The Senate

Standing Committee on Economics

Australia's space science and industry sector

Interim report

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Senate Standing Committee on Economics

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Chapter 1

Introduction

1.1 Australia was an early leader in some aspects of space science and industry. It was the fourth nation (after the USSR, the US and France) to successfully build and launch a satellite from its own territory, when WRESAT was launched from Woomera in 1967.[1] The 'big dish' at Parkes had an important role in the Apollo missions.

1.2 In some areas it remains a leader. At the time of writing, the Phoenix Mars Lander is transmitting data back to Earth using the Deep Space Tracking Station at Tidbinbilla. Australia has some world class space scientists. It is a leading user of remote sensing satellite data.

1.3 But in some other aspects it now lags behind. There are no Australian-owned satellites. Since 1996, there has been no co-ordinating agency for Australia's involvement in space, and it is often pointed out that Australia is one of the few (large or medium-sized) rich countries without one.

1.4 Does this matter? To investigate this issue, on 19 March 2008, the Senate referred the topic to the Senate Standing Committee on Economics for report no later than October 2008. The reference specified that an interim report be prepared by 23 June 2008.

1.5 This interim report seeks to summarise what the Committee sees as the key questions that need to be answered to assess in what ways, if any, the government needs to act to optimise Australia's capabilities in space science, industry and education; and their contribution to the nation. The Committee does not see 'contribution' in purely economic terms. Space science has the capacity to inspire, to excite and to create a sense of wonder, and these aspects are also valued.

1.6 As well as asking the key questions, this interim report summarises views on these questions gleaned from the over eighty submissions received so far (Appendix 1), and from witnesses at public hearings held in Canberra and Adelaide (Appendix 2). Having focused on some key questions, further and supplementary submissions are welcome to help the Committee answer these questions.

1.7 The Committee's conclusions and recommendations will be contained in its final report later this year, after it conducts further public hearings and the Green Paper from the National Innovation System Review is released.

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1 Source: Australian Department of Defence.

1.8 The Committee thanks those who have contributed to the inquiry so far and welcomes further involvement.

Terms of reference

1.9 The Committee was asked to investigate:

> 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.

Chapter 2

The Questions

Should Australia have a whole-of-government 'space policy'?

2.1 In a sense this is an overarching question that should be the first asked. But in another sense it follows on from how the following questions are answered. If the response to the other questions is that Australia needs a profound change in its attitude to space science and industry, the release of a new government space policy might give them a focus and be a rallying point.

2.2 At present the Department of Innovation, Industry, Science and Research (DIISR) describes the current framework for space policy as one which:

> articulates a decentralised approach in which agencies of the Commonwealth have their own operational responsibilities in the space arena. The Bureau of Meteorology has responsibility for securing access to weather data. Geoscience Australia has responsibility for maintaining a range of ground stations that can downlink Landsat and a range of other information and distributing that to appropriate agencies and to the private sector. Defence obviously has its defence related responsibilities, including national security remote sensing and defence communications. [1]

2.3 DIISR also chairs the Australian Government Space Forum, which brings together representatives from various government departments and agencies to exchange information about twice a year.[2]

2.4 Many witnesses, however, feel this decentralised approach falls short of what is required as a 'space policy'. The ANU's Professor Butcher advocates a 'space plan' which would be:

> …a national sector plan…not a government plan or a plan from CSIRO but a plan which all stakeholders—industry, government and universities—would consider to be their own.[3]

2.5 The key stakeholders in space science include the CSIRO, other government agencies such as the Bureau of Meteorology and Geoscience Australia, at least fifteen Australian universities, the Cooperative Research Centre for Spatial Information and

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1 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 3. The decentralised approach is set out in the November 2006 document *Australian Government Space Engagement: Policy Framework and Overview*, attached to *Submission 7*.

2 The Forum's terms of reference are included in an attachment to *Submission 7*.

3 Professor Harvey Butcher, *Proof Committee Hansard*, 16 May 2008, p. 52.

the large number of private companies who use satellites for communications or remote sensing data, or could contribute components, software or other services to an expanded space sector.

2.6 The Australian Academy of Science has produced its own draft 'decadal' plan, which will be revised in the light of the rigorous discussion it is currently receiving.[4]

2.7 The South Australian government called for a white paper, suggesting:

> In developing the white paper, the Australian Government should rely heavily on the 2005 Chapman Report, *Space: a Priority for Australia*, which to date has been inadequately considered.[5]

2.8 The CEO from the CRC for Spatial Information opined:

> We need a policy that properly addresses the long-term requirements of Australia in this area. It needs to set a vision for Australia and it needs to have the right policy settings. It is vital that that be developed at the same time as the right suite of market drivers to ensure that we, as a nation, can have a prospering private sector in this area.[6]

What should Australia's role be in pure space science?

2.9 The choices are essentially to choose between three approaches:

- be a 'free rider', drawing on the insights achieved by others but not contributing ourselves;
- contribute our 'fair share', perhaps commensurate with Australia's 1 per cent share of world GDP[7];
- be a 'leader', seeking to drive forward projects and expand the frontiers of knowledge.

2.10 The choices could be, and probably should be, different for different areas of space science. It makes sense for Australia to specialise in areas where it has a comparative advantage. While the emphasis in this section is on 'space for space's sake', it is also reasonable to ask which areas of pure science might conceivably best assist aspects of applied science relevant to Australia.

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4 The plan is discussed by the Australian Academy of Science (*Submission 38*). It is commended by the Universities of Sydney (*Submission 18*), Tasmania (*Submission 20*), La Trobe (*Submission 24*) and Newcastle *(Submission 53)*, as well as the Geological Society (*Submission 30*) among others. The plan is reproduced in *Submission 41*.

5 South Australian Government, *Submission 79*, p. 12.

6 Dr Woodgate, *Draft Committee Hansard*, 23 May 2008, p. 39.

7 Australia's share of world 'above-subsistence' GDP and wealth are somewhat higher.

Does the Australian Research Council provide adequate funding for pure space science?

2.11 Some evidence presented to the Committee was quite critical of the ARC's attitude to space science:

> We all apply to ARC, which is very difficult to work with from a user's point of view. Even if you are successful in ARC, you very rarely get funding that is of an international level. That means that it is very difficult for all of us to compete in an international business like space science or my own business of astrophysics.[8]

> When a discipline falls below a certain 'critical mass' in Australia, it is regarded as a 'backwater' and finds it very difficult to convince Australian Research Council assessor panels (of necessarily non-experts) that the work is worth doing, however well it is regarded internationally.[9]

> [Due to the] focus on building links between research and industry…very few research grant applications that focus on fundamental research, such as planetary science have been funded by the ARC.[10]

2.12 The Committee hopes to call the ARC to a future hearing to discuss these criticisms.

Is Australian space research too diffuse?

