

Committee Secretary
Senate Economics Committee
Department of the Senate
PO Box 6100, Parliament House
Canberra ACT 2600
Australia

May 20, 2008

RE: Inquiry into Australia's space science and industry sector

Dear Committee Secretary:

I am pleased to be able to provide this submission to the Senate Standing Committee on Economics in regard to Australia's space science and policy sector.

Before I address the specific items requested by the inquiry, let me first provide a brief description of my background and experience in this area. I am a geoscientist with 27 years of experience in the university, industry and government sectors. Educated in Canada and trained as a postdoctoral fellow at the California Institute of Technology, I immigrated to Australia in 1995 to join the CSIRO.

More recently, I was the 2007 Australian-American Fulbright Professional Business/Industry Scholar, an award that supported a 3 month secondment at NASA's Goddard Space Flight Center in Maryland. During this period, I investigated opportunities for cooperation between CSIRO, NASA and affiliated US institutions on the development and application of autonomous robotic analytical platforms in terrestrial and planetary exploration. I am a Member of the American Institute of Astronautics and Aeronautics, and am familiar with the current US space policy as redefined by the 2004 Vision for Space Exploration and ratified as the 2005 Space Authorization Act. I served as the Australian representative at the Lunar Exploration Analysis Group and Global Exploration Strategy Workshop hosted by NASA in Houston in October 2007. On May 9, 2008 I provided a public lecture to a packed 190-seat theatre at Perth's Scitech Planetarium about NASA's plans to return humans to the Moon by 2020.

I will address the Committee's terms of reference as follows:

(i) Australia's capabilities in space science, industry and education

Space Science

The term "*space science*" encompasses a diverse set of scientific disciplines involved with the exploration, commercialisation and militarisation of space. Although the exploration of space involves cross-disciplinary research in the fields of physics, chemistry, biology, geology, astronomy and engineering, I will limit my comments in this submission to the geosciences (geology, geochemistry and geophysics), my area of expertise.

The exploration of space from a geoscience perspective involves both human spaceflight and robotic planetary probes, which I will cover separately:

Australia and human lunar exploration programs: *Apollo* and *Constellation*

The *Apollo* program to explore the lunar surface from 1969 to 1972 was a crowning achievement in human spaceflight and remains an indelible memory for those born prior to the mid-1960's. Of the 12 astronauts that have set foot on the Moon, only geologist Harrison "Jack" Schmitt on the final Apollo 17 mission was scientifically trained. A total of 382 kg of lunar samples were returned by the Apollo program for scientific studies which have placed significant constraints on the age and evolution of Moon, and the genesis of the Earth-Moon system. Australian geoscientists have participated intensively in the age characterization of *Apollo* samples using world-class ion microprobe technology developed and commercialised in Australia¹.

The *Constellation* program to return humans to the Moon by 2020 and to establish a permanently manned lunar base by 2025 is a key pillar of the recent redirection of US civilian space policy². In what may prove to be the largest international science and engineering initiative of the 21st century, scientists from 14 nations, including Australia, have begun to investigate collaborative opportunities for the establishment of a permanently manned lunar base³. Geoscience considerations are a key component in decisions regarding site selection, payload capacity, payload manifests, habitat and rover design, surface power system design, science instrument and mission prioritization, as well as astronaut selection and training.

Australia is well positioned for involvement in the Constellation space program because we have both an internationally competitive geosciences capability⁴ and an innovative resources sector contributing significantly to the growth of our economy⁵. The Constellation program requires exploration and mining expertise because astronauts will need to prospect for the natural resources required to build

¹ Examples of investigations of lunar samples using the Australian SHRIMP ion microprobe include: Compston, W., Williams, I.S. and Meyer, C. 1984. U-Pb geochronology of zircon from lunar breccia 73217 using a sensitive high mass-resolution ion microprobe. *Journal of Geophysical Research*, **89**, Supplement, B525-B534. & Fletcher, I.R., Rasmussen, B. and Muhling, J.R. 2008. SHRIMPing in the Sea of Tranquility. Proceedings of the ACMM-20 and IUMAS-IV "Through the Looking Glass" Conference, p. 283., Perth Australia. The SHRIMP instrument has been commercialised by Australian Scientific Instrument in Canberra and is exported around the world (<http://www.asi-pl.com/>).

² In 2005 the US Congress passed the NASA Authorization Act instructing NASA to cancel the Space Shuttle and International Space Station Construction Programs by 2010, and to build new rockets and systems capable of returning humans to the Moon by 2020.

³ In May 2007, 14 international science agencies including NASA and CSIRO prepared a paper entitled "The Global Exploration Strategy: The Framework for Coordination", a plan for international cooperation in the next stage of lunar and planetary exploration. Australia will participate in the next international planning session to be held in Montreal in July 2008.

