Introduction
Malcolm Davis

The first of July 2018 marks an important day for Australia’s quest to become a more important actor in space, with the creation of an Australian Space Agency under the leadership of Megan Clark. For the first time, Australia looks to have direction, coordination and focus in its endeavours beyond earth. Understanding what this means for Australia is the focus of this report.

The decision to boldly go into space marks an important step forward for Australia, which traditionally has been content to be dependent on foreign providers for space capability. For much of the period from the 1960s onwards, Australia adopted a supporting role in space—providing a suitable piece of real estate for ground facilities, supplying skilled personnel and managing the data coming from the satellites. However, we’ve not done anything significant in terms of developing sovereign capability in terms of ‘the space segment’.
Now, the stage looks set for Australia to take a more ambitious path that could eventually lead to the launching of our own satellites from an Australian launch site. At the same time, there’s a huge opportunity to supercharge Australia’s utilisation of space capabilities on earth, particularly through innovative use of ‘Space 2.0’ capability.

So, it’s important that in parallel to funding a space agency, the federal government is also seeking to propel the growth of the Australian space industry sector to make it competitive with a rapidly growing global market, of which currently we have a less than 1% share. There are very clear implications for boosting Australia’s space industry in terms of stimulating a new high technology sector of the economy, generating rapid and significant jobs growth, enhancing outreach to the next generation of Australian space leaders through education in STEM, and offering new national capabilities in line with government requirements.

For defence and national security, space is a vital domain. Space is no longer a pristine global common that’s a sanctuary from warfare. In the 21st century, it’s recognised to be a warfighting domain that’s ‘contested’ through the growing threat of adversaries’ counter-space capability. It’s also increasingly ‘congested’ as a result of growing space debris. Finally, space is increasingly ‘competitive’ as new approaches to space activities such as Space 2.0 see the acquisition of space capabilities by a broader range of state and non-state actors. Space is no longer dominated by only the major powers, and the impact of the private sector is clearly visible every time SpaceX launches—and then lands—one of its rockets.

Ensuring access to space is vital to Australia’s defence capability and to our approach to military tasks. Without an ability to access space capabilities—either our own, or those of an ally—our ability to fight and win information-based warfare and undertake ‘multi-domain operations’ is severely limited, and our adversaries are better placed to impose costs or even military defeat against our forces.

So, there’s now greater focus within Defence on how the ADF can operate in this contested, congested and competitive warfighting domain. A key task is to determine how best Australia can work alongside the United States and other partners to deter threats to our critical space capabilities, and if necessary to mitigate the effects of warfare in space.

Another key development that could influence Australia’s approach to space is Space 2.0, which seeks to embrace new technologies and business approaches to accessing and utilising space. The technology of ‘cubesats’ and ‘small satellites’, as well as ‘reusable rockets’, is important but it’s the business model that underpins these technologies that really drives Space 2.0. The goal is rapid transformation and revolutionary effect, rather than slow, steady, incremental evolution of capability. The old model—Space 1.0, akin to the post-Apollo era approach—was risk averse, which drove costs up and slowed progress.

In contrast, Space 2.0 embraces risk and recognises that space technology needs to be smaller, better and cheaper to open up space to more users than traditional technologies such as large, expensive satellites permit. Rapid innovation drives Space 2.0.

Australia needs to make wise choices as to the best path for developing space capability. It’s unlikely we’ll foreswear US-provided ‘strategic space’ systems entirely, but Australia can best contribute in niche areas through a Space 2.0 business model that is far more affordable, and is able to exploit rapid innovation within the civilian commercial sector. The Australian Space Agency has to support that approach if it’s to be successful, rather than simply being a ‘NASA down under’.

That means getting our business model right and listening to new approaches from the next generation of space leaders and thinkers. This leadership cadre needs to be expanded and sustained if we’re to be successful in promoting Australia as a credible space actor in coming years. So promoting outreach through STEM education, supporting Australian space science activities and astronomy, and getting the business and education sectors to work together is going to be important.

ASPI’s role as Australia’s leading defence think tank means that we have to anticipate key changes in our security environment, including the rapidly growing importance of the space domain. Government now recognises the vital importance of space to defence and national security affairs, as well as its role in promoting innovation and economic growth.

