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CSIRO

Our Ref: 08/284

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

15 May 2008

The Review Secretariat,

Re: CSIRO's Submission to the Review into the Current State of Australia's Space Science and Industry Sector

We thank you for the opportunity to provide a submission to the Review into the Current State of Australia's Space Science and Industry Sector. Our attached comments are written with an understanding that CSIRO is actively undertaking research of particular relevance to the Australian Space Industry.

CSIRO, through its various is research initiatives, is committed to delivering sustainable economic, social and environmental solutions to further Australia's essential space technology requirements.

The development of innovative solutions in areas related to Earth Observation, Navigation and Communication, Radioastronomy and Advanced Space Technologies feature strongly in CSIRO's research portfolio. CSIRO is uniquely positioned to address these issues on a national scale and incorporate research from wide ranging disciplines into a single research program. As such, the Organisation sees itself as an integral innovation partner of the Australian Space and Science Industry Sector.

Our specific comments are attached.

Please do not hesitate to contact me or the main submission contact should you require any further information.

Yours sincerely

Alex Zelinsky
Group Executive
CSIRO Information and Communications Sciences and Technologies Group

CSIRO Submission 08/284

Review of the Current Status of Australia's Space Science and Industry Sector

"CSIRO's role in Delivering Space Science for the National Benefit"

May 2008

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Terms of Reference

On 19 March 2008, the Senate referred the following matter to the Senate Standing Committee on Economics for report no later than October 2008 with an interim report by 23 June 2008:

The current state of Australia's space science and industry sector, examining options to strengthen and expand Australia's position in fields that strongly align with space science and industry, giving consideration to any national strategic coordination requirements and taking into account findings and policy options of the National Innovation System Review, with particular reference to:

a. Australia's capabilities in space science, industry and education, including:

    i. existing Australian activity of world-class standard, and

    ii. areas in which there is currently little or no activity but that are within the technical and intellectual capacity of the country;

b. arguments for and against expanded Australian activity in space science and industry, including:

    i. an assessment of the risks to Australia's national interest of Australia's dependence on foreign-owned and operated satellites,

    ii. the potential benefits that could accrue to Australia through further development of our space capability,

    iii. economic, social, environmental, national security and other needs that are not being met or are in danger of not being met by Australia's existing space resources or access to foreign resources,

    iv. impediments to strengthening and expanding space science and industry in Australia, including limiting factors relating to spatial information and global positioning systems, including but not limited to ground infrastructures, intergovernmental arrangements, legislative arrangements and government/industry coordination, and

    v. the goals of any strengthening and expansion of Australia's space capability both in the private sector and across government; and

c. realistic policy options that facilitate effective solutions to cross-sector technological and organisational challenges, opportunity capture and development imperatives that align with national need and in consideration of existing world-class capability.

In addressing these terms of reference the CSIRO submission provides a factual account of CSIRO's space research activity, the national benefit towards this activity is directed and the issues which CSIRO faces in building on past success.

Executive Summary

Since becoming the third nation to launch a satellite in 1967, Australia has become a sophisticated and mature user of space. Although Australia has chosen not to invest heavily in establishing national assets in space, it has used its international reputation to gain access to foreign assets and has consequently matured as a sophisticated user of data provided from space. In addition to exploring space through world-leading astronomy, Australia has developed a world class expertise in use of information and services provided from space-based infrastructure to monitor the changing Australian environment and to navigate and communicate across our continent.