2.13 Particularly given the shortage of funding, it may be better to concentrate on a few elite schools which could then afford better equipment and have more, formal or serendipitous, exchange of views and collaborations. For example, at present there are fifteen Australian universities teaching astronomy.

2.14 Asked about the merits of concentrating expertise in fewer centres of excellence, some academics were generally supportive:

> when we had the cooperative research centre for satellite systems, we had a kind of a concentration like that, and it was extremely beneficial.[11]

> I think there is certainly benefit in having some nodes…one of the main things that the National Committee for Space Science actually put forward was actually a National Institute for Space Science.[12]

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8 Professor Clay, *Draft Committee Hansard*, 23 May 2008, p. 46.

9 Professor Paul Cally, *Submission 1*, p. 5.

10 School of Geosciences, Monash University, *Submission 19*, p. 1.

11 Professor Grant, Institute for Telecommunications Research, *Draft Committee Hansard*, 23 May 2008, p. 9.

12 Professor Dyson, *Draft Committee Hansard*, 23 May 2008, p. 21.

2.15 Of course, there may be less agreement if the discussion reached the specific stage of deciding which university schools to close. This is particularly likely if offering space science attracts better students to the university.

How do space and Antarctic research link together?

2.16 There are some synergies between space research and Antarctic research. The Australian Antarctic Division of the Department of Environment, Water, Heritage and the Arts commented how Antarctic facilities could assist in space science:

> For six decades Australia has conducted a program of scientific research in east Antarctica and much of it has been in the fields of physics of the atmosphere above the stratosphere, and beyond it into space.[13]

2.17 They also referred to how space science can assist work in Antarctica:

> …knowledge about the ice sheet overlying Antarctica, and the continent's fringing sea ice is sketchy…undertaking the research needed into these aspects of the globe will require…increasingly, remote sensing from space.[14]

2.18 They drew attention to how satellite information could be improved for this purpose:

> Many existing satellites are not designed to view the South Pole and are only observing small swathes of the continent as they pass on their way to the northern hemisphere. Australia needs to take leadership in the various international forums where future satellite deployments are developed to ensure technical specifications enable coverage of Australia's Antarctic Territory.[15]

In what areas of applied space science and industry does Australia have a comparative advantage?

2.19 Australia has some unusual endowments, such as an expanse of southern hemisphere land to capture signals from space, and a well educated workforce that may give some advantages in applied space science, particularly signals processing. Among other strengths, Australian astronaut Dr Andy Thomas nominated the following areas where Australia could excel:

> I believe Australia is uniquely positioned to engage in a whole range of activities from spacecraft fabrication, even through to the launching of space vehicles, just because of its unique technical capabilities, education system and geography.[16]

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13 *Submission 40*, p. 1.

14 *Submission 40*, p. 2.

15 *Submission 40*, p. 2.

16 Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, p. 11.

2.20 The then government's assessment in 2006 was that 'Australia has competitive advantages in the ground-segment aspects of space infrastructure'.[17]

Should Australia be a launch site?

2.21 The Committee has heard conflicting views about the current state of the Woomera rocket range. The DIISR said 'there would be considerable investment required to resurrect any role that it might aspire to'.[18] On the other hand, the South Australian government describe Woomera as 'an active space launch site'.[19] Dr Andy Thomas described Woomera as 'an ideal test range':

> The Woomera test range is a facility that is unique in the world. It is unfortunately literally gathering dust, but it is a test range that many countries would love to have. It is a capability that Australia can really build on uniquely to its own interests.[20]

2.22 A possible reconciliation of these views is that Woomera is currently not suitable for large scale launching of orbital payloads but suitable for smaller suborbital launches. The Australian Space Research Institute has been a regular user of the Woomera rocket range since 1993 giving students the opportunity for involvement in over 100 small-scale launches using 'sounding rockets'.[21]

2.23 One witness suggested Australia had now missed its opportunity as a launch site:

> I think things like launch capability are now closed off to us; it is just too competitive for us to compete.[22]

Should Australia be researching/designing propulsion systems?

2.24 Australian engineers have had some success in this area. The DIISR commented:

> Professor Allan Paul, with his hypersonic scramjet research, has been successful in winning quite a large contract from the Americans to further develop that work.[23]

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17 *Australian Government Space Engagement: Policy Framework and Overview*, attached to *Submission 7*.

18 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 3. An even more sceptical view was expressed by Hendrik Gout, 'Lost in Space – the Woomera rocket fizzer', *Independent Weekly*, 13 January 2007.

19 South Australian Government, *Submission 79*, p. 3.

20 Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, pp 17–8.

21 Mr Gary Luckman, *Proof Committee Hansard*, 16 May 2008, pp 33–4. The rockets were donated to the Institute by the Australian Government on the condition that ASRI use them to promote space science and engineering. The rockets were military rockets that had ended their useful life, and were modified to launch payloads.

22 Mr Matt Miller, SMS, *Draft Committee Hansard*, 23 May 2008, p. 28.

2.25 Scramjets are supersonic combustion engines with potential aerospace applications. They do not have to carry most of their propellent as they can draw oxygen from the atmosphere. Australian research is being conducted under the Australian Hypersonics Initiative, bringing together the University of Queensland, ANU, Australian Defence Forces Academy, the Defence Science and Technology Organisation and the state governments of Queensland and South Australia. Hypersonics refers to speeds about five times the speed of sound (ie mach 5).[24]

2.26 An ANU team has recently developed two revolutionary designs for rocket engines; an ion engine and a plasma engine.[25] The work has attracted interest from the European Space Agency.

2.27 The Committee hopes to hear more about this work before it concludes the inquiry.

Should Australia be a base for space tourism?

2.28 There has been increasing discussion about the prospects for space tourism. Some market research suggests space tourism revenues could be around $700 million in 2020.[26] The Australian company, Grollo Aerospace, has expressed an interest in offering space tourism experiences.[27]

2.29 The scramjet technology potentially could be employed for tourism. The South Australian Government suggested 'the Woomera site remains a favourite location for…the establishment of a space base for space tourism.'[28]

2.30 Dr Andy Thomas thought Australia was well-placed, but it would not happen soon:

> Australia provides an ideal forum for many of these high altitude parabolic flights, which is what most of them are... However, the market is still small, so I think it will be quite some time before it would be buoyant enough to have operations in Australia as well as the other planned operations, for example, in New Mexico that Richard Branson is supporting, and so on. Ultimately, that could happen.[29]

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23 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 4.

24 *Submissions 36, 39 and 49* give more detail.

