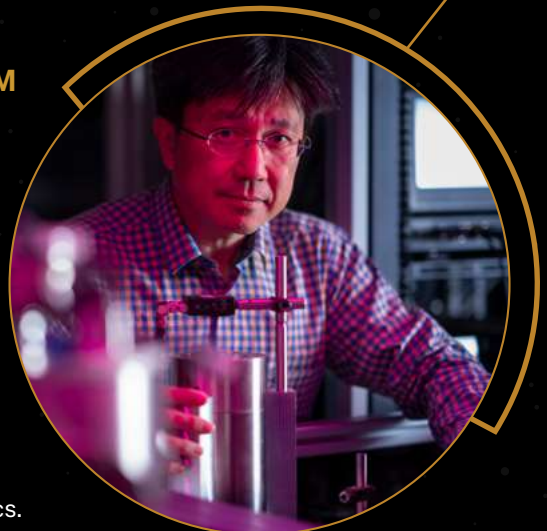
Professor Penny King examines surface and interior processes on planetary bodies, aiming to improve our understanding of the fundamental aspects of how materials in the solar system behave. Her work creates better tools to explore our solar system, the deep Earth, and understand climate change. Penny is a champion for diversity in STEM industries, a Professor in the Research School of Earth Sciences at ANU, and Associate Dean (Research) in the College of Science, ANU.



PROFESSOR PING KOY LAM

Professor Ping Koy Lam is a world-leading expert in quantum optics, quantum key distribution, quantum repeaters and quantum optical information processing. Ping Koy is working to build the next generation of communication via lasers, securing it with quantum key distribution to create virtually unhackable communication. He was the chief scientist and co-founder of QuintessenceLabs, a spin-off company that commercialises quantum communication technology.

Ping Koy was elected to Fellow of the Australian Academy of Science (2020). He is a program manager of the Centre for Quantum Computation and Communication Technology and a 2015 ARC Laureate Fellow. He works in the Department of Quantum Science and Technology in the Research School of Physics.





ASSOCIATE PROFESSOR MARIA RACIONERO LLORENTE

Associate Professor Maria Racionero Llorente is an expert in public economic theory, including optimal taxation theory and methods to improve gender equity in public policy. Maria is a great example of the multidisciplinary researchers adding diversity of thought to InSpace. She is keen to contribute her public economics expertise to address issues with market decentralisation, market failures and regulation of the space economy. Maria is an Associate Professor in the College of Business and Economics, ANU.



PROFESSOR ROBERT MAHONY

Professor Robert Mahony's research interests are in non-linear control theory with applications in robotics, geometric optimisation techniques and systems theory. Using his specialised knowledge of aerial robotics, Robert has developed prototype autonomous aerial water gliders that can carry enough water to saturate specific targets and stop fires before they can spread, contributing to the goals of InSpace's OzFuel Mission. Robert is a Professor in the School of Engineering at ANU. He is also an Institute of Electrical and Electronics Engineers Fellow.

ASSOCIATE PROFESSOR KIRK MCKENZIE

Associate Professor Kirk McKenzie and team are developing lasers for precise measurements that will map Earth's gravitational field from space to understand important processes like water movement and climate change. Kirk leads one of the Moon to Mars missions to develop laser measurement technology for deployment on the next NASA Gravity Recovery and Climate Experiment (GRACE) mission, in partnership with CEA Technologies. Kirk is Associate Professor and Senior Fellow at the ANU Centre for Gravitational Astrophysics.





PROF AIR VICE-MARSHAL (RET) TRACY SMART AO

Retired Air Vice-Marshal Tracy Smart is a Professor of Military and Aerospace Medicine and Public Health Lead of the COVID Response Office at ANU. She is a physician, aerospace medicine specialist, health leader, and retired Royal Australian Air Force (RAAF) senior officer. She is developing the Space Medicine program as an InSpace Mission Specialist. Tracy is also President of the Australasian College of Aerospace Medicine, a Fellow of the Aerospace Medicine Association (US), an Academician of the International Academy of Air and Space Medicine, and a member of the Australian Space Agency's Technical Advisory Group on Space Medicine and Life Sciences.

DR CASSANDRA STEER

Dr Cassandra Steer specialises in space law, space security and international law. She researches and teaches space law, policy and governance, to ensure space remains safe, secure and sustainable. Her current research focuses on space situational awareness, space traffic management, and the application of the law of armed conflict and the use of force in outer space. She is a member of the Australian Space Agency's Technical Advisory Group for Space Situational Awareness and the International Institute of Space Law. Cassandra is a Senior Lecturer at the ANU College of Law.



PROFESSOR PAUL TREGONING

Professor Paul Tregoning is a geophysicist who uses Earth observation data from satellites to study how the Earth surface changes through geophysical processes, including tectonic deformation, climate-driven variations in sea level, and melting of polar ice caps. Paul is a member of the NASA Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission and a Fellow of the International Association of Geodesy. Paul is a member of the ANU Institute for Climate, Energy and Disaster Solutions, ANU Institute for Water Futures and Professor at the Research School of Earth Sciences. He is also a member of the Australian Space Agency's Technical Advisory Group on Earth Observation as well as Positioning, Navigation and Timing.





DR EMMA TUCKER

Dr Emma Tucker is an emergency medicine registrar (Australasian College for Emergency Medicine) at the Calvary Emergency Department in Canberra and a senior research fellow in space medicine at the ANU College of Health and Medicine. Emma's research specialty is the effect of microgravity on the cardiovascular system. After completing a PhD in astrophysics and a medical degree, Emma had an aerospace medicine clerkship at NASA's Johnson Space Center. She is a member of the Australian Space Agency's Technical Advisory Group on Space Medicine and Life Sciences.

