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CSIRO: our roadmap for space

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Introduction

CSIRO, Australia's national science agency, was established more than a hundred years ago and has 75 years of space science heritage. Fifty years ago CSIRO played a key role in supporting NASA's Apollo 11 mission to the Moon.

Today the $350 billion global space market is growing, NASA is calling for a return to the Moon with international participation, and Australia is uniquely positioned and eager to take advantage of this opportunity. The Australian Space Agency was established with the goal of tripling the size of the Australian space industry in terms of economic value, and creating up to 20,000 jobs, by the year 2030. Investing in R&D to assist Australian industry growth and solve Australia's greatest challenges is CSIRO's core role. CSIRO aims to be a key technology partner to the Australian Space Agency, driving technological innovations and providing science and research facilities that will support the Agency's industry growth goal.

CSIRO hosts several national space facilities, including the Australia Telescope National Facility, or ATNF, and the Canberra Deep Space Communication Complex, or CDSCC. The ATNF includes three radio telescopes in New South Wales at Parkes, Narrabri and Mopra, near Coonabarabran, plus the Australian Square Kilometre Array Pathfinder in Western Australia, which is an array of 36 antennas.

Australia is uniquely positioned in the Southern Hemisphere to support international space missions through the provision of tracking and communication services. CSIRO was recently appointed to provide operational support for the European Space Agency's Deep Space Tracking Station at New Norcia in Western Australia. And CSIRO also manages the operations of CDSCC, which is one of three stations worldwide that make up NASA's Deep Space Network. CDSCC is currently tracking around 35 Deep Space missions, including the well-known Voyager 2 spacecraft. After 42 years Voyager 2 is now approximately 18 billion kilometres from Earth travelling through interstellar space, and due to Voyager 2's southward trajectory out of the solar system and its distance from Earth, the CDSCC tracking station and the Parkes radio telescope are now the only two facilities in the world that are capable of having contact with that spacecraft.

CSIRO has had world-leading capabilities in Earth observation data analytics, calibration and validation for decades, which are coordinated by the CSIRO Centre for Earth Observation. This centre is also home to CSIRO's first CubeSat, CSIROSat-1, which is under development in partnership with Adelaide space technology company Inovor Technologies, and is due to be launched from the International Space Station in 2021.

The Centre for Earth Observation also manages CSIRO's 10 per cent capacity share of the UK-operated NovaSAR-1 satellite, which is expected to become fully operational in 2020. NovaSAR-1 is a synthetic aperture radar (SAR) satellite which can operate day and night, and through smoke and cloud, making it well suited to assisting with managing many of our national bushfire and flood challenges. CSIRO will operate our share of NovaSAR-1 as a national facility for all researchers to access.

Space Technology Future Science Platform

In addition to these activities, CSIRO's newest space research program is the Space Technology Future Science Platform, or Space FSP. The aim of this program is to further CSIRO's space capabilities by identifying and developing the science to leapfrog traditional space technologies, and to identify new areas for Australian industry to work in — areas in which we can leverage our existing space and terrestrial capabilities for new space applications, and in which Australia can be globally competitive in order to support the Australian Space Agency's industry growth goals.

The Space FSP was established in late 2018 with a program lifetime currently of three and a-half years. Over the past 12 months the Space FSP has already initiated 23 projects with a total program value of over $21 million already. Its activities focus on the National Civil Space Priorities outlined by the Australian Space Agency and address a wide array of opportunities, including:

- advanced satellite technologies, particularly in relation to CubeSats and small satellites, including power, control and sensing systems, structural technologies and onboard data processing
- remote operations and in situ resource utilisation, including new technologies for off-Earth resource exploration and synthetic biology approaches to resource extraction
- human factors and biomedical technologies to better support human space missions
- Earth observation data analytics and applications development
- new high bandwidth space communication technologies using optical and terahertz band links, and
- new techniques for space object tracking.

Current projects

The following section highlights a few examples of the projects underway through the Space FSP.

NASA is planning to return humans to the Moon by 2024 and establish a permanent human presence there, and the Australian Government recently committed to supporting the Australian space sector to participate in this mission. There is significant interest in accessing valuable lunar resources, particularly water ice, to support human missions to the Moon. Remote mining operations and asset management are already a strength of the Australian resources sector, and applying this to the space environment through in situ resource utilisation is a challenge that Australia is looking to play a role in.

The Space FSP currently has four projects in the robotics, remote operations and resource utilisation area, and one of these projects is developing a predictive analytics software platform to produce 3D resource

models of the Moon, asteroids and other bodies to support future prospecting and resource utilisation planning. The Space FSP is also looking at potential new opportunities relating to providing space analogue facilities here in Australia, which encompasses everything from Mars surface analogues to microgravity facilities to digital twins.

The Space FSP is also leveraging CSIRO's existing Earth observation expertise and facilities to make significant developments related to the accessibility and application of satellite-derived data. This includes: utilising the NovaSAR-1 satellite to grow SAR expertise nationally and drive the uptake of SAR data in Australia; and building on CSIRO's data cube expertise to create high-performance data processing infrastructure to better analyse, integrate and utilise multiple Earth observation data types including hyperspectral and lidar data. This latter project aims to improve satellite data accessibility and utilisation for a broad range of applications, from agricultural crop and freshwater algal bloom modelling to carbon stock and greenhouse gas monitoring.

Globally, rapidly growing Earth observation data volumes are an ongoing challenge both with regard to effective handling and use of the data for various applications, and with respect to the increasing bandwidth required to downlink the data from satellites. Under another Space FSP project, the CSIROSat-1 satellite will provide a platform to demonstrate sophisticated onboard data processing techniques to reduce the amount of data needing to be downlinked from the satellite.

In the materials and manufacturing domain one of the Space FSP projects is demonstrating novel additive manufacturing techniques — namely electron beam melting and cold spray — for Invar, which is a low coefficient of thermal expansion alloy, to create metallic composite components, including precision optics mounts, for CubeSats. Using these manufacturing techniques, the mechanical properties of a composite component can be tailored in different locations on that component.

With regard to space biomedicine and space life sciences, experimental "labs in a cube", based on the CubeSat format, are a permanent fixture on the International Space Station (ISS). One of the Space FSP projects is developing a new "lab in a cube" testing platform called an Optocube, which will enable human cells, particularly bone cells, to be studied on the ISS. The Optocube is unique in that it will use light as the only stimulus to control cells and to detect results, so the experiments are able to be completely contactless.

The Space FSP is also in the preliminary stages of exploring opportunities related to bio-manufacturing for healthcare in space, and space agriculture.

Future pathways

The projects mentioned here are not an exhaustive list of the Space FSP's activities. Furthermore, the Space FSP currently runs until mid-2022 and it will continue to invest in new collaborative activities over the next two and a half years.

All of these investments of course produce the best outcomes when they are done in partnership with other research organisations and with industry, which provides the path to impact for these new technologies, and the Space FSP welcomes opportunities for new collaborations. CSIRO will also continue to partner on other R&D pro-

grams to build Australian space industry capability, like the DMTC High Altitude Sensor Systems Program and the SmartSat CRC.

CSIRO looks forward to continuing to work closely with the Australian Space Agency and Australian industry on the next giant leaps to the Moon, Mars and beyond.

https://research.csiro.au/space/