25 ANU, *Submission 13*, p. 3.

26 Cited by Australian Hypersonics Network, *Submission 36*.

27 Grollo Aerospace, *Submission 54*, p. 1.

28 South Australian Government, *Submission 79*, p. 9.

29 Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, p. 17.

Should Australia be building satellites, rockets and similar equipment, or designing software?

2.31 Australian manufacturing has moved away from trying to compete with imports of mass consumer products to specialising in high-tech niches.[30]

2.32 The Director of the Mount Stromlo observatory opined that:

> Australia has the capability to build space instrumentation. There are a number of people who have the background, the experience and the capability, but it is clear that the capacity to do so is very fragmented and quite limited.[31]

Are remote parts of Australia analogues for Mars?

2.33 After a return to the moon, the next step in mankind's journey is almost certainly Mars. Placing a base there would require developing expertise in operating in, and physiologically coping with an isolated life in, a remote rocky desert landscape. The Geological Society has suggested that the Australian outback might be the nearest terrestrial analogue, with features such as salt lakes and inverted river channels.[32] Another possibility in terms of practice in dealing with isolated and cold conditions is the Australian Antarctic Territory.[33]

Would greater involvement in space science be inspirational for students and others?

2.34 Space seems to capture the public imagination in ways that most other science struggles to do. Almost everybody over fifty can remember what they were doing when Neil Armstrong took that one small step onto the lunar surface. Many younger people have used the internet to share in watching the pictures beamed from Mars as probes explore the Martian terrain.

2.35 Space seems to particularly captivate children:

> Any of us who have had children knows that space, astronomy and dinosaurs are the things that seem to grab all of the kids' attention.[34]
>
> …students at schools are very excited about space.[35]

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30 See House of Representatives Standing Committee on Economics, Finance and Public Administration, *Australian Manufacturing: Today and Tomorrow*, July 2007.

31 Professor Harvey Butcher, ANU, *Proof Committee Hansard*, 16 May 2008, p. 51.

32 Geological Society, *Submission 30*, pp 3–4. See also Mars Society, *Submission 22*, p. 3.

33 Mr Desmond Lugg, *Submission 9*, p. 1.

34 Mr Roger Franzen, Earthspace, *Proof Committee Hansard*, 16 May 2008, p. 43. At least for some, these passions endure. 'When asked at enrolment, first year students enrolling in geosciences state that their thee main interest areas are "volcanoes", "dinosaurs" and "space" '; School of Geosciences, Monash University, *Submission 19*, p. 2.

> …dinosaurs and space bring children into science and engineering...[36]

2.36 The importance of getting children interested early was emphasised by some witnesses:

> Anything that turns the kids on and gets them started down that path is desirable. My understanding of the education theory is the earlier you do it, the better, and the more chance you have of retention. We would love to see anything that gets them excited happen.[37]

2.37 Space also fascinates many graduates:

> The very best students around the world do look at astronomy as something that they would like to do. They also look at things like theology, philosophy and so on—the big questions that engage mankind. Astronomy does have some big questions, and it does attract some very bright people.[38]

2.38 The Committee has heard stories of the inspirational role that space played in driving people to scientific careers:

> Seeing the achievements of the space programme had a profound influence upon me and was one of the reasons why I became a professional engineer.[39]

2.39 A group of university students warned that:

> [While] there is an enormous amount of enthusiasm in the general public and among students studying in science and engineering towards almost anything to do with science; student enthusiasm is dampened because of a lack of a space industry in Australia to give a clear future for people skilled in space engineering and related fields.[40]

2.40 Australian astronaut Dr Andy Thomas put his view:

> There is no doubt in my mind that a robust national space project is unmatched in its ability to inspire the next generation and motivate youth to seek higher education…after my first flight into space, enrolments in engineering where I studied skyrocketed,[41]

2.41 A contrary view about the inspirational role of space science was put by Dr Michael Green from DIISR:

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35 Professor Dyson, *Draft Committee Hansard*, 23 May 2008, p. 23.

36 National Committee for Space Science, *Submission 41*, p. 2.

37 Dr Pigram, Geoscience Australia, *Proof Committee Hansard*, 16 May 2008, p. 31.

38 Professor Butcher, ANU, *Proof Committee Hansard*, 16 May 2008, p. 56.

39 Dr Gregory Seil, *Submission 2*, p. 1.

40 Bluesat University of New South Wales Student Satellite Project, *Submission 51*, p. 1.

41 Dr Andy Thomas, *Proof Committee Hansard*, 23 May 2008, p. 13.

> …there is no evidence that I have seen to support that particular claim…it would be a very expensive science awareness initiative. Arguably, if you want to raise the interest of people in science, there would be more cost-effective ways of doing it than funding a space programme.[42]

2.42 Responding to this, Professor Dyson said:

> …there is a perception that space is extremely expensive, and it can be, but I do not think it has to be. I think the proposals put forward in the National Committee for Space Sciences [decadal] plan has a range of projects going from a few million up to tens of millions of dollars.[43]

2.43 An initiative to boost the interest of the community, and school students in particular, in space is the Victorian Space Science Education Centre.[44] It also helps with the professional development of teachers.

2.44 Beyond inspiring interest in science, participation in space can be 'nation-building' in a broader sense:

> …human exploration of Mars…will be the great exploration voyages of this century, regarded by future historians as we regard the voyages of Columbus, Magellan and Cook. As Australian children look to the sky and, say, at returned photos of human footprints on the lunar surface or the Martian surface, they will see no Australian role, no Australian participation that they can be proud of. I consider this a very bland legacy to leave the next generation…[by contrast] Imagine the community response to knowing that there is an Australian flag on the side of an instrument sitting on the surface of the Moon or of Mars.[45]

Is there an economic case for government assistance?

2.45 Even if the answers to some of the questions in the preceding section are affirmative, this could just mean the government stands back and applauds as the private sector gets on with it, or just concentrates on providing a supporting environment in terms of ensuring an adequate supply of suitably skilled workers.

2.46 The case for government financial support for space industry requires evidence that there are 'positive externalities' from the space industry. In other words, the space industry needs to be able to demonstrate that there are benefits generated for

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42 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 7.

43 Professor Dyson, *Draft Committee Hansard*, 23 May 2008, p. 24. A similar argument has been made by Dr Andy Thomas. The National Committee for Space Science argue that the research projects proposed in the decadal plan would cost less than a dollar per Australian a year; *Submission 41*, p. 3.

44 See *Submissions 4 and 44*.

45 Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, p. 11.

other parts of the economy from the sector's activities that do not accrue to the space sector itself. This would imply that without assistance the amount of private sector involvement in space would be less than socially optimal.

2.47 Otherwise, especially in an economy near full employment and suffering from skill shortages, assistance to space programmes will have the effect of redirecting resources away from areas where they would be more productive.