ASSOCIATE PROFESSOR MARTA YEBRA

Associate Professor Marta Yebra uses satellite data to support fire managers with critical information to make decisions to prevent, respond and recover from bushfires. She leads the multidisciplinary InSpace OzFuel team. This team is designing Australia's first satellite mission to help forecast areas where bushfire fuel conditions create the highest risk of fires starting or burning out of control. Marta is also Director of the ANU Bushfire Initiative, Associate Professor in remote sensing at the ANU Fenner School of Environment & Society and the School of Engineering. She is also a member of the Australian Space Agency's Technical Advisory Group on Earth Observation.



MISSION SPECIALIST AWARDS

- **Professor Ping Koy Lam**, RSPHys, Fellow of the Australian Academy of Science, and a Top 5 Lifetime Achiever in Physics and Mathematics on The Australian Superstars of Research List;
- **Professor John Close**, RSPHys, Academic of the Year and Defence Excellence Award; Australian Defence Industry Awards;
- **Associate Professor Francis Bennet**, RSAA, Innovator of the Year, Australian Defence Industry Awards;
- **Dr Cassandra Steer**, ANU College of Law, Finalist, Women in Law Awards.

INSPACE MISSION CONTROL

InSpace Mission Control is a team of world-class space industry professionals working to support space initiatives at the ANU and develop new opportunities for cross-disciplinary collaboration with the global space industry.

We are a multicultural team with members from seven different countries across four continents. We believe that this creates stronger diversity of thought and ultimately more success. We also believe it is very positive for younger generations to see that scientists and people who work in the space industry are from a diverse range of backgrounds.

The InSpace team has a 2:1 ratio of women to men, while in Australia, only about 13% of STEM-qualified occupations are held by women. During World Space Week 2021, InSpace celebrated the contributions and achievements of each of our female Mission Specialists. InSpace has also championed the idea of a career in space to younger generations through several events.

In 2021, groups across the ANU had access to assistance and time from the InSpace team valued at

\$1.5M

PICTURED FROM LEFT TO RIGHT: Dr Jia-Urnn Lee, Business Development Manager; Lisa O'Farrell, Executive Assistant; Kathleen Sweetapple, Marketing & Communications Manager; Professor Anna Moore, Director; Dr Kate Ferguson, Business Development Manager; Sacha Coles, Executive Officer

NOT PICTURED: François Lambert, Special Counsel; Helene Baron, Manager of Programs & Partnerships





INSPACE JOINT OPERATIONS

We collaborate to build strong teams of multi-disciplinary experts across the ANU. Together, we solve challenges for Australia and deliver excellence through successful space missions.



InSpace Joint Operations team member Dr Zena Assaad studies issues like meaningful human control for autonomous systems.



InSpace Joint Operations team member, Associate Professor Catherine Ball, is a scientific futurist working on global projects where emerging technologies meet humanitarian, education and environmental needs.



Joint operations include the ANU space qualification experts, who have an outstanding record of strengthening industry outcomes through \$200M in world-class space testing infrastructure across two campuses. You can read more on page 31.

InSpace team members are passionate and influential advocates for space innovation. They represent the ANU, its space capability and world-leading research expertise by joining and leading influential groups shaping the future of Australia's space industry.

Australian Space Agency Technical Advisory Groups

Nine InSpace community members are involved with five of the Australian Space Agency's (ASA) Technical Advisory Groups (TAGs), which shape 10-year, national roadmaps for each of these areas:

- Earth Observation
- Space Situational Awareness
- Communications Technologies and Services
- Space Medicine and Life Sciences
- Positioning, Navigation and Timing

InSpace TAG members contributed to the development of the ASA Communications Technologies and Services Technical Roadmap, the Bushfire Earth Observation Taskforce Report, and the ASA Earth Observation from Space Technical Roadmap.

Australian Space Industry Leaders Forum

Professor Anna Moore is a member of the Australian Space Industry Leaders Forum. The forum provides input into Australia's national civil space strategy and policy, along with industry representatives and associations and other non-government space organisations.

Australian Academy of Science National Committee for Space and Radio Science

Associate Professor Francis Bennet is a member of the National Committee for Space and Radio Science (NCSRS) which aims to foster the space and radio sciences in Australia. Professor Anna Moore is an observer. NCSRS links Australian space and radio scientists with relevant scientific societies and overseas space and radio scientists.

INSPACE AUSTRALIAN SPACE INDUSTRY LEADERSHIP

Standards Australia SV-001 Committee for Space System and Operations

François Lambert of InSpace Mission Control sits on this mirror committee of the International Standard Organization's ISO/TC 20/SC 14 Committee. His role focuses on informing the technical discussions on space situational awareness and orbital debris mitigation, with a regulatory angle, especially in relation to low earth orbit constellations.



Professor Anna Moore, named Female Leader of the Year at the Australian Space Awards, with the Head of the Australian Space Agency, Enrico Palermo.



InSpace hosted members of the House of Representatives Standing Committee on Industry, Innovation, Science and Resources, chaired by Hon Barnaby Joyce MP, at the National Space Test Facility on Mt Stromlo, in response to the ANU InSpace submission on Australia's future in space.