ASPI believes it’s important to generate debate and undertake analysis on this subject. This publication seeks to illuminate the thoughts of key thinkers in both the public and private sectors on where Australia is headed in space. We hope you find this compilation of articles published in the lead-up to ASPI’s June 2018 conference on ‘Building Australia’s strategy in space’ a stimulating and useful reference.
Executive Summary

Malcolm Davis

Following the introduction by Dr Malcolm Davis, the report begins with a keynote article by the inaugural director of the Australian Space Agency, Professor Megan Clark, discussing the future of Australia in space, and considering the opportunities and challenges that lie ahead.

Then Dr Malcolm Davis lays out the implications of the space domain as a ‘contested, congested and competitive’ warfighting environment. He considers how Australia might exploit Space 2.0 capabilities to play a more significant role alongside the United States to increase deterrence in orbit by enabling reconstitution and resilience. He also considers the likely role an Australian space agency will play in supporting the Australian space industry and enabling Australia to reduce our dependency on foreign providers for space capability.

The Hon. Senator Michaelia Cash, Minister for Jobs and Innovation, will be the minister responsible for the new space agency, which will sit within the Department of Jobs and Innovation. She gives her perspective on the government’s efforts to develop the agency, and on its likely role and direction. She also talks about the importance and likely direction of the rapidly growing space industry sector.

The Hon. Senator Kim Carr provides his perspective on how best Australia can proceed with the new space agency and promote space industry. He makes the point that Australia can take on a more assertive and ambitious role to counter the challenge posed by growing counter-space threats and, at the same time, take on a more visible global role.

We then examine the commercial sector, with Fleet Aerospace CEO Flavia Tata Nardini explaining how Space 2.0 may enable the ‘internet of things’, then goes on to explore what the next generation of Space 2.0 might look like. Space is dominated by the commercial sector—rather than traditional government-run space activities—and this will in turn demand that greater emphasis be put on boosting space awareness in education through science, technology, engineering and mathematics (STEM).

The series then turns to the role of the Australian Space Agency, with Brett Biddington exploring the opportunities and risks for the new agency, which was announced in October’s International Astronautical Congress in Adelaide. Biddington is sceptical of Space 2.0, and identifies a range of activities that the space agency could promote and support, including space launch activities.

Space 2.0 features again in Dr Malcolm Davis’ second contribution on how the Australian Space Agency might support Defence’s space capability, and in particular how the agency can contribute to ensuring that Australia can access space even in the face of adversary counter-space threats and the challenge posed by space debris.

Naomi Mathers, the deputy chair of the Space Industry Association of Australia, gives a great overview of the opportunities and challenges of accessing a range of satellite services available to Australia for communications, earth observation, and precision navigation and timing. She talks about the importance of the Satellite-based Augmentation System, Precision Navigation and Timing, and the Digital Earth Australia project. She makes the point that small satellites will never challenge large satellites due to constraints on power, sophistication and sensitivity of the sensors on board.

The next article in the series reviews the history of Australia’s space activities. Malcolm J. Phillips, a former engineer for the European Launcher Defence Organisation, was present at Woomera, SA, during the 1960s. He recounts his experiences in those early years. He also gives his thoughts on where Australia is headed in space. It’s useful to remind ourselves how far we have come, and where we are going.

Turning to a defence focus we have Wing Commander Darin Lovett, the RAAF’s Chief of Air Force air and space fellow, who considers how Australian space doctrine needs to evolve in this contested, congested and competitive space domain. He argues that there needs to be a culture of ‘space mindedness’, not only in the armed forces but also within industry and government.
He identifies steps that Australia can take to strengthen international collaboration in space, and in promoting the growth of a cadre of space experts that can sustain Australian space activities in the future.

Building on the space deterrence theme, Dr Todd Harrison from the US Center for Strategic and International Studies looks at how conflict in space might occur, and how escalation might emerge. He reinforces the importance of innovation in developing space capabilities, and how integrating the space capabilities of the ‘Five Eyes’ intelligence partners could contribute to space deterrence. But deterrence is all about communication, and Harrison makes clear that for space deterrence to work, it’s vital to communicate to adversaries and commercial actors how the US will perceive and respond to activities in orbit.