2.48 The potential spin-offs from a space programme are not limited to technical skills or scientific discoveries that turn out to have other applications. They include broader skills. Professor Colin Norman described space science as 'character building'.[46] In a similar vein were comments that:

> The spin-off benefits from space technology are various, ranging from the personnel development and managing complex systems through to the actual technological systems that they are involved in.[47]
>
> …there is the question of whether one can solve some of our major climate problems, water problems and so forth without the expertise gained from organising large projects with many, many people and from different sectors and so on. That kind of effort is one that the space industry and the military have spent a lot of time worrying about, so there is a lot of experience in how to do that in the space industry…You want people who can do things—people who can manage technology, who can manage big projects and who know how to marshal industry and do things of a considerable magnitude. That is what space trains you to do.[48]

2.49 Professor Butcher questioned whether this economic approach is adopted in other countries:

> …there really is no level playing field in space. Most countries feel that space technologies, in particular space capabilities, are strategically too important to leave to the market. The sector is generally characterised by what the Europeans call 'juste retour', where the governments try and invest as much as they can in their own countries. So, if we do not have a space program, it is difficult to develop a competitive space industry. If a significant space presence for Australia is desired, I do not think it will happen without government investment, certainly not in the foreseeable future.[49]

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46 Professor of Physics at Johns Hopkins University, *Submission 25*.

47 Mr Cameron Boyd, *Proof Committee Hansard*, 16 May 2008, p. 36.

48 Professor Harvey Butcher, ANU, *Proof Committee Hansard*, 16 May 2008, pp 53 and 58.

49 Professor Harvey Butcher, ANU, *Proof Committee Hansard*, 16 May 2008, p. 51.

2.50 There are some government programmes that currently provide some support to the industry:

- International Science Linkages programme;
- general support for research and development, such as the tax concessions and grant programmes;
- Australian Research Council grants;
- funding for CSIRO and other agencies; and
- special funding for the Square Kilometre Array (see below).

2.51 DIISR claims that over $30 million has been provided for space industry development programmes since 1996 under the AusIndustry suite of programmes.[50]

2.52 In addition, there are space-related services the government provides because they are a 'public good' such as information gleaned from satellites.[51]

2.53 Professor Butcher advocates government support for science

> I know that in the Netherlands…the government has concluded that…for every dollar the government invests in the space industry, in space activities, there are $3½ worth of economic activity generated, not always directly related to space but indirectly as well. In the United States I think it is over a factor of four. [52]

Is there a security case for government assistance?

2.54 Alternatively it could be argued that on military or security grounds Australia needs to do more than the private sector would undertake on its own initiative. For example, while the Australian defence forces can buy satellite information from foreign satellite operators, it might be argued that there is an unacceptable risk that these data may not be available in a period of international tensions. This could build a case for having Australian-owned and operated satellites even if during more normal times this is less cost-effective.[53]

2.55 Dr Andy Thomas told the Committee:

> I believe Australia must control its defence assets, and that is only possible if the country can maintain and operate the assets that it owns and those

50 DIISR, *Submission 7*, p. 2.

51 The Bureau of Meteorology and Geoscience Australia both characterised much of their work in this way; *Proof Committee Hansard*, 16 May 2008, pp 19 and 20.

52 Professor Harvey Butcher, ANU, *Proof Committee Hansard*, 16 May 2008, p. 52.

53 This argument is made, for example, by Mr Ralph Buttigieg, *Submission 3*.

> assets which support national security. That can only be achieved if Australia can build the satellite systems and the ground based support systems, and communication networks that it needs for its own unique applications, and possibly even maintain the technical infrastructure to be able to launch these systems to the required orbital planes on demand. That is a basic capability that does not exist in Australia at present.[54]

2.56 Another aspect of security concerns is that in some cases they interfere with international collaborations. A witness gave this example of where such barriers lead to a case for government support for Australian research:

> …the major limiting factor for that sort of environment is our national treaty obligations with the Missile Technology Control Regime and the US ITAR, International Traffic in Arms Regulations. That limits the transfer of that sort of technology to ensure that missile systems and weapons technology is not proliferated across many nations. These limits stop us from being able to interact across international borders, for fear that we may be proliferating these technologies. That almost drives a need to have indigenous and internal development of these technologies to ensure that not only do we not proliferate but we also have the skills to be able to utilise and provide an informed audience to those sorts of applications in future.[55]

2.57 The Committee will be better placed to assess these arguments once it hears from the Department of Defence and its agencies at its Canberra public hearing in late July. The Department of Defence is currently developing a White Paper and 'the impact of space systems on the Australian Defence Force's ability to contribute to Australia's security will also be addressed in this major policy statement.'[56]

Should Australia be making more use of satellites?

Wide uses of global navigation satellite systems

2.58 There is an increasingly wide range of applications for satellite-sourced information. This is especially true of the global navigation satellite systems (GNSS). The best known of these is the US-operated Global Positioning System. This is shortly to be joined by the European Galileo, a revamped Russian Glonass and China's Beidou. Australia should have access to all these systems which will increase precision.

2.59 The GNSS are vital to the operation of the financial system:

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54 Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, p. 13.

55 Mr Cameron Boyd, Australian Space Research Institute, *Proof Committee Hansard*, 16 May 2008, p. 36.

56 Department of Defence, *Submission 70*, p. 5.

> the timing signals of those satellites are perhaps more pervasive than all of the navigation information. The timing signals are used to synchronise our national power grids, to synchronise the time stamping of financial transactions and even to synchronise our cellular phone networks. Were someone to deny that time signal, you would have an immediate consequence in the transaction and therefore potentially the economics of our finance industry.[57]

2.60 One witness warned that:

> GPS jammers…can be bought on the international market or constructed from readily available electronics parts to designs that are available on the Internet. Australia has conducted no study on the magnitude of our risk exposure. We have no quantification of the risk of denial of GPS, no backup plans at national level, and no national approach to responding effectively to GPS interference events.[58]

2.61 There are also satellites which transmit pictures of the earth and 'radar satellites' which can see through cloud cover.

2.62 Professor Sinnott described:

> There is a substantial but very distributed base in Australia's manufacturing industry, small to medium enterprises in the main, that seek to add value to what are a free good in terms of the signals raining down on us, in terms of getting better precision, making these systems work better indoors where a typical GPS receiver does not work too well, and adding some bells and whistles in terms of added services such as telling you which restaurant you are closest to and functions like this. A most particularly important one, which I think will come to Australia—it is already in Europe and the US—is reporting where you are from a mobile phone call when you call emergency services.[59]

Monitoring through remote sensing

2.63 Geoscience Australia hosts the Australian Centre for Remote Sensing, which operates satellite ground station facilities at Alice Springs and Hobart to acquire data over Australia. Satellite data can be of great assistance in mineral prospecting.