CSIRO is critical to the national effort to benefit from the growing utility of space. As Australia's premier space research agency CSIRO is able to broker partnerships with other research players, sustain dialogues across government and industry to identify future priorities, and work with government and industry to develop space-related capabilities to support their programmatic measurement requirements. CSIRO has substantial expertise in both ***looking from space*** to observe the globe and ***looking into space*** to understand the universe. Key areas of activity include:

- **Earth observation –** based on international relationships that provide access to foreign satellites, CSIRO has developed expertise in using earth observation for diverse applications that include carbon monitoring, disaster management, water accounting, ocean monitoring, carbon accounting, sustainable agriculture and minerals exploration. In many cases CSIRO expertise is relied upon by governments and industry to deliver operational services;

- **Navigation and communication** – CSIRO has helped meet Australia's demand for technologies based on satellite navigation and communication, including use of satellite navigation for remote mining to improve efficiency and safety, and to improve agricultural and linking distributed sensor systems. In addition to continuing this application development, CSIRO will focus on ensuring Australia can use new satellite navigation systems (e.g. the EU Galileo constellation) and improving accuracy through the validation and augmentation of navigations signals;

- **Radioastronomy –** CSIRO supports Australia's world-leading astronomy community through operation of the Australia Telescope National facility. CSIRO will work to sustain this reputation and support the national effort to win the right to host the Square Kilometre Array Telescope, including through delivering the Australian Square Kilometre Array Pathfinder (ASKAP); and

- **Advanced space technologies –** through its relationships with industry and foreign space agencies, CSIRO is creating markets for local industry to export niche technologies in areas that will include sensors, materials, robotics, information and computer technology, and health. CSIRO is developing low cost opportunities to contribute technologies to international missions to the moon, mars and beyond.

CSIRO is confident that it can deliver space research in areas that provide national benefit. However, it recognises that the domestic and international space environments are changing and that it will need to address a range of issues to guarantee a path to impact. These include managing and growing diverse domestic demands for space research, providing skills required to sustain space research and dealing with the rapidly growing data streams from space. International issues will include finding alternate data sources as existing foreign sources may become unavailable in the future; benefiting from the increasing number of space players while accommodating diverse national interests and engaging effectively with large multinational initiatives. In dealing with these issues, CSIRO takes a national approach and will rely on input from stakeholders across Federal and State governments, industry and the wider research sector.

1. Australia's growing reliance on space

1.1. Australia has become a sophisticated and mature user of space-based technologies. Rather than focussing on accumulating its own space assets, Australia has succeeded in leveraging the investments made by international partners to deliver solutions that deliver national benefit. This includes using assets to **look from space** at Australia and our region and **looking into space** to further our understanding of the universe.

1.2. ***Looking from space –*** using space-based platforms (primarily satellites) Australia receives data from space which it uses to deliver a range of critical services for public-good and commercial gains. The areas in which these services are relied upon include:

- **environmental sensing** – using satellites to observe changes in the Australian and global environments to understand climate change, lead global carbon accounting efforts; manage water resources and respond to natural disasters (such as bushfires and floods);
- **sustaining the minerals boom** – using satellite imagery to help identify valuable mineral deposits, particularly important now as Australia has recently increased its Exclusive Economic Zone (EEZ);
- **sustaining agriculture** – managing agriculture in new ways by using space to monitor the productivity of farming lands;
- **navigation** – using satellite navigation systems (e.g. GPS) to find a way around this vast country, support novel technologies (e.g. remote mining to increase the productivity and safety in mines) and provide critical timing signals; and
- **communication** – using satellites to connect remote communities and deliver services such as e-health and tele-education.

1.3. Australia has developed a critical reliance on satellite-derived services to look from space. A recent survey commissioned by Geoscience Australia[1] indicated that 70% of respondents from the public and private sectors have an operational reliance on satellite based earth observations, with 52% regarding this reliance to be critical. Agencies responsible for defence and climate change are pursuing strategies that cannot be delivered without reliable access to earth observation, satellite navigation and communication services and data infrastructure.

1.4. Australia has a growing spatial information industry reliant on satellite data to develop and deliver services from space. A recent (2008) ACIL Tasman study commissioned by the Cooperative Research Centre for Spatial Information estimated Australia's spatial information contributed from $6.4 to $12.6 billion to GDP in 2006-7, with forecasted growth of up to 50% in 2008. This reflects a global trend. A recent OECD report[2] indicates that there has been growth in worldwide revenues from satellite services from $US 28.9 - $US 62.6 billion over 2000-06.

