Duncan Ivison
Deputy Vice-Chancellor (Research)

29 August 2017

Dr Megan Clark AC
Chair of the Expert Reference Group
Review of Australia's Space Industry Capability

By email: space@industry.gov.au and uploaded to review website

Dear Dr Clark,

Review of Australia's Space Industry Capability - Issues Paper, released August 2017

The University Sydney welcomes the opportunity to make the attached submission in response to the Issues Paper released recently by the Expert Reference Group.

Attached to our submission is a specific proposal lodged separately with the review by Warwick Holmes, Executive Director of Space Engineering, in our Faculty of Engineering and Information Technology's School of Aerospace, Mechanical and Mechatronic Engineering.

We look forward to working closely with you and other members of the Expert Reference Group to help advise the government on the steps that need to be taken to build a strategic framework to guide the development of a strong Australian space industry.

Yours sincerely,

Signature removed for electronic distribution

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University of Sydney submission to the Minister for Industry, Innovation and Science's Expert Reference Group's review of Australia's Space Industry Capability Issues Paper, released August 2017

29 August 2017

The University of Sydney welcomes the opportunity to contribute to the *Expert review of Australia's space industry capabilities to participate in a global market*. In this submission to the Review we raise some key considerations which we hope will assist the Expert Reference Group to maximise the potential for growth in the industry and for cross-societal benefits as it formulates its recommendations for the future of the Australian Space Industry.

In our view, the current reliance on multinational companies (even their local subsidiaries) or foreign governments for the space data and services that the nation requires, does not provide the 'assured and secure' access envisaged in Australia's *Satellite Utilisation Policy*. The shortcomings of the current approach are both strategic and economic, and the benefits of Australian ownership of these data and services would be enormous. The development of a local Australian space industry and associated national capabilities is therefore vital for national and commercial security. But from the University's point of view it is also crucial for the Expert Reference Group to recognise that space-related education and public good research should be a major component of the Australian space industry.

We encourage the Expert Reference Group and the Government to take a holistic view of Australia's space sector that includes public-good research and education, and the academic and commercial applications of public-good research, data, and services, as well as commercial research and applications, and identified national/government needs. It is of some concern to us that much of the Issues Paper and Terms of Reference are focused on commercially-oriented research, when the benefits of public-good or fundamental research (not focused on answering particular commercial or government needs) are well known. These benefits range from the attraction of the best researchers, to the many cases where basic research results in unprecedented solutions to real world problems.

Education and public-good research on space also contribute to workforce development for sustainable, globally competitive industry and public sector space sectors in the USA, the UK, Europe, Japan, Canada, and elsewhere. Australia's space industry should aim for the same flow-through effect into our education systems and public understanding of space science. Well-publicised results from public-good research, for example from NASA's current Juno mission, draw student, academic, and public interest towards STEM subjects, including space, from where individuals are attracted to the academic, commercial, and government sectors of space industry (defined broadly) and space research.

Around the world, globally significant space agencies are not focused only on commercial development and the defined needs of government. NASA, ESA, UKSA and JAXA all spend in the order of 30-50% of their budgets on public-good research, data, and services. Notably, most of the positive public interest they receive comes from public good research, data, and services.

Bearing the above general points in mind, it is the University's view that an Australian Space Agency should specifically support the following key elements:

1. Fundamental, basic public good science and technology research;
2. Research on predicting and mitigating space weather events (broadly the conditions in space that affect human systems and activities on Earth and in space) driven by solar activity, which have the potential to catastrophically affect the economies and societies of Australian and the world as a whole;
3. Public-good and government applications that involve remotely sensing the Earth from space via optical, GPS /GNSS, and radar techniques; and
4. Commercial applications involving remote sensing data and services, communications, and other space industry data and services, the importance of which is well-attested in the Issues Paper.

We will now make some comments specific to the discussion questions posed in the Issues Paper.

CAPABILITY

What are Australia's space capability strengths? What are the factors that contributed to the development of these strengths?