2.64 Among the applications to which monitoring by satellite is applicable are agriculture, climate, weather, water, fire control, tsunami, marine ecosystems.

2.65 A major user is the Bureau of Meteorology. It stressed the importance of international cooperation:

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57 Mr Roger Franzen, Earthspace, *Proof Committee Hansard*, 16 May 2008, p. 43. A similar point was made by Professor Sinnott, *Draft Committee Hansard*, 23 May 2008, p. 32.

58 Professor Sinnott, *Draft Committee Hansard*, 23 May 2009, p. 32.

59 Professor Sinnott, *Draft Committee Hansard*, 23 May 2008, p. 32.

> Through international agreements under the UN based World Meteorological Organisation, the WMO, Australia gains free access to more than $10 billion worth of data annually from more than 180 member countries in exchange for an Australian investment, through the bureau's observations programs, of around $100 million. The bulk of the $10 billion international investment is associated with space based systems, while Australia's contribution is largely surface based.[60]

2.66 There are areas where Australia could get more benefit from using satellite information:

> …there is a lot of data that is available. We use a lot of it but there is potential to harvest that a lot more and use it for a much wider range of applications… There is a lot of data in areas such as oceanographic monitoring, water resource monitoring, climate monitoring—environmental monitoring right across the range. But there are subsequent applications that you can get from those in terms of benefits through improved forecasting of rainfall for agricultural regions. I think there are a large number of specific application areas for which you could derive more value from that data.[61]

2.67 Improved GNSS-derived data will also be useful for earthquake prediction:

> …we will have better understanding of the earthquake risk because we will have better understanding of the deformation that is taking place on the continent. Currently those rates of deformation are below the limits that we can detect, but when we improve it by an order of magnitude we will actually be in a position to measure some of those movements and have a better sense of which parts of the continent are actively mobile and which therefore have the potential to generate earthquakes. [62]

2.68 A concern for users is adequate access to the radio frequency spectrum.[63] The Australian Communications and Media Authority is forming a radiotelecommunications committee to examine this issue.

Remote control mining and farming

2.69 Before too long it may be commonplace for mining operations to be controlled remotely from city offices. Reliable satellite links are crucial for these operations. [64]

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60 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, p. 13.

61 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, p. 13.

62 Dr Chris Pigram, *Proof Committee Hansard*, 16 May 2008, p. 22.

63 Dr Chris Pigram, *Proof Committee Hansard*, 16 May 2008, pp 20–1; Dr Lewis, *Proof Committee Hansard*, 16 May 2008, p. 32.

64 'Spatially enabling Australia', ASIBA October 2007, reproduced in *Submission 37*.

2.70 There is similar scope for farming equipment such as harvesters to be controlled remotely, or operators to be assisted through satellite information.[65]

2.71 There is also potential for remote farms to control stock movements with 'virtual fences'; collars fitted to the animals deterring them from straying.

Inventory management and transport logistics

2.72 Satellites can help keep track of the movement of goods and therefore reduce inventory costs.

Is there a case for Australian-owned satellites?

2.73 There are currently no Australian-owned satellites. (Optus owns satellites but it is now owned by Singapore Telecommunications Ltd.[66])

2.74 The above discussion shows that satellites are widely used and are likely to be an increasingly important resource. This led a number of witnesses to argue that Australia can afford to, and should, have its own satellites, or least share in the ownership of satellites:

> …today, we can launch our own mission with a seven- to 10-year mission life for as little as $80 million…Why would you do that? The dependency that we have on other missions is affecting the timeliness of the data that we can get…Radar satellites are becoming more prevalent and, as we discussed this morning, they are all in polar orbits for the simple reason that eventually they will all cover every part of the globe because the owners are commercial and they want to sell to the whole of the world. The result of that is that your missions are time limited. The satellite only spends a certain amount of time over any particular point. Therefore, when you ask a satellite provider to provide you with information, typically you will get it within 14 to 40 days, depending on the availability of the satellite when it overflies your target…the satellite operators or owners have a means of monitoring other people's crops and positioning themselves economically in the marketplace to their advantage. [67]

> …you do not know exactly when you might be denied access, and the best way for a country our size to try to cover the risk to some extent is to be actively involved with other nations in developing observing programs and make some contribution, whether it is in terms of providing an instrument or part of an instrument so that we are in the game, so that we have some involvement in the game and therefore some influence as to what happens.[68]

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65 'Spatially enabling Australia', ASIBA October 2007, reproduced in *Submission 37*.

66 Optus had taken over the formerly government-owned Aussat. *Submission 63*.

67 Mr Roger Franzen, Earthspace, *Proof Committee Hansard*, 16 May 2008, p. 46.

68 Professor Dyson, *Draft Committee Hansard*, 23 May 2008, p. 22.

> I am not being paranoid about this. But if we rely on foreign defence satellites, they can be turned off at any time and we lose that capability. If we rely on foreign satellites for, say, GPS, the American's GPS constellation, if that is turned off, we lose an enormous capability. Whereas, if we had our own, the risk set becomes different; the risk set then becomes: can another nation actually damage our assets in space?[69]
>
> We have not asked ourselves the questions, what is the value of the flow of all the satellite imagery that tells us what our wheat crops are going to be yielding next season? What is the value of that flow of information going to five other nations overseas who are predicting our wheat yields months before we know what they are going to be? It is good enough for them to do it and we do not do it. For example, from a simple trade based situation, we are putting ourselves at a significant disadvantage. There are many, many examples like that which will be borne out if we did a proper risk analysis.[70]
>
> Australia needs to participate financially and collaborate in their missions and deploy sensors that are purpose-designed for Australian issues.[71]

2.75 Not owning a satellite means Australia has no input into its capabilities:

> …without having an indigenous capability, we do not have the possibility of being parts of programs that are specifying and designing new systems that will be useful for Australia. We really can be limited by the products that we end up buying, basically.[72]

2.76 The Bureau of Meteorology commented:

> While Australia can exert some influence on internationally coordinated efforts through forums such as the WMO Space Program, key decisions on mission payloads are, not unexpectedly, driven strongly by those that are making the investments. [73]

2.77 On the other hand, autarky is generally very inefficient. It was argued to the Committee that Australia is not self-sufficient in many other important areas:

> I am sure you all have Microsoft Office on your desktops. This is made by a company in Seattle; 98 per cent of computers in Australia are dependent on a foreign company for their applications software. Every commercial aeroplane that flies in Australia is built not in Australia.[74]

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69 Mr Matt Miller, *Draft Committee Hansard*, 23 May 2008, p. 29.