⁴ In a citation survey conducted over the period 1995-2005, Australia was found to have 2 institutions that rank in the top 20 geoscience institutions in the world: ANU (15th) and CSIRO (20th). The highest ranking geoscience institutions were NASA (1st) and NOAA (2nd), both of which have significant space science programs. Other international institutions that featured in the top 20 include the Max Planck Institute (Germany), Russian National Academy of Science, ETH Zurich (Switzerland) and Cambridge University (UK). Source: http://www.in-cites.com/institutions/geo_1995-2005.html

⁵ The Australian minerals industry accounts for approximately 8% of GDP, 45% of merchandise exports, and underpins the employment of 320,000 Australians.

infrastructure and support life on the Moon⁶. Australian scientists and engineers certainly have the technical and intellectual capacity to tackle these challenges, and have a systemic competitive advantage in contributing to a resource-focused lunar exploration program.

Australia and planetary exploration programs using robotic space probes

Exploration of the solar system beyond the Moon is limited to robotic space probes for the foreseeable future due to the significant distances involved⁷. This has led to the development of highly sophisticated robotic space probes with the ability to land, move around and analyse materials on Mars and other planets. The robotic exploration of Mars has produced some sensational discoveries⁸ and the 2009 Mars Science Laboratory (MSL) rover will be the next highly capable robotic analytical platform sent to explore Mars.

Australian scientists are eager to participate in such missions because they represent the cutting edge of planetary exploration and robotics technology⁹. Researchers such as Marion Anderson at Monash University have participated in MSL landing site selection panels, while I have personally spent 3 months embedded within the Atmospheric Experiments Laboratory when the MSL Sample Analysis at Mars (SAM) instrument package¹⁰ was built. There is no doubt that Australian scientists have the capability to engage in international space projects such as Mars exploration,¹¹ however their capacity to conduct collaborative space R&D is limited by current funding structures¹² and the lack of an Australian space policy framework to facilitate collaborative research.

⁶ Cost estimates for transporting 1 kg of water from the Earth to the Moon range from \$150,000 to \$200,000 per kilogram. Developing a method for in-situ extraction of water from lunar materials for utilization at the lunar base is likely to be more cost-effective than transporting it directly from Earth.

⁷ The International Space Station orbits the Earth at an average height of 400 km, while the Moon is 384,000 km from Earth. Mars has a highly elliptical orbit ranging from 58,000,000 to 400,000,000 km from Earth. If we had rockets and systems capable of sending humans to Mars and safely returning them to Earth, the minimum length of time it would take for the round trip mission would be ~15 months.

⁸ Significant scientific discoveries on Mars include: (i) ancient ocean shorelines, (ii) recent glacier movement, (iii) siliceous deposits similar to hot spring deposits on Earth, (iv) Fe-oxide/sulfate minerals similar to those found in the Australian outback, and (v) ~3.5 km of water ice deposits below the polar regions that, if melted, would submerge the surface of the planet to a depth of 11 m.

⁹ For example, the ChemCam masthead instrument conducts remote chemical analysis of rocks and minerals (<http://uk.youtube.com/watch?v=fEZ5dEi4oPo>). CSIRO is discussing a collaborative arrangement with Los Alamos to investigate the application of the ChemCam technology in the Australian exploration and mining sector.

¹⁰ <http://ael.gsfc.nasa.gov/marsSAM.shtml>

¹¹ Space-related projects identified for potential collaboration include: (i) In-situ Alphachron™ helium-dating of Fe-oxides on Mars (GSFC; Caltech); (ii) Application of Mars Science Laboratory ChemCam LIBS Technology in Mineral Exploration and Mining Environments (Los Alamos National Lab); and (iii) Induced Solar-Thermal Sublimation Extraction of Water from Polar Lunar Craters (GSFC, Honeywell, Honeybee Robotics).

¹² DIISR International Science Linkage Program limits support for collaborative Australian-US research to the fields of climate change, clean energy technologies, nanotechnology, advanced computing and biotechnology.

(ii) Arguments for expanded Australian activity in space science & industry

Expanding Australia's innovation base through investment in space science and technology: Industry examples from the United States and Canada

From satellite navigation to weather to communications to search and rescue, space technologies are a fundamentally important part of life for all Australian citizens and industries. The minerals and petroleum industries are highly innovative and adopt technology from a range of R&D institutions and private sector sources¹³. In the business of mineral and petroleum exploration, geoscientists use a wide range of satellite remote sensing instruments¹⁴⁻¹⁵ to develop exploration plays and define drilling targets. These technologies would be better tailored to the needs of Australian businesses if Australian scientists and engineers were involved in the planning, development and construction of these technologies in Australia.

The resources industry of the United States is highly integrated with NASA, with companies such as Oceaneering¹⁶ and Caterpillar¹⁷ participating in the design and construction of new systems for the Constellation Lunar Program. Companies like Caterpillar strategically engage in the space sector via NASA's Innovative Partnerships¹⁸ program because it enables them to access new robotic and sensor components developed for space exploration, and adapt them for integration into future product lines. In addition, numerous small-to-medium scale enterprises work with NASA through its Small Business Innovation Research (SBIR)¹⁹ and Small Business Technology Transfer (STTR) programs to develop new technologies such as robotic mining tools (e.g., Honeybee Robotics²⁰). The development of new robotic technologies is one strategy that Australia's resources industry could adopt to compensate for the growing skills shortage in that sector. Space exploration technologies (such as autonomous analytical robots) that can operate under potentially hazardous submarine or underground environments are of particular interest²¹.