In a thought-provoking article, Lieutenant Colonel Greg Rowlands from the Australian Army looks at how space capabilities can enable the use of remotely operated and autonomous systems in expeditionary joint operations. He paints an amazing picture of expeditionary forces comprising robotic ‘avatars’—remotely piloted from Australia via satellite link—undertaking an opposed amphibious landing. It’s a tapestry of capabilities—space, cyber, and autonomous systems—that could form the core of the future ADF.

Wing Commander Richard ‘Rex’ Harrison gives us a compelling overview of the challenges of monitoring the space environment, in particular noting the likely effect of the deployment of ‘mega-constellations’ of thousands of satellites in low-earth orbit and how they’ll affect the risk of space congestion.

Turning to the importance of STEM in education as a means to build space awareness, Geoffrey McNamara and Ingrid McCarthy, two leading practitioners in science education, have written excellent articles explaining how STEM education and science outreach is vital for sustaining Australia’s profile in space science and astronomy, and more broadly for creating the next generation of space thinkers.

Scott Wallis of Equatorial Launch Australia then shows how Australia can play a credible and profitable role in space launch. He makes the point that Australia is already developing its own launch capabilities, and new approaches to manufacturing such as the Fourth Industrial Revolution, as well as 3D printing, could open up new pathways to an Australian space capability.

ASPI Executive Director Peter Jennings then brings the series to a conclusion with an overview of the key findings from these articles and the importance of space for Australia.
A universe of opportunity

Megan Clark, 12 June 2018

Every day space provides essential data for banking, TV, internet access and GPS. Space underpins almost every part of the broader economy—helping farmers seed a crop between the rows of last year’s crop, helping marine vessels navigate and providing emergency crews with up-to-date information. Growing how we use space will change the way we live and work, including providing new opportunities for communications in regional and remote areas.

The government has supported all the key recommendations of the recent Review of Australia’s Space Industry Capability, and in the May 2018 federal budget it announced over $300 million in space investment. Of this, $41 million is to establish Australia’s Space Agency and $260 million goes to Geoscience Australia to bring Australia’s global positioning system from our current five-metre accuracy to a world-class standard of 10-centimetre accuracy on our land and seas and in our airspace. Importantly, Geoscience Australia will also be funded to build world-leading three-centimetre precise positioning accuracy in our cities.

The budget also provided funding for Geoscience Australia’s Digital Earth Australia platform to be commercialised and exported as a global standard. Australia is the first country to create a fully corrected, digital library of satellite data, collected over decades, for every 10 square metres across Australia and its coast. This funding means two of the six strategic priorities for Australia that were highlighted in the review have now been funded.

The government's decision to allocate $41 million to establish the first Australian Space Agency is an exciting development. This includes a commitment of ongoing funding for the agency, as well as $15 million of seed funding dedicated to opening the door internationally for partnerships in the space sector to grow our emerging space industry and lift the broader economy.

The agency’s purpose is to transform and grow a globally respected Australian space industry that lifts the broader economy and inspires and improves the lives of Australians. This will be underpinned by strong international and national engagement. Australia can step up as a responsible global citizen helping to ensure safe and secure operations on earth and in space. Building partnerships that realise shared ambitions will be key to our success. In a sector undergoing transformation and rapid growth, the agency will bring an entrepreneurial spirit. We will be curious to find out more—and do some really cool things.

The key roles of the agency will be to provide one door and one voice internationally, ensure that Australia is a responsible global citizen, set national policy and strategy for the civil space sector, and coordinate Australia’s domestic space-sector activities. A vital part of the pathway for Australia in space will be to share with all Australians our expanding role in space and its importance to the nation’s economy, security, safety and living standards. The agency will play an important role in strengthening the connection that young people and their parents have with space—sparking their curiosity and expanding their knowledge and interest in space and science and technology.

Australia must make some hard choices to build on our strengths and also nurture areas where we are behind globally but could leapfrog into world-class capability. The funding in the May budget addresses two of the six strategic priorities highlighted in the review—lifting Australia’s position, navigation and timing infrastructure to the highest standard, and building the platform to commercialise and export Australia’s world-leading earth observation analysis capability. The review highlighted a further four strategic priorities—communications technology, services and ground stations; space situational awareness and debris monitoring; quantum communications, astronomy, planetary science, space medicine, and antennae and sensor technology; and remote asset management that will link how we work in space to how we work on earth.