70 Mr Matt Miller, *Draft Committee Hansard*, 23 May 2008, p. 40.

71 ASIBA, *Submission 37*, p. 6.

72 Professor Grant, Institute for Telecommunications Research, *Draft Committee Hansard*, 23 May 2008, p. 4.

73 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, p. 16.

74 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 9.

2.78 Most agencies seemed to think the prospect of being locked out of access to date was remote:

> I think the risk of losing international collaboration and access to international satellites across the board is very low.[75]
>
> It has not been a problem for us to date and I do not foresee it will be in the future.[76]

2.79 Some witnesses therefore argue there were better uses of funds in collaborative approaches:

> …we would see the ideal investment, if the cost-benefit analysis took us that way, in sensors and instruments, not in satellites themselves. Through the collaborative arrangements we have, particularly with Japan, the United States, China and Korea, who are about to launch a geostationary satellite in a year or so, there would certainly be some capacity, I would hope, to collaborate in designing an instrument—perhaps a hyperspectral instrument—that would sit for example on a Japanese satellite which is very conveniently located right over Australia, to the north of Australia. That would potentially allow us to get a lot more detailed information about the atmospheric profile, temperature and humidity and really understand a lot more about the atmosphere above Australia. Investments like that would be very worth while.[77]

Should there be a space cluster?

2.80 There are often argued to be synergies in bringing together related expertise. A 'cluster' is 'a geographic concentration of interconnected companies, specialised suppliers, service providers, firms in related industries, training institutions and support organisations within a local area or region. One mark of a successful cluster is that its value as a whole is greater than the sum of its parts'.[78]

2.81 Clusters may develop because of the availability of some key resource or position,[79] become established where the item produced was first invented,[80] grow

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75 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, p. 17.

76 Dr Chris Pigram, Geoscience Australia, *Proof Committee Hansard*, 16 May 2008, p. 30.

77 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, p. 17.

78 House of Representatives Standing Committee on Economics, Finance and Public Administration, *Australian Manufacturing: Today and Tomorrow*, July 2007, p. 133.

79 For example, Sweden developed expertise in speciality steel products due to its iron ore deposits and in timber products due to its forests.

80 For example, over five centuries after Gutenberg invented the printing press, around half the world's printing presses were still being manufactured in central Germany.

around a university[81] or spin off from another cluster.[82] Some clusters develop in a particular location for no obvious reason but, once established, act as a magnet for skilled people in that industry, and supporting industries, and so remain a prime location.[83]

2.82 The literature suggests clusters can take considerable time to develop but are then long-lasting.[84] In some cases, once clusters have emerged, governments have encouraged them by funding more educational facilities and supporting infrastructure. But some attempts by governments to create clusters have been less successful.[85]

2.83 In principle, with modern communications there could be a 'virtual cluster'. But there still appear to be advantages from physical proximity in the cross-pollination of ideas. The most prospective locations for space clusters in Australia would appear to be Adelaide and Canberra.[86] One pivot for a cluster would be a Cooperative Research Centre, such as the one that operated for Satellite Systems from 1998 to 2005 and built and deployed FedSat.

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81 For example, Silicon Valley (headquarters to leading IT companies such as Apple, eBay, Google and Yahoo!) developed near the Californian universities, as did Silicon Fen around Cambridge.

82 For example, Basel's success as a cluster for the pharmaceuticals industry partly reflects its former importance in the dye industry.

83 For example, Hollywood has such a concentration of actors, writers, directors, cinematographers, producers, costume and set designers, lighting specialists and so forth that it remains the leading centre for film production despite relatively high costs.

84 Michael Porter, 'Clusters and the new economics of competition', *Harvard Business Review*, November 1998.

85 Michael Porter, the Harvard academic regarded as the leading writer on clusters, concludes 'government policy will be far more likely to succeed in reinforcing an existing or nascent cluster than in trying to promote an entirely new one, however tempting that might be for national prestige', *The Competitive Advantage of Nations*, Free Press, New York, 1990, p. 655.

86 A cluster in Adelaide could develop around the Institute for Telecommunications Research at the University of South Australia, research centres at the University of Adelaide and a number of Adelaide-based companies and benefit from relative proximity to Woomera. The South Australian government regards the state as 'the natural home of Australia's space effort'; *Submission 79*, p. 1. A cluster in Canberra could develop around the Acton-Black Mountain area which houses the ANU and CSIRO. Also in the Canberra region are the relevant Australian government departments, Mount Stromlo observatory and the Deep Space Tracking Centre at Tidbinbilla. Arguments could be mounted for adding Sydney and/or Melbourne but Australia is too small to have a large number of space clusters.

Should Australia have (or join) a space agency?

2.84 A number of witnesses pointed out that Australia is unusual among larger and more affluent economies in not either having a space agency of its own or being affiliated to a supranational agency.[87]

2.85 From 1987 to 1996, the Australian Space Office provided some focus. The closest thing Australia has currently is the Australian Government Space Forum (described in paragraph 2.3 above).

2.86 Notwithstanding the role of DIISR and the Forum, many witnesses felt there was no prominent point of contact in Australia for overseas agencies or private companies who wish to discuss space matters:

> 'Who do we come and see?' has been the question to many of us in the industry.[88]
>
> …the NSSA has frequently been approached by businesses and individuals frustrated at the lack of support and communication channels from the Australian government…Without a point of contact, organisations such as the European Space Agency are discouraged from doing business.[89]
>
> …there should be a centralised coordinating body…which has the capacity to act as an international point of contact.[90]

2.87 The Australian Space Research Institute argued that an agency would:

> give cohesion to the various disparate space elements that are still in Australia and help bring back some of the expatriate space assets that have had to go overseas to look for work in the last decade or so.[91]

2.88 The lack of an agency may mean that Australia misses out on larger interdisciplinary projects:

> What is missing is large coordinated programs of research and development that span many organisations both in Australia and obviously

87 For example, Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, p. 11; Mars Society, *Submission 22*; Dr James Moody, *Submission 32*; Australian Spatial Information Business Association, *Submission 37*, p. 5; Mark Ramsey, *Submission 43*, p. 7; Australian Space Research Institute, *Submission 46*, p. 4; Luke Webb, *Submission 47*, p. 2; Epsilon Foundation, *Submission 56*, p. 1; Australian Space Industry Chamber of Commerce, *Submission 64*, p. 10.