In Australia we have a strong research base in space science, engineering, technology, and associated fields (e.g. agriculture, geosciences, business) that is well placed to address various big-picture issues (e.g., water, agriculture, minerals, environment, mining, marine/coastal) with major commercial and national importance. STEM strengths in our schools and universities have contributed to the development of these research capabilities, as well as the power of several of our industries including mining, agriculture and tourism. However, even with this strong research base, collaboration tends to be on an individual and small group level with existing space programs and industrial companies overseas. This is a result of limitations in funding and government-supported infrastructure and programs here.

Several Australian companies (e.g., Solana and Saber Astronautics), as well as various Australian government agencies are researching and developing globally-competitive space products. Key factors in developing a world-recognised Australian space industry sector will be access to research funding, consistency in the allocation of research funding to enable long-term planning, and the development of a supportive national environment academically, commercially, and policy-wise.

What are the weaknesses in the Australian space industry sector?

One weakness we recognise is the lack of a readily implemented national strategy to fund and promote the development of the space industry sector, access to research funds and access to venture capital and investment funds for the development of an advanced manufacturing industry suitable for component and small system manufacture. We need a national strategy and a national implementation body to help the disparate parts of government and industry and research institutions come together to perform research in priority areas and to develop products and solutions for export and Australian consumption.

Australia appears to have a reasonably strong 'downstream' space industry, providing services based on foreign-sourced data, but is weak in 'upstream' aspects or source data and services that could provide

stronger economic and capability growth. Another likely weakness that requires further analysis is in exports: we are of the view that most 'downstream' products are also likely to be used domestically.

What is the cross-over potential of space-related industry capabilities to the rest of the Australian technology/manufacturing sector?

There are many synergies in advanced manufacturing technologies between the space and other sectors. One is between the satellite and unmanned aerial vehicle (UAV) sectors, where improvements in hyperspectral imagers and other instruments, calibration/validation techniques, and high-speed communications in one sector will benefit the other. These are among the targets for the newly-funded *ARC Training Centre for CubeSats, UAVs, and Their Applications*, led by the University of Sydney in collaboration with the University of New South Wales, five commercial groups, four Australian government units, and two US universities.

Are there space systems or activities that require Australia to maintain specific sovereign space industry capabilities?

As a nation we should aim to reduce our reliance on other nations for data and services we need, for instance about our own country, its climate, and key issues such as water, crops and arable land, vulnerability of Australian coastal areas to climate change, and improved understanding of oceans. Likewise for global data we need for economic intelligence or national security. This was recognised in the *2013 Space Policy*. There are key data sets, which need to be collected and analysed by Australia, while maintaining those data-gathering partnerships that have already been put in place. We should also develop the capability to lead and implement new space projects, alone or with others, that provide new data sets and services (public good, commercial, and government) useful to Australia and others worldwide.

For so long as Australia relies exclusively on partnerships with satellite-launching nations to meet our requirements for data and services, there is the risk that access to and use of data could be constrained by the cost and availability of satellite services, data collection and processing services. Another nation may openly or otherwise limit what data and services are provided, refuse access, or increase the cost of critical data and services. Because there can be no certainty that current levels of access and cost will be maintained in the future, Australia should look to create more certain and independent access to data from space.

Specifically, Australia should have the capabilities to design, build, test, and operate CubeSats and larger satellites, their systems, and advanced sensors/instruments for Earth observations, GPS/GNSS, satellite communications, space weather, and space situational awareness (SSA) at least. These all have public good, commercial, and national security aspects, with both export and domestic commercial possibilities. We should also the capability to produce advanced services from such data, whether Australian or sourced from foreign satellites, that are useful across the public good, commercial, and national security domains and have major export and domestic uptake potential.

Are there specific space services that provide greater opportunities for the Australian space industry sector within Australia or the Australian region?

As detailed above, necessary elements of the space industry will be the ability to design, build, test, and operate CubeSats and larger satellites, their systems, and advanced sensors/instruments for Earth observations, GPS/GNSS, satellite communications, space weather, and space situational awareness (SSA) at least. In addition, we believe there will be significant opportunities in the development of further advanced services from such data, whether Australian or sourced from foreign satellites, that are useful across the public good, commercial, and national security domains and have major export and domestic uptake potential.

What space products, upstream or downstream, are being exported by Australia? What products could be exported in the future?