1.5. ***Looking into space*** – in addition to looking back from space-based infrastructure, Australia benefits significantly from exploring the universe. Australia has a world-leading astronomy community and contributes to foreign space exploration activity, which provide benefits that include:

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[1] *National Remote Sensing Data Requirements – Gaps and Opportunities for Australia*, Athena Global, June 2006 – a study commissioned by the Australian Centre for Remote Environmental Sensing, Geoscience Australia.

[2] *The Space Economy at a Glance 2007*, the Organisation for Economic Cooperation and Development (OECD), 2007.

- allowing Australians to participate in answering some of the 'big' remaining questions in science, such as the nature and origin of the universe;
- using Australian space science discoveries to stimulate national interest in science and inspire young Australians to pursue careers in scientific and technical professions;
- showcasing Australian science, and ensuring Australia is regarded as world-leading science nation;
- securing international connections, and thus access to the best infrastructure for observing and exploring space; and
- providing an avenue for Australia to develop and commercialise advanced technologies (e.g. advanced materials, robotics and ICT), especially in niche aerospace and avionics markets.

1.6. CSIRO recognises that recent Australian Government investment in astronomy has largely guaranteed Australia's future as a world-leader in astrophysics and associated disciplines. This includes investment in projects such as the Square Kilometre Array telescope and the Giant Magellan Telescope.

1.7. In addition to providing Australians with access to the world's best facilities, participation in these initiatives will provide a path to market for local industries in areas such as antennae design, precision optics, high-volume signal processing and high speed data connections.

2. CSIRO's role in meeting Australia's growing reliance on space

2.1. Consistent with CSIRO's legislated role in delivering research for the public good[3], and supporting Australian Government policies, CSIRO directs its space research at national benefit, as described above. CSIRO's remit includes all civilian applications of space; with military and strategic uses considered to be the responsibility of the Defence Science and Technology Organisation (DSTO) and other defence agencies.

2.2. A focus of CSIRO's space research is to provide the science that allows industry and government agencies to deliver services (and products) from space-based platforms (e.g. products for minerals mapping). In order to achieve this outcome CSIRO invests substantial effort in maintaining a dialogue with governments and industry to ensure that it can provide outcomes that meet both current and future needs. This user-research provider interface is critical to ensuring the impact of CSIRO's research.

2.3. CSIRO also works to ensure that contact with local and domestic industry provides Australia with a path to market for innovative space technology, particularly in the aerospace and avionics industry. For example, CSIRO has a long-standing research alliance with Boeing, which will extend to include developing solutions relevant to satellite and space exploration technologies. This is one of the few relationships which Boeing has entered into, trusting CSIRO to share strategic insights. Both organisations meet regularly to identify projects of mutual interest in areas that include advanced materials, ICT and sensor design. This relationship has helped to secure Boeing's establishment of an Australian branch of its Phantom Works advanced research and development unit.

2.4. Consistent with the expectation that CSIRO provides national science leadership, CSIRO seeks to be the leader in Australian civilian space research. This implies responsibility for partnering with Australian research agencies in the university and public sectors to bring diverse skills to bear on specific challenges and research questions.

[3] Article 9(1) of the *Commonwealth Science and Industry Research Act 1949* requires that CSIRO has functions that include conducting research to further the interests of the Australian community and contributes the achievement of national objectives or the performance of national and international responsibilities of the Commonwealth.

2.5. In addition, CSIRO takes responsibility for sustaining 'critical mass' in areas of importance to Australia. Whereas expertise in university groups may vary with the interests of academic appointees, CSIRO is in a position to ensure specific skills have longevity provided through targeted recruitment and long-term strategic investment.

2.6. Furthermore, given the diverse science activity, CSIRO is in a unique position to bring to bear multidisciplinary expertise to space research projects and to make technical connections that might otherwise be missed. Conversely, CSIRO also has the capacity to transfer lessons learnt from space activity to other areas of research. For example CSIRO 801.11g wireless patent resulted from activity originally focussed on supporting the ATNF.