88 Mr Roger Franzen, Earthspace, *Proof Committee Hansard*, 16 May 2008, p. 44.

89 National Space Society of Australia, *Submission 27*, p. 7.

90 Institute for Telecommunications Research, *Submission 48*, p. 2.

91 Mr Luckman, *Proof Committee Hansard*, 16 May 2008, p. 35.

> internationally. We cannot do things like this alone. As director of a research institute, that is really where I see the lost opportunity.[92]

2.89 Dr Andy Thomas argued:

> I do personally believe that a single coordinating body is needed in Australia…I do have a sense that there are a lot of competitive organisations in the Australian arena in all of those various dispersed activities that you referred to. I am sure the people in those organisations have the best of intentions of their organisations, but I think you do need an operation that has a vision that looks at the national scale of what has to be done on a national basis and pull all of those things together to support that national programme.[93]

2.90 A number of other groups also felt the absence of a single space agency was damaging to Australia:

> Australia has become ever more dependent on space based services, often invisibly. Much like water in a tap, we do not understand where the services come from; we just expect them to be there…there appears to be no whole-of-government coordination that addresses our dependencies and hence our vulnerabilities that arise from those dependencies...[a space agency] should initially reside probably within the Department of the Prime Minister and Cabinet so that it holds a whole-of-government perspective and does not need to consider individual departmental priorities, and therefore it can look at all of the nation's dependencies at a strategic level.[94]

> The primary impediments [to strengthening space science and industry in Australia] are first, that Australia has no single coordinating body for space science.[95]

> There is an urgent need to establish a single coordinating framework for Australian space related research and applications.[96]

2.91 The Bureau of Meteorology commented:

> Australia would benefit from a more coordinated national policy framework on space matters, developed and administered through a whole-of-government mechanism; that, through such national policy arrangements, the value of current and continued international collaboration on space is recognised and coordinated; and that targeted national investments in space science and technology in relation to both ground and

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92 Professor Grant, Institute for Telecommunications Research, *Draft Committee Hansard*, 23 May 2008, p. 3. Similarly Dr Woodgate was approached by a Chinese agency interested in a joint satellite venture but unable to find an agency in government to approach.

93 Dr Andy Thomas, *Draft Committee Hansard*, 23 May 2008, p. 15.

94 Mr Roger Franzen, Earthspace, *Proof Committee Hansard*, 16 May 2008, p. 42.

95 University of Sydney, *Submission 18*.

96 University of Newcastle, *Submission 53*, p. 2.

> space segments should build on and complement the international effort, with a special focus on Australia's national objectives—for example, in relation to climate monitoring, water resources, environment, and disaster mitigation… in terms of a coordinated engagement with other countries, there is no single framework for that to happen. [97]

2.92 One possible model is the British National Space Centre, which 'essentially coordinates the activities of a range of ministries that still retain their budgets and their responsibilities'.[98] This was attractive to some witnesses:

> Perhaps the UK approach, which is more like a national committee which has the key representatives at the table, may be an appropriate model. [99]

2.93 The European Space Agency has four times offered Australia an associate membership. Some leading space scientists advocate taking up the offer, pointing out it would allow Australian companies and universities to win contracts with the ESA and gain better access to satellite data.[100] Another possibility would be for Australia to take a leadership role in forming an international space agency, such as an Asian or Pacific Space Agency.

2.94 An interesting case is Canada, arguably the most similar country to Australia, which has its own space agency. When asked why Canada was increasing its involvement in space, DIISR responded:

> The Canadians do have a very large neighbour immediately to their south that could be the target of, for example, Russian nuclear weapons that would fly over Canadian territory to reach their intended targets. I think they have some strategic reasons for wanting to have their own capability in this context: if a nuclear war were to eventuate, their country would be in the flight path and potentially hit by some of those were they to be aimed at the United States—which I think we could all presume would be the case. They also control at their northern border a range of Arctic seaways, which I understand they have some interest in being able to monitor. I think those are two reasons that are slightly different in Canada from Australia.[101]

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97 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, pp 14 and 18.

98 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 5.

99 Dr Susan Barrell, *Proof Committee Hansard*, 16 May 2008, p. 18.

100 Associate Professor Lachlan Thompson and Professor Pavel Trivailo, *Submission 33*, p. 3.

101 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 6.

Should the Australian government be giving more support for the Square Kilometre Array?

2.95 The Square Kilometre Array (SKA) is a giant radio telescope. It is designed to do leading edge radioastronomy. The CSIRO is the lead agency.

2.96 The DIISR commented:

> …it will be an extremely high-tech instrument that will potentially provide a lot of opportunities for high-tech Australian companies to participate. Our assessment is that, given that the infrastructure is largely sophisticated radio antennas and a range of supercomputing, visualisation and other application software—which are areas where we do have leading-edge capability, particularly in antennas and ground station technology—we think there is quite a good opportunity for Australia to benefit from that project. [102]

2.97 Australia has made the final two in the selection process and the DIISR sounded confident about Australia's prospects of hosting the SKA:

> I think we have a very compelling case. We have committed in the last year to hosting a demonstration instrument, which will be a significant instrument in its own right. It was discussed as part of ministerial and prime ministerial visits to Europe recently. I am not sure that there is more that we could do at this stage. [103]

Is Australian education adequate for a space future?

2.98 Some witnesses questioned whether the teaching of science and mathematics in Australia's high schools is providing an adequate basis for tertiary study of space-related fields. They noted fewer students are studying physics.

> Our school education in mathematics and science is not preparing students to come to university to do some of the difficult undergraduate physics that is required to prepare them for that work. That has been a trend for quite a few years.[104]

> …post primary students in Australia generally did not sustain any enthusiasm for science beyond their second year after entering junior high school.[105]

2.99 There is also concern about a 'brain drain' of space scientists from Australian universities. These 'technogees' are leaving Australia as they do not see adequate research and employment prospects here:

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102 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 12.

103 Dr Michael Green, DIISR, *Proof Committee Hansard*, 16 May 2008, p. 12.

104 Professor Clay, *Draft Committee Hansard*, 23 May 2008, p. 46.

105 Ms Jeanette Rothapfel, *Submission 45*, p. 1.

> Having significant dealings with many of the students involved in our operations, I would have to say that a significant proportion either do not continue their activities in an aerospace related field or they go overseas. There is very little opportunity for graduates from those sorts of environments to gain a work career in aerospace in Australia.[106]
>
> …like many of my university peers, my aspiration is to work within the Space industry. In Australia, this ambition is near unachievable, partly due to the ongoing failure of Australian government policy. As such, I am currently preparing to move with my family to Europe for the prime reason of working in the Space industry.[107]
>
> I am an Australian (with a PhD in space engineering from the University of Queensland) but owing to the state of Australian space activity…I have worked in the UK and in Germany for the last decade…[108]
>
> Engineers and scientists with experience in space projects have been forced to move overseas or are unable to return to Australia because of the lack of employment opportunities in their chosen field.[109]

2.100 Professor Clay lamented:

> Space science is not as fashionable as it used to be and it is more difficult than a lot of other areas.[110]

Concluding remarks

2.101 There is clear commitment by many involved in space science and excitement about the untapped potential of this area of science and technology. The committee looks forward to completing its enquiry about this industry.