Space will be a defining domain for human endeavour and will change what we do on earth. It is why NASA and Woodside are working together to develop ‘Robonaut’ to perform similar tasks on the International Space Station and on an offshore oil rig in Western Australia.
In some areas Australia has yet to develop world-class capability, but we have some encouraging sparks in our start-up, small business and research sectors. These areas will need additional nurturing to leapfrog onto the global stage. We will keep a close watch on technologies such as artificial intelligence, internet-of-things networks, robotics, quantum technologies, and next-generation propulsion systems, and leverage our strengths to create a sustainable space sector.

The agency’s initial task will be to develop a detailed investment plan for the development of our space industry that builds international engagement and works with states and territories to determine the contributions they can bring to the national space enterprise, and to consider the most suitable strategic location arrangements for the agency. These consultations will be guided by the purpose of the agency: to transform and grow a globally respected Australian space industry that lifts the broader economy, and inspires and improves the lives of Australians—underpinned by strong international and national engagement.

Some may argue that Australia might be late to the party, but we are entering a time when the space sector is moving from the realm of government to the commercial world. Our agency will be one of the most industry-focused space agencies in the world. Australia can be a leader and a responsible global citizen, drawing on our homegrown Aussie ingenuity.

No other industry can inspire nations quite like space, where human ambition can set its sights on interplanetary missions, colonisation beyond earth and the opportunity of finding new life. We can dream this big because of the space-based technologies that have connected the world in unprecedented ways. And in the coming decades, Australia has the opportunity to become a global leader in pushing earth’s links with space even further.

We look forward to commencing operations on 1 July 2018.

*For print readers, the original piece with live links is at* [https://www.aspistrategist.org.au/a-universe-of-opportunity/](https://www.aspistrategist.org.au/a-universe-of-opportunity/)

**Australia takes on the high frontier**

Malcolm Davis, 2 March 2018

Australia is set to embrace a more active role in space. This shift away from a primarily earth-bound focus on space opens up some interesting possibilities. Certainly, we’ve come a long way from the early days of the European Launcher Development Organisation launching Blue Streak and Europa rockets out of Woomera in the 1960s. Equally certain is that a bright future beckons for Australia on the high frontier. But there are some challenging risks too.

Firstly, the space domain is no longer a sanctuary free from warfare. Space has been ‘militarised’ since the 1960s in the sense that satellites support terrestrial operations. And though the ‘weaponisation of space’ has its earliest roots in the Cold War, its pace has gathered momentum.

The US intelligence community and US Air Force are now warning of growing counter-space threats from peers and regional adversaries. Space in the 21st century is a ‘contested’ operational domain. Adversaries are developing ‘hard kill’ anti-satellite weapons and ‘soft kill’ systems that range from GPS jamming to electronic warfare to cyberattacks against satellites.

The dependency of terrestrial military forces on space support is growing to the point that its loss—a ‘day without space’—would have a devastating effect on the ability of joint forces to fight and win in information-led warfare. The US is beginning to take urgent steps to address this growing challenge. Australia will need to do the same.

The contested space domain also presents legal challenges. The 1968 Outer Space Treaty remains the key document regulating space activities and preventing the deployment of weapons of mass destruction in orbit. But it’s very dated and no longer suited to the nature of modern counter-space capabilities.

It also does little to prevent commercial entities operating on behalf of states from claiming resources in space, or from controlling the territory where the resources are located. Competition over space resources, even between private actors operating in states’ interests, opens up all sorts of intriguing questions, as well as the possibility that competition could become conflict.
The contested nature of space is complicated because it’s also ‘congested’, with a growing risk posed by ever-accumulating space debris, which ranges from spent rocket stages down to metal fragments that can easily threaten satellites and spacecraft. Australia already performs a space situational awareness mission in support of the US, a task that will only become more important in the future.

Finally, space is ‘competitive’. Cheaper Space 2.0 technologies and the rise of commercial space actors are democratising space by lowering the entry cost of launching a payload into orbit, allowing a greater number of states and non-state actors to acquire space capabilities. For Australia, the lower cost of Space 2.0 makes it possible to undertake meaningful roles in orbit for the first time since the dawn of the space age.

Certainly the ability of the ADF to contribute to operations in orbit—either by providing niche space systems to fill operational gaps, or to rapidly expand space support and ‘bandwidth’ prior to a conflict—offers a useful way for Australia to support our major allies, and to show regional space leadership.