3. The critical role of international engagement

3.1. Given that Australia has limited (or no) space assets of its own, engaging with the international space community is critical to ensure CSIRO can perform world-class space research. International cooperation provides access to expertise to infrastructure and data downloaded from satellites. It is estimated that Australia currently downloads roughly 20 terabytes of data from foreign satellites each month. Much of this is provided by international partners largely free of charge.

3.2. Australia's access to foreign satellite data is due to close relationships established and maintained by CSIRO and other government agencies. CSIRO for example has a long-standing relationship with NASA (see example 3.1 below) and other space agencies that include the Japanese Aerospace Exploration Agency (JAXA), the European Space Agency (ESA) and the German Space Agency (DLR). It is also developing strategic relationships with the Chinese National Space Agency (CNSA) and the Indian Space Research Organisation (IRSO), which are emerging as important space leaders.

3.3. CSIRO also engages closely with a number of multinational initiatives. These provide mechanisms by which CSIRO and Australia can participate in the use of space to solve global challenges such as climate change. For example, CSIRO and other agencies are valued participants in the development of the Global Earth Observation System of Systems (GEOSS), a 70-plus country initiative pooling space infrastructure and expertise to develop a system capable of monitoring the global environment.

3.4. Multinational forums, such as the Committee on Earth Observing Satellites (CEOS), the International Astronautical Federation (IAF) and the Asia Pacific Regional Space Agencies Forum (APRSAF) also provide CSIRO and Australia with a voice in international policy-making processes. Of particular interest is dialogue on international data standards, to ensure the data Australia receives form diverse sources can be used seamlessly, with minimal effort to ensure consistency.

Example 3.1 – CSIRO's relationship with NASA

CSIRO has a long-standing relationship with NASA, which rates as CSIRO's premier international alliance in terms of the funds contributed to science and technology projects. CSIRO has responsibility for managing the Canberra Deep Space Communication Centre (CDSCC), one of three facilities that NASA relies on to communicate with its probes exploring the universe. CSIRO manages a contract with Raytheon Australia to operate the CDSCC which, in turn, provides employment for more than 100 Australians. NASA has recently commented that they consider CSIRO's management of CDSCC as setting the standard for operation of its other communication facilities.

4. CSIRO's current space activity

Looking from space

4.1. **Earth observation** – Observation from satellites provide a cost effective and efficient means for observing and monitoring the Australian continent and our region. Over the past 20 years advances in sensors mounted on satellites and the interpretation of data has meant that earth observations has gone beyond just providing coarse pictures. Sensors can provide an array of information including, for example, the species represented in a forest, soil types, water quality and health of coral reefs. This information has become more detailed with spatial resolution improving from tens of metres to several centimetres.

4.2. CSIRO now has a 20+ year time series of the land surface, at very detailed resolution (< 1 km) across the continent. These 'environmental time series' show trends and shifts in land cover (or land condition) in response to drivers such as climate variability and climate change (rainfall, temperature), land use change etc. An example is the vegetation anomaly time series showing a "browning" of the Australian continent. Temporal resolution and continuity as well as spatial coverage is a key element of CSIRO's earth observation activity.

4.3. Through its international links that provide access to critical (research) data, CSIRO has developed international renown as a sophisticated user of earth observation resources. Areas in which CSIRO has made national and international impact include:

- **Carbon accounting** – CSIRO has a 20-plus year history in developing methodologies to use satellite data to monitor vegetation changes that affect the uptake of greenhouse gases from the atmosphere. This methodology is a critical element of the National Carbon Accounting System, NCAS (see example 4.3 below).

- **Climate monitoring and weather prediction** – CSIRO has diverse expertise in earth observation to monitor climate changes, including temperature changes, sea-level rise and ocean currents. CSIRO has entered into a research alliance with the Bureau of Meteorology to build the next generation earth system and climate model (ACCESS), which will require a step-change in the use of satellite data. ACCESS will provide Numerical Weather Prediction (NWP) seasonal forecasting and the climate modelling capability Australia requires to be able to respond and adapt to climate.