Australia is comparable to Canada in that both countries have similar standards of living, systems of government, vast sovereign frontiers, endowments in natural resources and significant economic dependence on primary industries. The Canadian government's space agency, CSA²², works with domestic high-technology companies such as MDA²³ to provide robotics capabilities as part of Canada's investment in the

¹³ See 12 August 2006 article *Digging Deep for the Future*, New Scientist, v 191, No 2564, p. 54-57.

¹⁴ <http://asterweb.jpl.nasa.gov/>

¹⁵ <http://gs.mdacorporation.com/rsic/geology/geology.asp>

¹⁶ <http://www.oceaneering.com/spacesystems.asp?id=966>

¹⁷ <http://www.cat.com/cda/layout?m=8703&x=7&f=177263#/nasa/stories/the-perfect-partnership/>

¹⁸ <http://www.ip.nasa.gov/>

¹⁹ <http://sbir.gsfc.nasa.gov/SBIR/SBIR.html>

²⁰ <http://www.honeybeerobotics.com/overview.html>

²¹ An example of this technology type is the ChemCam instrument on the Mars Science Laboratory mission. ChemCam is a laser induced breakdown spectroscopy (LIBS) instrument that uses a laser beam to vaporize the surface of a rock from up to 9 m away and analyse its chemical constituents (see <http://uk.youtube.com/watch?v=fEZ5dEi4oPo>).

²² <http://www.space.gc.ca/asc/eng/resources/publications/success13.asp>

²³ MDA Space Systems (<http://sm.mdacorporation.com/index.html>), which received federal contracts to build the robotic "Canadarm" for the space shuttle and International Space Station and the RADARSAT2 satellite, was offered ~\$1.3 billion for its space business in March 2008 (http://www.mdacorporation.com/news/press/Dan_Friedmann_Eng.pdf). The Canadian government

International Space Station. MDA also built the government-backed RADARSAT2 satellite and provides data products to both the government and private sector for mapping and monitoring its Arctic sovereign regions. Other public-private space initiatives in Canada include NORCAT²⁴, a research, development and training center established in Canada's mining heartland to develop the next generation of planetary exploration technologies. By investing in space, the Canadian government has supported its high technology capability sector while at the same time diversifying its industrial innovation base. An Australian space science and engineering capability with public-private partnership programs similar to those managed by NASA and CSA would surely strengthen Australia's innovation base.

Impediments to strengthening and expanding space science and industry in Australia

A number of impediments face Australian scientists and engineers wishing to ply their trade and pursue innovation in space science and technology:

- *Lack of National Space Policy* - Australia has no civilian space strategy or national space policy, making it difficult for its scientists and engineers to comprehensively engage with the international space community²⁵.
- *Lack of Funding* - There are few sources of significant domestic funding to support Australian ideas and innovations with regard to space science and planetary exploration, requiring scientists and engineers to look overseas for opportunities.
- *US ITAR Issues* - Cooperative engagements with US counterparts can be stymied by compliance requirements placed on US citizens and agencies by US government International Traffic in Arms Regulations (ITAR²⁶). The regulatory compliance overheads associated with potential civilian satellite and space technology projects with US partners requires significant high-level coordination at an intergovernmental level, and behooves the formation of a government entity with the resources necessary to manage bilateral and multilateral space science and engineering programs.

Concluding Statements

Space can and should play a role in improving the quality of life of Australian citizens by enhancing our economic competitiveness and advancing our knowledge of the universe. The Australian government should support these pursuits by establishing a formalized civilian space R&D capability, commensurate with the size of our economy²⁷ and aligned with our national strengths and interests. Australia should become an international partner in the Constellation Program, and support the

blocked the sale on national security grounds
(http://www.nasawatch.com/archives/2008/04/ottawa_says_no.html)

²⁴ <http://www.norcat.org/innovation-space.aspx>

²⁵ The UK recently released its 2008 space strategy:

http://www.dius.gov.uk/publications/UK_Civil_Space_Strategy.pdf. Canada, Brazil, India, China, Korea, Japan, Italy, France, Germany, and Russia each have nationally funded space programs.

²⁶ International Traffic in Arms Regulations (ITAR) is a set of United States government regulations that control the export and import of defense-related articles and services, including satellite and space technology.

²⁷ Canada, with an economy and educational standard comparable to Australia, invests ~\$300 million per annum in space R&D.

United States in its plans to return humans to the Moon by 2020, and to establish a lunar outpost by 2025.

Australian participation in space will provide challenges and opportunities that will inspire and educate the nation's next generation of scientists, technologists, engineers and mathematicians. This cadre will create new high technology industries, strengthen and diversify our existing industrial base, and help to build a secure future for Australia.

Sincerely,

Brent McInnes, PhD FSEG