Most importantly, an Australian space program would strengthen deterrence in orbit. Improving the ability to rapidly reconstitute space capability after a counter-space attack increases space resilience and, by extension, the deterrence value of space assets.

In this regard, emphasising the development of disaggregated constellations of small satellites and Cubesats is the best path forward for Australia. The low cost of CubeSat technology offers the ability to rapidly update orbital infrastructure and install innovative new capabilities. By contrast, large satellites tend to be expensive, complex and hard to update. To put it another way, Cubesats are the iPhone to the large satellite mainframe.

Two key developments—the rapid growth of an Australian space industry and the establishment of an Australian space agency—will have a big impact on our ability to undertake such roles.

First, the government is finalising a review of the Australian space industry, which will be released later this month. The report will show that the Australian space industry is growing rapidly—not through aerospace giants but through innovative, small space start-ups. These small companies are well placed both to support Defence requirements in space and to boost Australia’s commercial space presence. It will be commercial enterprises that will eventually offer Australian space launch facilities, most likely from the Northern Territory. The prospective launch site will form the final link in the chain for an Australian sovereign space capability.

Secondly, an Australian space agency will be established that will tie all of this together. Ideally the agency will coordinate and support the rapid growth of Australian space activities, including by expanding Australia’s role internationally in space science and astronomy.

Australia is moving into a bigger role in space at an exciting time, one full of rapid change and transformational developments. There are opportunities to be had if we are bold and quick enough to grasp them. But with any period of rapid change comes also an increasing risk of disruption, instability and, potentially, conflict.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/australia-takes-high-frontier/
The new space race
Michaelia Cash, 24 May 2018

The global space industry has undergone a major transformation since astronauts first walked on the Moon in the late 1960s. Half a century later it’s more appropriately known as the global space economy.

The global space economy is worth around US$345 billion, and growing at nearly 10% a year. Australia, despite the outstanding capability here on our shores, only accounts for 0.8% of the global space economy.

We have strong capability in space-related industries. We’re world leaders in areas like automated mining and precision agriculture. We also have immense expertise and capability as an advanced manufacturing nation.

What we didn’t have is a national strategy for the sector that reflects both our developing strengths and national interests over the next decade.

In 2017, the Australian government announced a review of Australia’s space industry capability. Ensuring that the right strategic framework is in place to support the growth of Australian’s space industry was core to the review process.

The government tasked an expert reference group, led by Dr Megan Clark AC, to undertake the review.

This review built on the 2013 Australia’s Satellite Utilisation Policy and the findings from the recently completed review of the Space Activities Act 1998. Reform of the space legislation is now underway to reflect advances in technologies and provide a regulatory environment that is appropriately conducive to commercial investment in the space sector. It was therefore timely for the government to review its civil space policy and refine its strategic, long-term plans for this important sector.

The review was comprehensive, well informed and strategic. The expert reference group undertook extensive consultation, including with the space community in every state and territory of Australia. It also consulted at a global level. We engaged with industry leaders of the space community, as well as ministers and relevant government agencies. In total, they reviewed the activities of more than 170 companies and 34 research groups within the Australian space sector.

The expert reference group’s final report outlined Australia’s existing and potential areas of advantage, and the immense opportunities available to us. It looked at regional and international collaboration, capability gaps, strategies to promote Australian companies, and recommendations as to how the space agency should function and operate.

That report recommended that we establish the Australian Space Agency to ensure that Australia can capitalise on its areas of comparative strength in the space industry and develop a strong and globally competitive domestic sector.

The report noted that Australia has billions of dollars’ worth of existing space-related infrastructure, including that Australians are world leaders in space-related activities like automated mining and precision agriculture.

It also identified a vibrant community of active small and medium-sized space sector businesses, and domestic expertise in satellite data analysis, radio and radar communications.

Significantly, it identified that the Turnbull government has the opportunity to triple the size of our domestic space industry to up to $12 billion by 2030—and in so doing, to create up to 20,000 new jobs for Australians.

In May 2018, the government announced the creation of Australia’s first ever space agency. Dr Clark will lead the agency for the first 12 months.

Beginning its operations on 1 July 2018, the agency will support the long-term development and application of space technologies, growing our domestic space industry and securing our place in the global space economy.
We’re committed to the development of Australia’s space industry to drive investment, create jobs and position Australia as a key participant in the global space economy.