- **Remote sensing of the atmosphere**: especially aerosols (smoke, dust), clouds (CALIPSO) and greenhouse gas concentrations. CSIRO provides ground-based observations for validation and calibration and has had impact in using earth observations to quantify trends and variability in:

    - soil water availability, especially land surface evaporation – both at very detailed spatial resolution for target regions; and long time series at regional/continental scales; and

    - the net exchange of carbon at regional scales, across the continent is new work in progress.

- **Water resource management** – combined with ground-based measurements earth observation data provides a powerful tool for understanding water availability. With government partners CSIRO will deliver the Water Resource Observation Network (WRON) – a national facility for monitoring and forecasting Australia's scarce water resources.

- ***Ocean Monitoring* –** CSIRO is using satellite data sources to monitor oceans and coastlines. Achievements using satellites to monitor sea surface temperature and sea height which are important climate change monitors and inputs into ocean forecasting

models[4]. CSIRO has also worked with the Great Barrier Reef Marine Park Authority and other government agencies to develop remote sensing of coral reef health and changes in estuarial ecosystems.

- **Sustainable forestry –** CSIRO researchers are developing tools that use satellite instruments, including lasers and optical spectroscopy, to monitor the structure and health of forests. In addition to improving economic returns, these tools improve sustainability by ensuring that only useable timber is harvested.

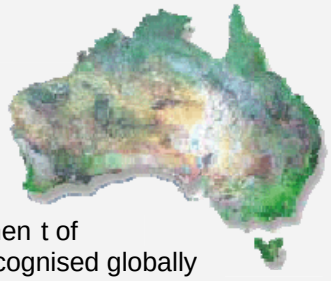
- **Minerals exploration –** in collaboration with mining companies and geological survey agencies, CSIRO is using satellite date to create mineral maps of Australia. Using advances that improve discrimination between mineral types, these maps provide a new resource for discovering new minerals deposits, thus helping to sustain Australia's minerals boom.

- **Sustainable agriculture –** through projects such as 'Pastures from Space' CSIRO researchers are using satellite data to improve agricultural productivity. Satellite imagery is being used to monitor grass available in pastures so that, for example, diary farmers can manage the grazing patterns of their herd to improve milk yields during drought.

4.4. CSIRO's has particular expertise in translating earth observation research to operational solutions, and is increasingly relied upon by governments and industry to do so. Through its participation in initiatives such as the WRON, the Australian led development of the Global Carbon Monitoring System (GCMS) and Sentinel Hotspots for bushfire monitoring, CSIRO is contributing to using earth observation for the national benefit and deliver on Australian Government policy.

4.5. Over the next 3 – 5 years CSIRO will focus on ensuring that Australia has access to and the expertise to use the next generation on-board satellite sensors. This includes hyperspectral imaging which will provide a step-change in both the quantity and detail of data available. For example, in minerals mapping hyperspectral data will have the potential to dramatically increase the accuracy at which mineral composition and abundance can be detected, while for vegetation mapping, hyperspectral technologies will be able to distinguish between species and track tree health. Other technologies CSIRO will seek to apply for Australian circumstances include Synthetic Aperture Radar, to provide information in regions of high cloud cover, and the next generation of thermal imaging (e.g. to improve bushfire monitoring).

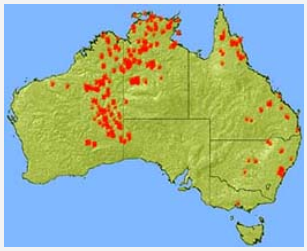
Example 4.2 – Australian leading global carbon monitoring



Over the past 15 or more years, CSIRO has worked with Commonwealth Departments, including the DCC, its predecessor and the former Australian Greenhouse Office to develop national wall-to-wall land cover maps. Using data provided from the US series of LandSat satellites and combined with models that estimate greenhouse gas uptake by vegetation, these maps are a critical elemen t of Australia's National Carbon Accounting System (NCAS). NCAS is recognised globally as the only continental-scale carbon accounting scheme and has been chosen by an international consortia, which includes the Clinton and Rockfeller foundations, as the basis of a Global Carbon Monitoring Systems. The Australian Government has recently announced its intention to support this initiative.