THE WORLD ECONOMIC FORUM GLOBAL FUTURE COUNCIL ON SPACE

Dr Doris Grosse is a member of The Global Future Council on Space, part of the World Economic Forum. The council serves as a global brain trust for leaders. It brings together experts to discuss the global space sector's most critical issues, including space traffic management, environmental and climate monitoring and the future of space exploration.

COMMITTEE ON EARTH OBSERVATION SATELLITES

Associate Professor Marta Yebra is a member of the Working Group on Disasters (Wildfire), part of the Committee on Earth Observation Satellites. The global group is chaired by NASA and explores collaborative pathways for the use of satellite imagery for disaster risk reduction, including risk mitigation of wildfires in Canada, Australia, Europe, the US.

INSPACE LEADERSHIP



The global group is chaired by NASA and explores collaborative pathways for the use of satellite imagery for disaster risk reduction...



THE AMERICAN CHAMBER OF COMMERCE IN AUSTRALIA SPACE COMMITTEE

Director of InSpace, Professor Anna Moore, is a member of The American Chamber of Commerce in Australia Space Committee which supports the development of the Australian space sector. Anna was recently part of its delegation to the Parliament of Australia.

CONSULTATIVE COMMITTEE FOR SPACE DATA SYSTEMS OPTICAL COMMUNICATION STANDARDS WORKING GROUP

Associate Professor Francis Bennet is an observer member of the optical communication standards working group, which helps to develop standards for optical communications that support optical communication systems for both Low Earth Orbit and Deep Space robotic and human-rated spacecraft.

ACROSS THE WORLD

“The council serves as
a global brain trust for
leaders...”

GROWING SPACE CAPABILITY FOR AUSTRALIA – INSPACE INCUBATOR INITIATIVES

At InSpace, we value research at many different levels of readiness. We have a pipeline of multidisciplinary projects we support, all at different stages in their lifetime.


WE INVEST IN INCUBATOR INITIATIVES

We call projects that need funding and development “Incubator Initiatives”. InSpace chooses these initiatives to help mature them to a point where they can become more developed “Flagship Missions” in the future.

The ANU has invested in the following Incubator Initiatives:

SPACE LAW – ANU College of Law – This initiative builds the capacity of the ANU to become a leader in space law and help shape Australia’s global space strategy.

SPACE MEDICINE – ANU College of Health & Medicine – There are many opportunities for Australia to have a role in human space exploration and travel. This funding enabled a Space Medicine and Life Science workshop leveraging cross-disciplinary healthcare, AI and irradiation expertise at the ANU to identify opportunities and capabilities for the ANU to contribute to this effort.

A stylized graphic on the left side of the page depicts a rocket launch. A yellow rocket with black outlines is shown ascending, with a large yellow sun or planet in the background. The scene is filled with black dashed lines representing orbital paths or trajectories, and several yellow and red circles of varying sizes scattered throughout, resembling stars or celestial bodies. The overall aesthetic is modern and scientific.

ROSELLA – ANU Research School of Astronomy & Astrophysics – This project fast tracks delivery of high-performance, low noise detector control electronics to fill a domestic market need for space-based optical and infrared sensor systems.

SPACE EDUCATION – ANU Research School of Astronomy & Astrophysics – This helped fund the first edition of the short course “The essentials of space government and industry,” which featured physics, engineering, space law, space medicine and space policy.

OZFUEL – ANU Fenner School of Environment & Society – This funded a state-of-the-art shortwave infrared hyperspectral camera for ground-based measurements of vegetation fuel bioparameters to enable verification of sensor system requirements for planned satellite missions.

ANU-DLR PROFESSORSHIP – Establish a joint ANU/DLR Professorial Chair to develop expertise in the field of Earth observation, astronomical instrumentation, and space technologies, particularly in infrared sensors to study astronomical objects outside the visible wavelength range.

QUANTUM MEMORY – ANU Research School of Physics – This project will evaluate key issues in operating rare-earth quantum memory technology on a satellite platform and assess its suitability for potential future space missions.

CHICO PARTNERSHIP – ANU Research School of Astronomy & Astrophysics investment into a DMTC-funded program to design a hyperspectral imager for surveillance of Australia’s land-maritime boundary.

A satellite view of Earth from space, showing a vast expanse of blue oceans and white clouds. The perspective is from a high altitude, looking down at the planet's surface. The text 'INSPACE FLAGSHIP MISSIONS' is overlaid in large, bold, black letters on the left side of the image.

INSPACE FLAGSHIP MISSIONS

Each financial year, we choose budding ideas and turn them into Flagship Missions. These projects form part of Australia's national action in the space industry, aligning with Australian Space Agency priority areas and Federal Government priorities in Defence, Home Affairs and Science. Flagship Missions are also critical in linking the space infrastructure and researchers at ANU InSpace to the global space industry.

Our Flagship Missions are nationally-recognised major initiatives with substantial potential for research translation, with an immediate impact and return on investment. They benefit from an intense one-year period of work with our team of world-class space industry professionals to boost their capacity and enhance their capability. This is done through forming robust multidisciplinary teams, bringing in funding, and guiding the program toward maturation. We also raise awareness of each Flagship Mission's impact in the space ecosystem, nationally and internationally.



“nationally-recognised
major initiatives with
substantial potential for
research translation...”

FLAGSHIP MISSION: AUSTRALASIAN OPTICAL GROUND STATION NETWORK

Australia's future is dependent on reliable, fast and high-volume communication infrastructure to meet increasing demands, especially during natural disasters and health crises. Optical communication is a breakthrough technology that will help us leapfrog to next-generation capability to allow very high volumes of data to be transmitted in real-time, with substantially enhanced security.