The space industry is immense. It spans the design and build of satellite technology, the ground systems that receive and store data, and the great challenges posed by the processing, interpretation and application of that data. Moreover, it underpins the long-term competitiveness of industries across the economy including communication, agriculture, mining, oil and gas.

These opportunities will bring new growth and capabilities to Australian businesses in every sector. This will create high-wage, long-term jobs nationwide—including in rural and regional areas, and especially in STEM disciplines.

Critically, the agency is only part of a broader space innovation ecosystem that the government is creating.

The Turnbull government is also investing more than $260 million to provide all Australians with world-leading core satellite infrastructure and technologies, including better GPS and satellite imagery across the whole country.

On its own, GPS typically provides Australia with positioning accuracies of five to 10 metres. Over the next four years, the government will make positioning data accurate to 10 centimetres everywhere in Australia through a satellite-based augmentation system. Areas with mobile coverage will have access to positioning data accurate to three centimetres thanks to the establishment of the National Positioning Infrastructure Capability.

A $37 million investment in Digital Earth Australia will give Australian businesses greater access to reliable, standardised satellite data that identifies physical changes to our environment on the ground.

These initiatives alone are game changers for many businesses that rely on this technology. Farmers will be able to cut costs and reduce waste by remotely tracking livestock and precisely targeting crops with fertiliser, water and pesticides. The Royal Flying Doctor Service will be able to land more safely in more remote locations. The world’s largest ships will have a quicker, easier and safer way to dock in busy ports like Sydney Harbour.

It will also enable the development of new technologies and businesses, such as autonomous cars.

The Australian Space Agency will ensure Australia is part of the new ‘space race’. Investing in our space industry is just one part of the Turnbull government’s plan to create new high-growth opportunities for Australian businesses. From the laboratory to the factory floor, the Turnbull government’s investment is helping create jobs for Australians right across the country.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/the-new-space-race/
Space: don't let the final frontier slip even further away
Kim Carr, 4 May 2018

Australia depends on satellite data for everything from defence surveillance and weather forecasting to restocking supermarket shelves and synchronising mobile phone conversations.

But for all of these things, it mostly depends on satellites designed, built and launched by others.

Yes, that has begun to change. Australia funded one of the satellites in the Wideband Global SATCOM (WGS), a system that gives the Australian Defence Force enhanced interoperability with the US and other allies.

The ADF also benefits from access to commercial satellites such as the Optus C1 and, potentially, from the work on cubesats undertaken by Australian universities.

But these developments haven’t altered the bigger picture, which is that Australia continues to be largely a free rider in space technology.

If the ADF and much of Australia’s industry, commerce and agriculture were suddenly deprived of the satellite access provided by governments and companies in other nations, principally the US, there would be chaos.

It may be objected that this is unlikely to happen, although in an increasingly uncertain strategic environment that cannot be said quite as confidently as might have been the case earlier in the decade.

In a conflict between major powers in the western Pacific, for example, competition for access to satellites would be intense.

Whether or not such a clash ever happens, the fundamental point is clear: Australia is vulnerable, militarily and economically, while we lack sovereign capability in space technology.

That’s the most important reason why we should develop a national space industry with the capacity not only to design satellites for our needs but to build and launch them as well.

Another reason, flowing from the first, is that by acquiring these capabilities Australia will be able to take a larger stake in the global commercial space industry, which is growing by 10% annually. At present the global industry is worth $420 billion, of which Australia’s share is only 0.8%.

Australia’s nascent space sector earns revenues of up to $4 billion a year and employs about 11,000 people. The Space Industry Association of Australia estimates that this could double within five years if there’s strategic leadership at the national level, including public investment measures.

This isn’t only about taking advantage of immediate commercial opportunities. Even more importantly, an expanded space industry would enable Australia to transform its broader manufacturing sector in line with the so-called fourth industrial revolution, or Industry 4.0.

This is crucial for both military and commercial applications of space technologies. Space-based systems are essential for Industry 4.0 capabilities that modern smart factories, which are integrated cyber–physical systems, depend on: big data, cloud computing, artificial intelligence and the internet of things.