Senator Annette Hurley
Chair

106 Mr Cameron Boyd, Australian Space Research Institute, *Proof Committee Hansard*, 16 May 2008, p. 35.

107 Mr Mark Ramsey, *Submission 43*, p. 2.

108 Dr Sean Tuttle, *Submission 50*, p. 1.

109 Australian Space Industry Chamber of Commerce, *Submission 64*, p. 12.

110 Professor Clay, *Draft Committee Hansard*, 23 May 2008, p. 46.

APPENDIX 1

Submissions Received

Submission Number	Submitter
1	Paul Cally, Professor of Solar Physics, Monash University
2	Mr Gregory Seil
3	Mr Ralph Buttigieg
4	Mr Ange Kenos JP
5	Mr Jacques Chester
6	Mr Matthew Allen
7	Department of Innovation, Industry, Science & Research (DIISR)
8	Mr Wesley Bruce
9	Mr Desmond J. Lugg MD
10	Emeritus Professor Ray Stalker, The University of Queensland
11	Professor Roger Clay
12	GPSat Systems Australia Pty Ltd.
13	Australian National University (ANU)
14	Sydney Section of American Institute of Aeronautics and Astronautics (AAIA)
15	SMS Management & Technology
16	Professor Stuart Phinn, University of Queensland
17	Mr Don Fry AO
18	University of Sydney, DVC Research
19	School of Geosciences, Monash University
20	Professor John Dickey & Dr Simon Ellingsen, University of Tasmania
21	Geoscience Australia
22	Mars Society Australia (MSA)
23	Spatial Sciences Institute
24	La Trobe University
25	Professor Colin Norman, Physics & Astronomy, John Hopkins University
26	Israel Aerospace Industries Ltd (IAI)
27	National Space Society of Australia (NSSA)
28	Professor Patrick G Quilty, University of Tasmania
29	Mr Jack Dwyer
30	Geological Society of Australia's Specialist Group in Planetary Geoscience
31	Ms Anntonette Joseph
32	Dr James Bradfield Moody
33	Associate Professor Lachlan Thompson & Professor David Trivailo, RMIT University
34	BAE Systems
35	University of NSW (UNSW)
36	Australian Hypersonics Network
37	Australian Spatial Information Business Association (ASIBA)

38 Australian Academy of Science
39 University of Queensland
40 Australian Antarctic Division of the Department of the Environment, Water, Heritage and the Arts
41 National Committee for Space Sciences (NCSS)
42 Ms Anne Kovachevich
43 Mr Mark Ramsey
44 Victorian Space Science Education Centre (VSSEC)
45 Ms Jeanette Rothapfel
46 Australian Space Research Institute (ASRI)
47 Mr Luke Webb
48 Institute for Telecommunications Research, University of SA
49 Centre for Hypersonics, University of Queensland
50 Dr Sean Tuttle
51 BLUEsat
52 Professor Don, Sinnott, Professorial Research Fellow in Radar Systems, University of Adelaide
53 University of Newcastle, Centre for Space Physics
54 Grollo Aerospace & RMIT University
55 Confidental
56 The Epsilon Foundation
57 Earthspace
58 Mr Brett Biddington
59 Ms Jo-Anne M. Gilbert
60 Symbios Communications
61 CRC for Spatial Information (CRCSI)
62 Australian Spatial Information
63 Optus
64 Australian Space Industry Chamber of Commerce (ASICC)
65 Bureau of Meteorology (BoM)
66 Professor Mervyn J Lynch
67 Engineers Australia
68 COM DEV
69 Ms Frances Brown
70 Department of Defence
71 Mr Roy Sach
72 Landgate
73 Mr Brent McInnes
74 Confidential
75 Auspace Pty Ltd
76 Mr Ian French
77 CSIRO
78 Intelsat
79 South Australian Government
80 Thales Australia

Additional Information Received

- Received from Dr Michael Green, Department of Innovation, Industry, Science & Research on 30 May 2008. Answers to Questions on Notice taken on 16 May 2008, Canberra.

TABLED DOCUMENTS

- '*Space Weather*', tabled by Professor Dyson, La Trobe University on 23 May 2008, Adelaide.

APPENDIX 2

Public Hearings and Witnesses

CANBERRA, 16 MAY 2008

BARRELL, Dr Susan, Assistant Director,
Observations and Engineering Branch, Bureau of Meteorology

BOYD, Mr Cameron Stewart, Academic Coordinator,
Australian Space Research Institute Ltd

BUTCHER, Professor Harvey Raymond, Director,
Research School of Astronomy and Astrophysics, Australian National University

FRANZEN, Mr Roger Leo, Principal,
Earthspace

GREEN, Dr Michael, General Manager,
Manufacturing Innovation Branch, and Director, Space Licensing and Safety Office,
Department of Innovation, Industry, Science and Research

LEWIS, Dr Adam, Group Leader,
Spatial Information Access and Remote Sensing, Geospatial and Earth Monitoring Division, Geoscience Australia

LUCKMAN, Mr Gary, Chairman,
Australian Space Research Institute Ltd

PIGRAM, Dr Chris, Deputy Chief Executive Officer and Chief,
Geospatial and Earth Monitoring Division, Geoscience Australia

REA, Dr Anthony, Project Leader,
Observations and Engineering Branch, Bureau of Meteorology

SAMUEL, Mr Richard Henry, Small Sounding Rocket Program Manager,
Australian Space Research Institute Ltd

TERKILDSEN, Dr Michael, Physicist,
Consultancy and Development, IPS Radio and Space Services, Bureau of Meteorology

ADELAIDE, 23 MAY 2008

BRUMFITT, Ms Anne, Consultant-Lecturer,
RMIT University

CLAY, Professor Roger William,
Private capacity

DOUGLAS, Mr John Stuart,
Private capacity

DYSON, Professor Peter Lawrence, Emeritus Professor of Physics
La Trobe University

GRANT, Professor Alexander James, Director,
Institute for Telecommunications Research, University of South Australia

KASPARIAN, Mr Jeffrey John, Business Manager,
Institute for Telecommunications Research, University of South Australia

MABBS, Dr Stephen, Director Defence Solutions,
SMS Management and Technology

MILLER, Mr Matt, Director Defence and National Security,
SMS Management and Technology

SINNOTT, Professor Donald Hugh,
Private capacity

THOMAS, Dr Andrew Sydney,
Private capacity

THOMPSON, Professor Lachlan Arthur, Associate Professor,
Aerospace Engineering, and Leader, Space Platforms Research, RMIT University

WOODGATE, Dr Peter Wyndham, Chief Executive Officer,
CRC for Spatial Information