The University is focusing on products that could be developed in the near future, such as components for small satellites (CubeSats) and larger satellites up to around 150kg, sophisticated sensors and instruments, and sophisticated optical systems. These rely on research across a wide range of disciplines and specialities. The University also believes that Australia has a role to play in the development and export of novel data analysis methodologies.

DEVELOPMENT

What elements of the global space sector are most beneficial for an Australian space industry to participate in?

We see significant opportunities in:

- creating of data products and services
- designing, manufacturing, and exporting component parts and systems for CubeSats, other satellites, and UAVs
- developing new propulsion systems
- developing high speed communication systems
- creating advanced imagers (including hyperspectral imagers), GPS/GNSS receivers, and other sensors/instruments
- manufacturing and operation of small satellites
- developing and testing in space quantum communication devices, testing theories for gravity, and enabling flight of astronomy and Earth
- monitoring and data collection
- analysing data
- developing new methodologies and techniques for big data analysis.

These all have applications in, or lead to benefits for, public good research, commercial products and services, and government needs.

Australian universities, through various research programs, have developed skills to address key deficiencies in communications, propulsion and imaging, enabling the manufacture of unique computer and electronic systems and instruments that collect increasingly sophisticated data, allowing production of novel data products and services for Earth observation in the areas of coastal health, agriculture, GPS (e.g., sea state), and space.

What are the key enabling technologies, infrastructure, processes and/or skills that will underpin the future of the Australian space sector?

One of the key problems encountered by Australia in entering the global space industry has been the economic cost of entry, with 1-m size satellites costing anywhere from $10 million to a few billion dollars, plus the associated large and costly infrastructure to design, build, test, and launch such satellites.

Encouraging the further development in Australia of high quality CubeSats would be one way of developing the enabling technology to underpin a future Australian space sector capable of designing, building and deploying larger satellites as proposed by Warwick Holmes from our School of Aerospace, Mechanical and Mechatronic Engineering in his separate submission included at **Appendix A**.

What are the competitive advantages available to space activities in Australia?

Australia has world-class researchers across space science, engineering, technology, and their applications, has a highly educated workforce, and has a well-developed ability in 'downstream' space services. Also, as noted above, the timing of the development of our space industry means that we can build domestic capability through the development of CubeSat technology, which has relatively very low barriers to entry (less than $1 million, or the cost of investing in a standard business franchise).

What opportunities are available to develop Australia's space industry capability?

As detailed above.

How can Australia grow the capabilities needed to foster an internationally competitive space sector?

Pursue the development of a national space program and capability through enhanced investment in education and research, and in the development of domestic capability to design, build and deploy CubeSats and larger satellites, as argued above.

What capabilities are needed to ensure access to the space systems and data flows that are becoming critical to Australia's economy?

As outlined above.

What linkages could be made between the space sector and other sectors to achieve the most benefit from the development of Australian space industry capability?

With the development of greater capability in the Australian space industry, and consistent and reliable research funding, collaboration between sectors will be inevitable and that there will be unpredictable broad-ranging benefits. However, obvious linkages would be with advanced manufacturing, agriculture, environment, and government agencies charged with future planning.

What are the technology trends over the next 5-10 years and what opportunities/impacts for Australia?

One major relevant trend is the continued development of CubeSats as a powerful, low cost, platform for space research space industry, and space-related government needs. As outlined above, there is a great opportunity for Australia to develop a real, globally-recognised, space capability based on CubeSats, with major commercial, public-good, and national benefits for Australia.

OPPORTUNITIES FOR AUSTRALIA'S SPACE INDUSTRY

What opportunities are available for Australia in the global space sector?

Australia is moving towards a future reliant on innovation to sustain and grow our economy and provide answers to challenges such as conservation and use of water and land resources, weather monitoring and natural disaster management.