[4] In collaboration with the BoM and the Royal Australian Navy (RAN), CSIRO developed BlueLink, a model which predicts currents in Australia's territorial waters. Important input to this model includes satellite based measurements of sea surface temperature and wave height. Apart from being relied upon by the RAN, BlueLink was recently used to identify the zone searched during the recent successful mission to find the HMAS Sydney.

Example 4.3 – Sentinel Hotspots



CSIRO worked with partners such as Geoscience Australia and DIGO to develop Sentinel Hotspots - a web-based system for detecting and monitoring bushfires across Australia. Using thermal imaging data from US satellites, Sentinel Hotspots provides information to the public and emergency management authorities. Fire maps are updated up to three times a day, significantly reducing the time taken to detect new fires and facilitating early action to protect property and life. The Sentinel Hotspots approach has been adopted by APRSAF to provide a web-based disaster monitoring system across the Asia-Pacific region.

4.6. ***Satellite Navigation*** – Australia is following the global trend and is increasingly taking- up Global Navigation Satellite Systems (GNSS), which make use of satellite constellations to provide terrestrial locations based on map coordinates. For example as evidenced by the increasing market for in-car and other personal navigation systems.

4.7. GNSS systems also provide critical timing signals. For example, the Australian Stock Exchange relies on satellite systems to time-stamp share transactions and the banking sector uses GNSS to record the time of ATM transactions. Such is the reliance, that the loss of GNSS access is regarded as a major risk in the financial sector.

4.8. CSIRO has a long-standing expertise in using GNSS to develop and support novel applications. For example, CSIRO has a focus on GNSS-based remote mining technologies which allow mining equipment to operate autonomously. Such technology has the potential to not only increase the productivity of Australian mines, but to also increase safety by removing humans from hazardous work areas. A second area of GNSS focus is the development of precision agriculture to improve production through automated sowing and harvesting and/or livestock management.

4.9. Although Australia relies on space-based satellite infrastructure provided by other countries (e.g. the US Global Position System, GPS), CSIRO believes there is a need to invest in developing domestic expertise in understanding the extent to which Australia's unique circumstances (e.g. geographical vastness and uneven population distribution) limit reliability. In particular, CSIRO intends to develop expertise in understanding new systems being deployed (e.g. the Galileo constellation to be deployed by the European Union) and technologies to improve accuracy and coverage through ground-based augmentation and validation.

Example 4.5 – Virtual fencing

CSIRO's virtual fencing technology is a novel use of satellite navigation for increasing the efficiency of cattle farming. Bracelets worn by cattle include GPS receivers that indicate the position of an animal. If a cow strays across a boundary defined by GPS coordinates it receives a stimulus that encourages it to return to its virtual paddock. Apart from reducing fencing costs, this technology potentially provides a means for farmers to remotely move cattle. Combined with CSIRO 'Pastures from Space' technology, which uses satellites to monitor feed available for grazing, this provides a powerful tool for ensuring grazing resources are used to maximise productions.

4.10. ***Satellite Communication*** – satellite communication services have become ubiquitous and, for civilian purposes, a commercial service easily accessed by governments, organisations and individuals. CSIRO regards satellite communication as an essential enabling technology for integrating both space-based and terrestrial applications. For example, satellite communication allows space-based monitoring to be combined with ground measurements to provide information across large areas and varying spatial scales.

4.11. CSIRO is pursuing the development of transformational sensor technology for acquiring data. For example, environmental applications include the use of sensor networks to make measurements (e.g. water availability) over large areas. Satellite communication is an essential component to allow communication of data back to a central processing node or between sensors that make collective decisions about responding to changing circumstances.

4.12. In addition to using satellite navigation to facilitate other novel applications, CSIRO's radioastronomy and ICT activities include the development of niche communication technologies. These include unique signal processing capability, antennae design and receiving and processing large datasets.