The ANU is leading the development of an integrated, optical satellite telecommunications research network to enable next-generation, secure satellite communication for Australia's nation-critical capabilities. The proposed Australasian Optical Ground Station Network (AOGSN) will be critical infrastructure, enabling cutting-edge scientific research, with a focus on developing a data pipeline for disaster-prone and rural areas as well as scientific outposts in Antarctica.

MISSION GOAL: To create an integrated laser communications network, providing significantly improved telecommunications capability, security and resilience across Australia.

ANU TEAM: Mission Specialists Associate Professor Francis Bennet and Professor Ping Koy Lam, Associate Professor Matt Sellars.

PARTNERS: Defence, Science and Technology Group, CSIRO, University of Western Australia, University of Auckland, German Aerospace Center DLR.

A night sky filled with stars and the Milky Way. A bright red laser beam originates from the left side of the frame, passing through the dark silhouette of a telescope dome, and extends diagonally across the upper half of the image. In the lower right, the dark silhouettes of evergreen trees are visible against the starry background.

2021 MILESTONES:

- The ANU Deep Space Optical Ground Station received \$200,000 in June 2021 through the Moon to Mars Demonstrator Feasibility Grants to build a prototype deep space laser communications transmitter compatible with optical communication technology developed by NASA.
- In 2021, InSpace has established an MOU between the Network partners to guide the development of the AOGSN.
- Network operations and specifications have been drafted in preparation for funding application and to assist with continued industry engagement for future commercial prospects for the network.
- A construction contract has been signed for the facility housing the ANU OGS. The facility dome is expected to be delivered in mid-2022. The telescope will undergo preliminary factory acceptance testing in December 2021, with delivery in March 2022.



MISSION GOAL: To establish a satellite bushfire fuel observing system that protects Australia from catastrophic bushfires and advances our space industry.

MISSION SPECIALISTS: Associate Professor Marta Yebra, Professor Rob Sharp, Dr James Gilbert, Dr Nicolas Younes.

PARTNERS: Skykraft, UNSW Canberra, Spiral Blue, LatConnect 60, Geoscience Australia.

FLAGSHIP MISSION: **OZ
FUEL**

To start a fire, you need fuel. With a lot of dry fuel and unpredictable weather, Australia's 2019-2020 bushfire season was devastating. Now we can mitigate such fire risks by knowing where the fuel is, how much there is, and how dry it is. The way to see these changes in our eucalypt-dominant bushland is with infrared sensing. The most effective way to measure the daily to weekly changes over the whole of the Australian landmass is with satellites.

The experts driving the OzFuel mission combine world-class research in bushfire fuel conditions, precision engineering in astronomy, and key industry partnerships in space systems technology. In a global market saturated with fire detection solutions, OzFuel's unique value proposition is that prevention makes suppression safer. Our advanced sensor system will help acquire high spatial, spectral and radiometric resolution data. Our aim is to provide this data freely to anyone involved in assessing bushfire risk, predicting fire behaviour, informing suppression efforts and planning prescribed burns.

OzFuel-1 will be a research mission to test science and technology hypotheses and to answer the question "How soon before Australia can build our own Earth Observation smallsats?" Our future ambitions for a disaster mitigation constellation lie in developing global partnerships and upscaling advanced manufacturing to enable sovereign missions. It will be critical to integrate data pipelines and share technology developments with the international community, creating complementary, resilient and redundant Earth observing systems to battle fires globally.

2021 MILESTONES:

- "OzFuel Pre-Phase A Study: Australian Forest Fuel Monitoring From Space" report released in August, detailing the mission requirements and staged development pathway for delivery of OzFuel-1.
- The OzFuel concept study supports the development of Australia's national missions for weather, climate and environmental monitoring.
- Fieldwork commenced to verify and validate the preliminary requirements for remote sensing of fuel conditions and measure biochemical properties of Eucalypts to verify sensor designs and provide data for machine learning.

APPROVED PROJECTS:

- Pre-Phase A: OzFuel Mission Requirements –detailing the remote sensing requirements for a pathfinder mission, funded by Geoscience Australia
- Phase A: Technical Overview –outlining the technical design and payload options for the OzFuel-1 mission, funded by the SmartSat CRC.

FLAGSHIP MISSION:
SPACE
QUALIFICATION



MISSION GOAL:

To supercharge Australia's space industry through a robust space testing and qualification process at the ANU.

MISSION SPECIALISTS:

Professor Anna Moore
(Director, InSpace)

PARTNERS:

The National Space Test Facility at the ANU Advanced Instrumentation Technology Centre and the ANU Heavy Ion Accelerator Facility

What does it take to stand up to the rigors of space travel? At the ANU, we help the Australian space industry find out before they launch their space missions.

The ANU has world-class space testing experts and \$200M in space testing infrastructure that rivals some of the best in the world and is the largest of its kind in the Southern Hemisphere. The ANU team and their facilities are critical to the development and testing of space hardware and sensors. They reduce barriers to entry for local design and manufacture of space missions, boost mission success, protect sovereign intellectual property and reduce costs for local space manufacturers.

At the ANU, we provide industry access to space testing at ANU for manufacture, assembly, integration and test (including radiation) of satellites and payloads. We are leading a national effort to boost the availability and types of space testing in Australia, including radiation testing. Radiation testing is critical to survival in space because radiation can end the life of a satellite mission immediately, destroying valuable research and data. The ANU Heavy Ion Accelerator Facility can be critical to providing this capability in the Indo-Pacific region.