Recent developments in miniaturisation of space vehicles, components and instrumentation (especially in connection with CubeSats), as well as the return of launch vehicles, combine to effectively lower participation cost in space activities, increase the performance and capabilities of sensors and vehicles, and also decrease the duration of the development cycles. As a consequence, the global space market is growing and is expected to continue to grow very rapidly for the next 10 years. Opportunities must be grasped early. The University is actively monitoring global trends and opportunities. CubeSats present an economic alternative and are generating new technology, sensors, spacecraft systems, and commercial opportunities which can produce new products, data, and services to contribute to Australia's economy and solve major Australian problems while also responding to the global space sector's needs for:

- advanced communication and propulsion solutions
- increasingly sophisticated optical imaging and GPS/GNSS receivers
- novel instrumentation,
- remote sensing capabilities, and
- more accurate and useful data about climate, weather, aridity, water, natural disaster, land and crop management.

Through our Australian Research Centre-funded Industrial Transformation Training Centre (the *ARC Training Centre for CubeSats, UAVs, and Their Applications*) we working to help develop a world-class Australian space industry in CubeSats, UAVs, and related products. The Centre aims to develop some of the required human capital, to significantly enhance the capabilities of CubeSats, UAVs, and their instruments, with applications to larger satellites, and to progress these devices to create major commercial value.

Other opportunities are provided by our strong education and training sector (across multiple fields of science, engineering, and business, among others) which can play a role in educating and training a skilled workforce not only for Australia but for international participants in the global space economy. The infrastructure and security of all developed economies rely on satellites, depending on them for our Earth observation capability and global navigation systems, all of which also require highly trained workforces.

What should the priorities be for the Australian space industry?

The Australian space industry will be able to take advantage of high quality research undertaken in Australia and elsewhere to pursue its strengths. These align with developing areas of space research which have commercial appeal, such as the design and advanced manufacturing of components such as sensors and platforms and products for CubeSats and other miniaturised vehicles, plus the development and provision of data and advanced services for public-good, commercial, and government purposes (whether from Australian or foreign satellites).

Australian priorities should also look to make greater use of data derived from satellites through the development of data-driven products, which would have an immediate and proven market in areas such as space surveillance, weather monitoring, analysis of remote sensing data and earth observation data.

How can the private sector be encouraged to invest in areas of Australia's comparative advantage?

A number of strategies could be pursued such as matching government funding for private investment, research and development financing or financial support, both financial and practical support for commercialisation of technology, government funding for niche capability development and enhancement, and support for export including support for finding export partners.

Another strategy would be to enable shared public-private sector projects involving satellites or downstream data, analysis and services. For instance satellite projects focused on marine/ocean issues might carry several novel sensors or components procured from various academic, commercial, and/or government groups on a shared platform. These groups could provide some funding which would then leverage or match funding from dedicated national space program.

Should priorities for space industry capability development be applied across all space-related research funding?

A cohesive and unified approach to capability development needs to be undertaken, however, there should always be funding for blue sky or fundamental research as by its very nature the direction and outcomes of successful research can't always be predicted and research success can be found in unexpected ways.

What should the vision for the Australian space industry be?

As at 2017, the Australian space sector has annual revenues of between $3 billion and $4 billion. It employs between 9,500 and 11,500 people and has a 0.8% share of the global space economy. The

space sector in developed economies enjoys growth rates of up to 10.7% per annum. Australia should develop an investment and research strategy which aims to match the growth rates in the space economies of developed nations and substantially increase Australia's percentage share of the global market. We support the Space Industry Association of Australia proposal that Australia look to capture 4% of the world market for Australian industry within 20 years.

Australia is reliant on other countries for much of the data we need for research in the areas of weather forecasting, resource management in the areas of water and mining, management of bushfire and floods and other natural disasters, land use, management of conservation zones and insurance assessment. Part of the vision for Australia's space industry would be to achieve a greater level of independence, particularly during a time of geopolitical change.

While it is important to have an achievable vision, a vision remains just that without a strategy. The University of Sydney supports the call, made by many others, to properly fund the establishment of an Australian Space Agency which would develop and implement a unified national space strategy to drive change in government policy in this area and lead investment decisions.

Australia's *Satellite Utilisation Policy*, while it has a laudable set of goals, does not provide a framework for national oversight by a single government agency which will be responsible for bringing together the activities of various departments and portfolios necessary to the success of growth in space. An implementing agency, such as a national space agency would be accountable for the development and implementation of a strategy for capability development, targeted investment opportunities, realistic and measurable growth targets, prioritisation of opportunities for development and export, and promotion of relevant STEM secondary and tertiary education and training.