Looking into space

4.13. ***Radioastronomy*** – Astronomy is amongst Australia's highest performing areas of research, as measured by international citations. CSIRO's radio astronomy research has global impact and helps maintain the world-class standard of CSIRO's scientists and Australian science.

CSIRO operates the world-class Australian Telescope National Facility (the ATNF) for the Australian and international astronomical community, supported by leading-edge technical innovation and high-quality astrophysical research. The ATNF facility includes the highest impact radio telescope in the world (The Parkes 'Dish') as measured by citations per paper, and the second most productive as measured by publications.

The ATNF enjoys high-international recognition, with 40% of its users coming from foreign countries. This reputation has been a key factor in Australia being selected as one of two countries to be considered to host the Square Kilometre Array (SKA) telescope – an 18 country, €1.0 billion project to build the world's most sensitive telescope capable of detecting the origin of the universe.

CSIRO is committed to supporting the Australian Government's aim to host SKA which, if successful, has been described as the science equivalent of winning the right to host the Olympics. CSIRO is committed to delivering the Australian Square Kilometre Pathfinder, a 1/100th demonstrator of the full-scale SKA. CSIRO has received more than $100 million in Australian Government funding to build ASKAP by 2010. This will prove Australia's credentials to host the full-scale SKA and provide a world-stage to demonstrate Australian innovation.

4.14. ***Space exploration technologies*** – CSIRO has diverse intellectual property (IP) of interest to nations with plans for human and robotic missions to the moon, mars and beyond. These include sensor technologies for monitoring the condition of space vehicles; advanced materials for lightweight and durable spacecraft; robotics for remote exploration and human health in space.

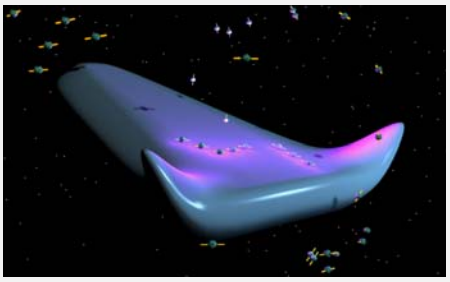
CSIRO has secured a path for Australia to contribute its niche expertise to the international exploration effort through its participation in the Global Exploration Strategy (GES)[5].

[5] The Global Exploration Strategy is a 14 space agency initiative that has developed a framework for international collaboration on the development of technologies required for prolonged robotic and human missions in space. A description of this agreed framework is available at: http://www.csiro.au/resources/pfw4.html.

CSIRO's participation has provided it with links to the main space agencies (e.g. NASA, JAXA, ESA and CNSA) and has secured awareness of Australia's potential contributions.

CSIRO will work with the GES partners and international companies (e.g. Boeing) to develop and prove niche space technologies. Through partnerships with local partners, CSIRO aims to provide new markets for the local aerospace and avionics industry.

Example 4.1 – Sensor technology for self-healing space vehicles



On long journeys to the moon, mars and beyond, spacecraft will need to be repaired if damaged. CSIRO has worked with NASA to develop prototype systems that uses networks of sensors to detect and assess surface damage through, for example, impacts with space debris. These sensors can provide information about the nature and area of damage. With a capacity to act autonomously, sensors can decide how to respond, either by reporting the damage to a centralised control system or taking localised action, such as isolating the effected area. Combined with the development of new materials, NASA values this technology as a step towards self-healing vehicles.

5. Issues affecting CSIRO's future space research activities

5.1. CSIRO considers itself well placed to continue playing a lead role in delivering research required to meet Australia's growing use of space. However, it recognises that changes in the domestic and global landscape will need to be addressed to maximise the impact of this research and ensure it is directed at national priorities. Issues that will influence future CSIRO space activity include the growing demand for space, pressures on skills, demands on data infrastructure and changes in the international environment that will affect access to critical data.