The success of Australia's space manufacturing industry is underpinned by domestic space qualification and we want to open this ANU capability to all of Australia for increased national success.

2021 MILESTONES:

We led a successful bid to secure \$2.5M in funding from the Space Infrastructure Fund from the Department of Industry, Science, Energy and Resources. This funding enables us to develop a network of space qualification services, facilities and expertise. You can read more about this national effort on pages 40 and 41.

FLAGSHIP MISSION: INSPACE HQ

MISSION GOAL: To bring together the best people and resources to advance space research in Australia.





To fully realise the powerful collaborations we are creating in Australia's space industry, we have developed a space innovation hub in the Canberra CBD called InSpace HQ. Co-located with ANU Enterprise and the Office of Business Engagement and Commercialisation at 121 Marcus Clarke, this hub brings together our best and brightest minds to build on space-focussed opportunities.

Our goal is to bring together researchers and industry, catalysing the translation of space research for commercial benefit. In 2022, we will be hosting events, outreach and training there. We will also focus on showcasing our Mission Specialists, their research, and creating new opportunities for their innovations.

KEY EVENT:

In February 2021, InSpace hosted members of the House of Representatives Standing Committee on Industry, Innovation, Science and Resources, chaired by Hon Barnaby Joyce MP, in response to the ANU InSpace submission on Australia's future in space. Advocacy is a key strategic focus area, and now we will be able to host high-profile meetings such as this in our HQ.

OUTCOMES:

- COVID lockdowns prevented in-person meetings in 2021, we look forward to bringing together the space expertise of researchers and industry and providing a home for high-profile space activities for ANU and the ACT in 2022.
- We are in the process of creating a face-to-face networking event at InSpace HQ for researchers, students and the space industry in 2022.

2022 FLAGSHIP MISSION PREVIEW

Here's a look at our upcoming Flagship Missions for 2022.

MAKING ADVANCED SATELLITE COMMUNICATION TECHNOLOGY AVAILABLE TO INDUSTRY

MISSION:

Provide industry with access to Australia's most advanced optical communication ground station and world-leading quantum random number generator for space applications.

THE ANU TEAM:

Mission Specialist Associate Professor Francis Bennet, Research School of Astronomy and Astrophysics and Mission Specialist Professor Ping Koy Lam, Research School of Physics

Advanced satellite communications is a strategic priority for Australia, and satellite communications (SATCOM) is a high priority for Defence. The ANU has world-leading capability in optical and quantum communications for satellite applications. Opportunities in 2022 give the ANU the ability to make infrastructure and world-leading research available to industry for technology demonstrations and operational utilisation.

AUSTRALIAN CENTRE FOR SPACE GOVERNANCE

MISSION:

Advancing Australia's 21st-century interests in space.

THE ANU TEAM:

Mission Specialist Dr Cassandra Steer, the ANU College of Law; Mission Specialist Associate Professor Maria Llorente Racionero, College of Business & Economics; Professor Brendan Sargeant, Coral Bell School of Asia Pacific Affairs; Paul O'Connor, Coral Bell School of Asia Pacific Affairs; Nicola Rosenblum, Crawford School of Public Policy

Australia asserts itself as a credible space player but lacks a national strategy to match this and suffers from low space literacy across government and our population. Space governance expertise at the ANU seeks to unify siloed national capability into a single source of advice and advocacy for industry, Defence, and wider government, through the Australian Centre for Space Governance.

SPACE GRAVITY MISSIONS

MISSION:

Securing Australian partnership and access to NASA's Mass Change missions.

THE ANU TEAM:

Professor Paul Tregoning, Research School of Earth Sciences; Associate Professor Kirk McKenzie, Centre for Gravitational Astrophysics and Professor John Close, Research School of Physics.

The Space Gravity Flagship Mission aims to accelerate the development of innovative new gravity sensing technologies for Earth observation and geodetic applications. The Flagship Mission will develop next-generation laser interferometry and inertial sensor payloads for international missions. These sensors will measure Earth (and planetary) gravitational data from space that is key to quantifying Australia's water resources.

INSPACE SOCIAL MEDIA AND MEDIA SNAPSHOT

InSpace uses media and social media to reach key audiences with the right message at the right time. We are building a community to grow relationships between ANU space researchers and industry, Government and Defence. We keep our audiences engaged with successful thought leadership.