As we argued at the beginning of this submission, and for the reasons detailed there, the University is strongly of the view that the Australian Space Agency should have a broad outlook based on best practices from the USA, UK, Europe, Japan, and elsewhere. This broad remit would take care to prioritise fundamental blue-sky and space weather research (both considered public-good research), alongside space industry development and commercial return, and accomplishing government (e.g. national security) needs.

Thank you once again for the opportunity to make a submission to the Expert Reference Group. We are certain that you share our excitement for the future of the space industry in Australia, and look forward to working closely with you on further consultations as to its development.

Appendix Submission lodged separately by Mr Warwick Holmes, Executive Director of Space Engineering, School of Aerospace, Mechanical and Mechatronic Engineering, Faculty of Engineering and IT, the University of Sydney

Proposal justifying the formation of an Australian Space Agency. An Earth observation satellite for the benefit of all Australians.

The following proposal to the Australian Government - Review of Australia's Space Industry Capability, is to demonstrate the economic, strategic and technology benefits from the development of a small but sophisticated remote sensing, Earth observation (EO) satellite for Australia. This technical project shall help to justify the formation of an Australian Space Agency as the focal point for definition, management, funding and co-ordination to develop the first and only Australian remote sensing and imaging satellite.

Many government reports, economic and business case studies have demonstrated the strong financial, social and strategic dependency Australia has on satellite Earth observation imagery. Economic benefits include: agri-business, border surveillance, disaster management, mineral exploration, environmental monitoring and geographic-information-systems (GIS).

A detailed system definition and design of the satellite exists and has been made by The University of Sydney, Executive Director of Space Engineering and AMME Engineers. A brief summary of the specifications is presented here to quantify the scale of the project: Size: 80x80x80cm, Mass:150kg, Lifetime:12 years, Payload: Multi Spectral or Hyperspectral + Hi-resolution panchromatic Orbit: Sun-Synchronous 600km, Optics: 70cm diameter Ground Stations: Three (X-band) in Australia Total cost: $85m-$100m Development time: Six years. Potential ROI after launch: 5 years

The aim of the project is to produce a commercially viable small imaging satellite fully designed, developed, assembled and tested in Australia with 50% of the on-board equipment sourced from Australian industry. The project will be an excellent opportunity for national collaboration between hi-tech Australian industries, Universities and Government departments to make Australia’s first and only remote sensing and imaging satellite. In particular the satellite has been specifically designed to allow for the first time full utilization of the environmental spacecraft testing facilities of the AITC on Mt. Stromlo, Canberra.

Significant expenditure (≈$500mill/yr) is made by eight different Government departments including: CSIRO, GA, DIIS, BoM, ADF, DPR, etc. All imagery of Australia and territories is acquired from overseas providers. Our and a vulnerable dependency on “donated” satellite imagery from foreign states. All Australia’s weather imagery is currently donated by Japan and most of our defence imagery is donated by the US military. Additional imagery for natural disaster management or commercial agri-business has been purchased from foreign providers including: (Spot Image, GeoEye, ASTER, IKONOS, DigitalGloge, etc) costing Australia $100’s millions/year.

The need for a sovereign, autonomous and independent Australian Earth observation satellite is of significant strategic importance for our country. A remote sensing Earth observation (EO) satellite optimised for Australian observations and applications, procured and operated within Australia has now become an issue of national urgency. Two US satellites, TERRA and AQUA which use the MODIS Infrared instrument data are now operating beyond their design and serviceable lifetime (>15 years old) on which Australia has become dependent for much of our critical EO data (E.g. “Sentinel Hotspots” Bushfire monitoring service provided by Geosciences Australia) https://sentinel.ga.gov.au/#/

The technical, economic, strategic and political validity of this proposal and the economic return for the Australian tax payer supports the justification and need for an Australian Space Agency (ASA). The ASA shall help manage and lead the definition, requirements, work sharing, procurement and risk management to help kick-start a an Australian Space Industry, to the benefit of all Australians!

Warwick Holmes | **Executive Director of Space Engineering** **20-Aug-2017**
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