Domestic issues

5.2. ***Increasing government reliance on space*** – the Australian Government has made recent investments in initiatives that depend on access to space services, including the recent commitment to establishing a global carbon monitoring system that will rely on large-scale earth observation. As this investment increases CSIRO will ensure that it understands government priorities for using space and is able to provide appropriate scientific support.

5.3. ***Managing a greater number of stakeholders*** – as reliance on space increases the number of government and industry stakeholders will increase substantially. To ensure CSIRO targets the most valuable space science and can effectively transfer outcomes to operational users, CSIRO will be required to manage an increasing number of stakeholders. Success is likely to rely on CSIRO being able to establish mechanisms for collective engagement that capture diverse interests and identifies priorities that satisfy any competitive interests.

5.4. ***Meeting the demand for space skills*** – as in many areas of science and engineering, there is a critical shortage of space skills. In areas such as earth observation CSIRO's existing human resources are almost entirely committed to supporting existing government initiatives in water monitoring, carbon accounting and climate modeling. To meet future skill needs, CSIRO will continue to invest in human capital. In the short- to mid-term this is likely to include sourcing talent offshore. In the longer term solutions will be based on training the next generation of Australian space scientists in collaboration with universities.

5.5. ***Data infrastructure*** – there is an impending data avalanche as more nations make increasing investment in satellites, and instruments deployed make increasingly detailed measurements. This will place increasing pressure on infrastructure for downloading, processing and archiving space data. CSIRO's related research in areas such as terabyte science and smart sensor systems will take into account these issues, with a view to avoiding a 'space data crunch'.

Global issues

5.6. ***Ageing space assets*** – CSIRO relies on foreign satellites (e.g. from the US, the EU and Japan) for critical data required for earth observation and other space applications. However, many of the older data sources upon which substantial intellectual property is built, are ageing and are becoming unreliable. LandSat data, relied upon to support the National Carbon Accounting System, is threatened by the expected failure of LandSat5 and ongoing problems with LandSat7. It is understood that launch of a replacement satellite, LandSat8, is not due until 2010.

To address ageing of long-relied upon assets, CSRIO is identifying alternative data sources compatible with existing archives and capable of continuing the historical record (e.g. for detecting environmental change). A key consideration for CSIRO is ensuring that any new data sources are compatible with existing data tools to minimise the need for reinvestment in data processing and analysis.

5.7. ***Increasingly complex international landscape*** - The recent rise of new space powers, such as India and China, and the entrance of new players (e.g. Thailand, Malaysia and Indonesia) will offset the loss of US and European assets, and provide CSIRO with more options to replace critical data sources. However, the dual-use of space assets (i.e. for military and peaceful purposes) and the diverse strategic interests of national players will mean that the international space landscape will become more difficult to navigate. CSIRO recognizes that it will need to make a greater investment in managing international relationships and engage partners across with government to take into account broader geopolitical issues.

5.8. ***Increasing reliance on space-assets for solving global challenges –*** the international community is increasingly relying on space assets to solve global challenges. Earth observation is being relied on to monitor climate change and to provide the reliable measurement system needed to underpin global carbon trading. During a recent keynote address to a multinational initiative on earth observation meeting, the Chairman of the Intergovernmental Panel on Climate Change and Nobel Laureate, Dr. Rajendra K. Pachauri, commented;

> *"…I want to emphasise the importance of global [satellite] observations, because the returns are so large that the investment becomes insignificant…"*

Since global challenges such as climate change will only be met through a concerted international effort, they will lead to greater coordination of space-based infrastructure, where such assets are part of the solution. Supported by the Australian Government, CSIRO will continue to engage in global space initiatives (such as GEOSS) and is able to influence directions through being seen as a valued contributor of science.

5.9. CSIRO is confident that it can rise to the challenges described above to ensure it continues delivering world-class space science research. In addressing the various issues CSIRO will seek to include the advice of government, industry and university stakeholders to bring divers expertise and avenues of influence to bear. Furthermore, such a collaborative approach will help ensure that solutions sought not only meet CSIRO's needs, but the also those of Australia more broadly.