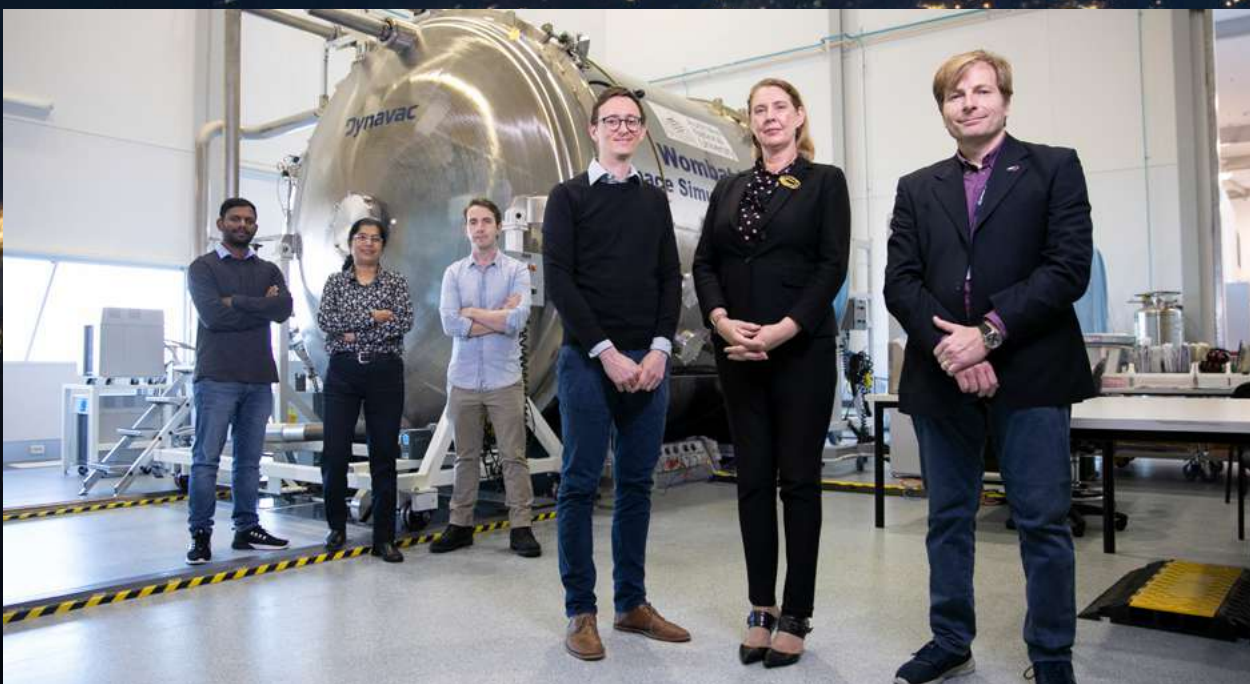
Social media growth since 2020. More than 450K people reached:

Twitter +156%

Facebook +228%

LinkedIn +773% in 2021

Photo credit: Keegan Carroll, Canberra Times. Our ANU team was featured on the front page of the Canberra Times on 17 June 2021 for winning a Space Infrastructure Fund grant to boost national space testing capability.



Twitter

AUDIENCE: academics and researchers
1514 Followers (Up 33%)
190,000 people reached in 2021
2.5% engagement
(0.09% industry average)

LinkedIn

AUDIENCE: industry, government,
Defence and researchers
1484 Followers (Up 45%)
41,000 people reached in 2021
6.4% engagement
(0.35% industry average)

Facebook

AUDIENCE: general public and students
1231 Followers (Up 50%)
70,000 people reached in 2021
6.2% engagement
(0.18% industry average)

InSpace is known for its effective thought leadership. In 2021, we published 18 thought leadership pieces with engagement rates between 15-20% on LinkedIn (average engagement = 0.35%).

From August 2020 to November 2021, the InSpace team conducted 521 media interviews, including a 12-minute ABC space documentary and a positive episode of ABC's 4 Corners. This media was worth more than \$5M.

Photo credit: Australian Broadcasting Corporation Library Sales. InSpace advocates for more public awareness about how space affects every Australian on programs like ABC's Four Corners.



The background of the entire page is a high-resolution image of Earth as seen from space. It shows a vast expanse of blue oceans, white clouds, and brownish-green landmasses. The horizon of the planet is visible at the top of the frame, with a thin layer of atmosphere. The overall tone is bright and airy, with a focus on the global perspective.

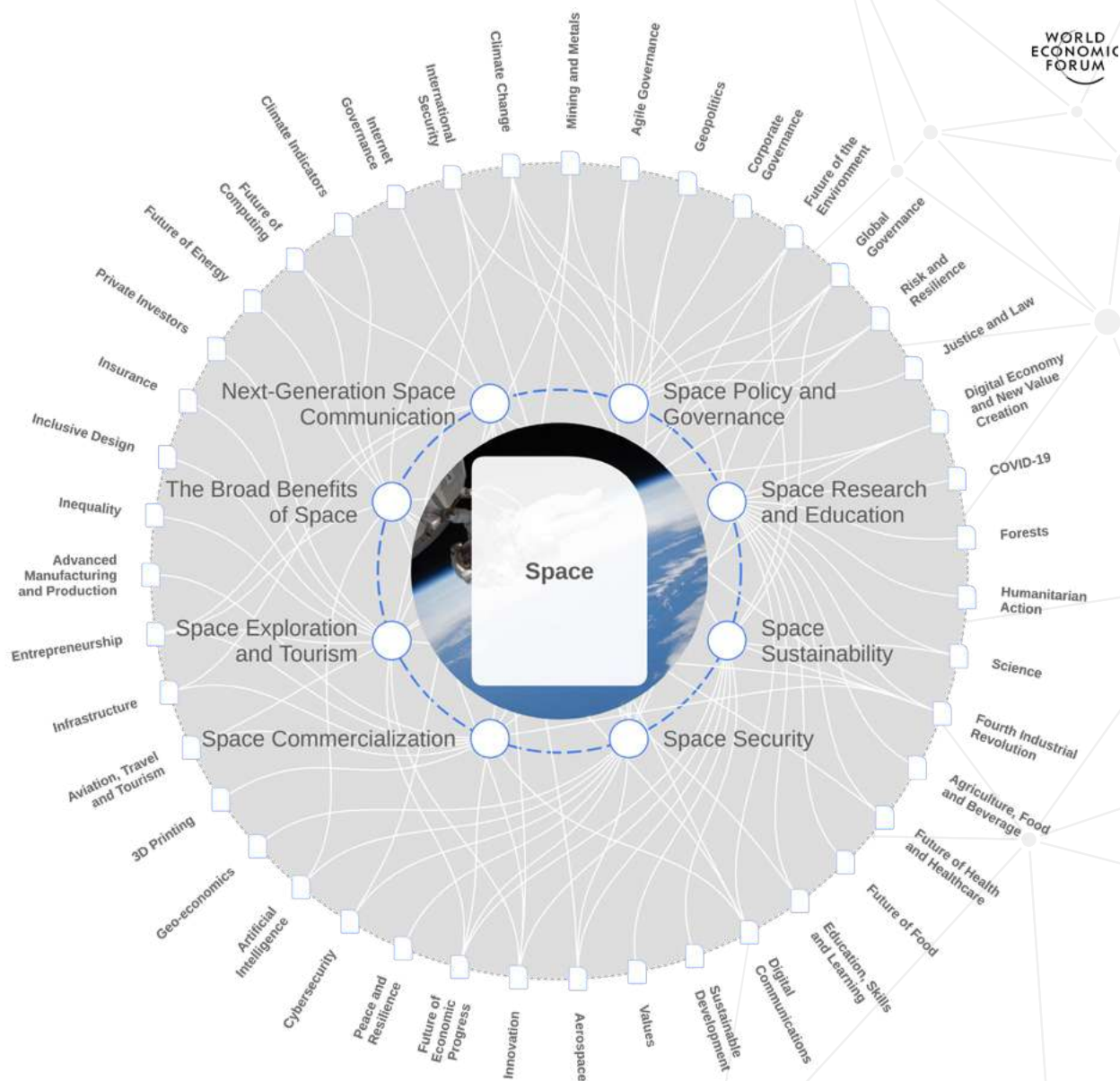
GOAL:

Partner with the World Economic Forum to develop its Space Strategic Intelligence Transformation Map to help people around the world understand the future of space and its influence in other sectors.

2021 ACHIEVEMENTS:

- Mission Specialist Dr Doris Grosse led the curation of the space map, with valuable contributions from Professor Anna Moore and InSpace Mission Specialists Associate Professor Francis Bennet, Dr Cassandra Steer, and Mission Control members François Lambert and Kathleen Sweetapple.
- InSpace researchers join the World Economic Forum Expert Network after profiling the forces driving change across the global space industry and its governance.

CASE STUDY: SHAPING GLOBAL SPACE INTELLIGENCE WITH THE WORLD ECONOMIC FORUM



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The World Economic Forum Strategic Intelligence Transformation Maps are where experts, policymakers, researchers and the general public go to find out more about global issues and their interdependencies. They are guides used by top-level decision makers around the world.

ANU InSpace Mission Specialists partnered with the World Economic Forum (WEF) to co-curate the Space Strategic Intelligence Transformation Map. This map shows global space trends, capabilities and challenges and is designed to help anyone understand the future of space.

The space map covers topics including Space Policy and Governance, Space Research and Education, Space Sustainability, Space Security, Space Commercialisation, Space Exploration and Tourism, Next-Generation Space Communication and finally, the Broad Benefits of Space. The most recent publications, videos and interactive data sets available from around the world are presented for each topic, along with visuals of how each topic interacts and is linked with other global issues.

The space map lives alongside other maps co-curated by top universities like the University of Oxford and Harvard University.



GOAL:

To build a national team and secure funding for a national network of end-to-end payload testing facilities for the global space industry and Australian manufacturers of space components while increasing the technology and capability levels of current infrastructure.

2021 ACHIEVEMENTS:

- Created a team of Australia's best research and industry space qualification providers to become founding partners in a national network.
- Created a bid and received \$2.5M in funding from the Space Infrastructure Fund of the Department of Industry, Science, Energy and Resources to establish this national network called the National Space Qualification Network (NSQN).

CASE STUDY: SPACE INFRASTRUCTURE GRANT



▲ ANU has some of the most advanced space testing facilities in the Southern Hemisphere.



With the SIF, the ANU Heavy Ion Accelerator Facility will now test space components for radiation.



ANU has space testing facilities across two campuses.

To ensure that space missions are successful, space payloads, components and spacecraft must be tested before they are launched into space. The NSQN will provide an assembly and testing facility for space components and satellites, next-generation space qualification business access and unique infrastructure that tests for radiation, one of the biggest threats to space hardware. Developing these testing capabilities will make Australia a sought-after testing destination for domestic and overseas space manufacturers.

ANU InSpace will deliver internationally recognised radiation testing through the Heavy Ion Accelerator Facility; sensitive hardware monitoring in the largest thermal vacuum chamber in Australia (the WOMBAT XL); the first standardised pyroshock testing facility in Australia to test the impact of the explosive forces generated during stage separation of rockets; and better temperature mapping during testing.

The NSQN partnership includes the Australian Nuclear Science and Technology Organisation (total ionisation dosage (TID) radiation testing), Nova Systems (developing an online database of off-the-shelf tested parts), the University of Wollongong (development of laser-based pre-screening), Steritech (large-scale radiation testing), and Saber Astronautics (determining the appropriate space environment profiles for qualification testing and integrating qualification data with Mission Control centre data).

CASE STUDY: ROSELLA: CREATING NEW WAYS TO SEE THE EARTH

The ANU has invested more than \$800K in Rosella, a revolutionary detector control electronics program led by Dr James Gilbert and Professor Rob Sharp at the ANU Advanced Instrumentation and Technology Centre. This Australian and ANU IP can be translated into many commercial remote sensing uses including, agriculture, bushfire mitigation, water monitoring, mining and Defence.

Rosella has its heritage in astronomy, but this technology had clear application for sensing of the Earth from space. The fridge-sized electronics package is being miniaturised for small satellites to undertake high-resolution imaging from low Earth orbit. A Rosella-enabled sensor system can differentiate between subtle changes in water content in vegetation or geochemistry of uncovered mineral systems, filling a gap in several domestic markets. InSpace has invested more than \$800k to accelerate the multi-million dollar program for space readiness and to help reach any team developing new sensors.

The first mission for Rosella is the ANU 'OzFuel' multispectral pathfinder for bushfire mitigation. Rosella's versatility will eventually be extended to hyperspectral imaging missions such as the ANU 'CHICO' mission. CHICO is being developed in partnership with the Defence Materials and Technology Centre, Skykraft and CSIRO for littoral mapping and information gathering of submerged objects in denied or contested access areas. Both OzFuel and CHICO are reference missions for Geoscience Australia's Satellite Cross-Calibration Radiometer program and CSIRO's AquaWatch Australia program. Accelerating the Rosella detector electronics package for our pathfinders will help accelerate the space readiness of these national missions.

GOAL:

To develop home-grown, high-performance detector electronics that will fill a market opportunity in optical and infrared space sensor systems.

2021 ACHIEVEMENTS:

- ANU is developing 'Rosella', a sovereign detector control electronics package, for commercial nano - and small satellites.
- Rosella will operate custom and off-the-shelf detectors for optical to shortwave infrared space missions.
- It accelerates collaboration in high-tech engineering and advanced manufacturing.
- Rosella is intended for a range of remote sensing applications in astronomy, agriculture, bushfire mitigation, water monitoring, mining and Defence.

The ANU team behind the Rosella detector designed it for a wide range of remote sensing applications such as astronomy, agriculture, bushfire mitigation, water monitoring, mining and Defence.



GLOBAL SPACE INDUSTRY WINS

Here are a few standout wins with our national and international partners.

AUSTRALIA'S QUANTUM LEAP: SATELLITE QUANTUM ENCRYPTION

Partners: Arqit

Funder: UK-Aus Space Bridge

Overview: This project will conduct a design study for an Australian quantum random number generator payload that could be hosted in a future Arqit satellite. In addition, the team will define the requirements for using the ANU optical ground station to provide ground support for Arqit satellites.

Expected outcomes: This will lead to commercial opportunities for ANU and Australia to provide ground services for global quantum satellites. It also provides a path for Australian space-ready quantum hardware to enter the global supply chain.

Expected impact: This will help international allies establish a new global satellite system for Quantum Key Distribution for government users to protect critical infrastructure against cyber-attacks.

AN INDIVIDUALISED MODEL-BASED DIGITAL TWIN FOR DECISION SUPPORT IN CRITICAL CARE

Partners: University of Twente

Funder: Netherlands Organisation for Scientific Research Rubicon Fellowship

Overview: This project will support clinical decision-making in critical care by providing a digital twin model to safely test proposed medical interventions prior to actual treatment on patients. A forward-looking view is to translate advances in terrestrial health care to remote and space-based medical care.

Expected outcomes: Smart and rapid treatment for space passengers and terrestrial, remote healthcare

Expected impact: Growth of the space medicine and life sciences capability in Australia for space tourism and deep space travel

COMPACT HYPERSPECTRAL IMAGER FOR THE COASTAL OCEANS

Partners: DMTC, CSIRO, Skykraft

Funder: Defence Materials and Technology Centre

Overview: This project completed a preliminary design study for an Australian space-based hyperspectral imager. The imager is intended for surveillance of shallow water and intelligence gathering of denied access areas in coastal zones.

Expected outcomes: A sovereign hyperspectral satellite for dual-use geospatial intelligence.

Expected impact: De-risking high-performance sensor systems for Australian civil and Defence small satellite programs.

EVALUATION OF RARE-EARTH QUANTUM COMMUNICATION TECHNOLOGY FOR SPACE-BASED APPLICATIONS

Funder: SmartSat

Overview: This project will assess the feasibility of operating rare-earth quantum memories in a satellite environment and gauge their suitability for future space missions. This is being done in collaboration with NASA Goddard Space Flight Center.

Expected outcomes: A quantum memory prototype will be developed and delivered to NASA GSFC for integration with their single photon detectors. This will be used to characterise the quantum memory and optimise the performance for use in a potential future satellite mission.

Expected impact: This project is the first step towards designing a quantum satellite mission. A quantum satellite network incorporating quantum memories will provide the underlying infrastructure for provably secure quantum communications across global distances and between multiple users.

LASER TECHNOLOGY FOR NASA'S NEXT-GRACE MISSION

Partners: CEA Technologies, NASA JPL

Funder: Australian Space Agency Moon to Mars Demonstrator Feasibility Grant

Overview: This project will advance laser measurement technology for NASA's next-generation gravity sensing mission (2026 launch). It extends the successful decade long Australian/NASA collaboration on the GRACE Follow-On mission to produce space flight technology for satellite monitoring Australia's water resources.

Expected outcomes: To extend a successful decade-long international collaboration on the GRACE and GRACE Follow-On missions and continue developing prototype space flight hardware for the Mass Change mission.

Expected impact: Establishes the superiority of hi-tech design and advanced manufacturing in Australia for international space missions; contributes to Australian access to critical international satellite data.





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Get in touch to learn more and meet our space experts.