The era of Industry 4.0 coincides with what Malcolm Davis, in his ASPI report *Australia’s future in space*, terms Space 2.0, the emergence of low-cost technologies such as the Biarri and Buccaneer cubesats developed by the UNSW/ADFA. This is a time of opportunity for a country such as Australia; what is lacking is action at the national level to ensure that the opportunities are seized.
That’s unlikely to happen while Australia remains one of only two OECD nations to lack a national space agency. The Turnbull government and the Labor opposition have both announced their support for the creation of such an agency, but to date the government’s announcement hasn’t been followed by specific details of when the agency would be constituted and what it would do.

Those details, the government insists, should wait until after the conclusion of a comprehensive review of Australia’s space industry capabilities. The review was supposed to be released in March this year, but at the time of writing there’s no indication of when it will actually appear.

The review, which is being conducted by an expert reference group chaired by the former CSIRO chief, Megan Clark, will no doubt do its work well. But enough is already known about what needs to happen for the space industry to expand. What is missing is the government’s willingness to act.

Labor has already outlined a plan for an Australian Space Science and Industry Agency to drive investment and coordinate action by industry, universities, research institutes and other government agencies. The agency would be advised by a Space Industry Innovation Council, and a Space Industry Supplier Advocate would be appointed to promote opportunities for Australian firms.

A Labor government would invest up to $35 million in an Australian Space Industry Program, with co-investment to be sought from industry and university consortiums. The program will consist of four Australian Research Council (ARC) space industry research hubs—to advance capabilities in space technologies—and two ARC industry training centres that would offer 25 industry-based PhDs.

All this could be done now, and we know that similar measures have enhanced innovation and productivity in other industries. Australia only needs to find the will to make it happen.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/space-dont-let-final-frontier-slip-even-away/

Space 2.0: building Australia’s strategy for space
Flavia Tata Nardini, 19 April 2018

Australia, and the world, is experiencing one of the most exciting revolutions of our time. The information age is evolving and we’re deep in the fourth industrial revolution, rapidly moving towards a society dominated by the internet of things (IoT) and artificial intelligence. This will be the most powerful revolution yet.

As we pivot towards a world where everything—from fridges to forests—will be connected to the internet, the dial will be shifted and our lives significantly affected. We’ll experience noticeable changes in the way we live, work and interact with each other. That will apply not only to individuals, but to businesses too.

The fourth digital revolution will no longer see individuals and businesses operating alongside devices. Instead they’ll be seamlessly and subtly integrated into our everyday lives. It’s here and it’s happening, but there’s a serious problem that we must address.

The world lacks the infrastructure to cope with the billions of devices that are set to dominate our lives. We need to build a better internet, one that fuses digital technologies. The first iteration of the digital age connected people. We now need an internet that connects not only people, but also things.

This is where the next wave in space industry comes in, one commonly referred to as Space 2.0. The first wave was very much dominated by government and authorities. The second will see the commercialisation of space, will be dominated by businesses and private companies, and will realise space’s potential to provide low-cost global connectivity.
This new era requires collaboration and partnership. No business, no matter how ambitious or determined, can do it alone.

In most cases, ‘commercialisation’ is linked to competition. But with space, collaboration and partnership is the only way forward. We mustn’t compete, but partner. Global connectivity is too big a job for any one business to handle alone. Engaging with corporate partners, educational institutes and industry leaders from day one is key for any organisation, commercial or otherwise, looking to be successful in the space industry.

A thriving space economy is starting to develop in Australia, and it’s about to accelerate. The federal budget this year will be the first ever that has a dedicated space budget, and that alone is a huge development. The money will go towards the Australian space agency, which in turn will attract overseas investment and talent, fuelling the local economy. Space 2.0 holds the potential to directly affect each and every Australian.

Space 2.0 isn’t just about commercialisation. It’s about future jobs, future skills and a new era of STEM education that will train the new employees that will staff space services. The Fleet Space Technologies mission control centre in Adelaide has already attracted some of the brightest minds in Australia, and the world. Having that talent on our own soil will sustain a healthy ecosystem of STEM expertise in Australia.

The past two years have seen a rapid advancement in the sophistication of Australia’s space operations. It’s therefore too easy to focus on the local effects that the Australian space agency and our commercial space industry have.

But we mustn’t forget the global potential. When we look globally, the effect is impossible to quantify. At Fleet Space Technologies, we’re trialling a precision agriculture project in Tasmania that could see farmers using nanosatellites to monitor irrigation levels via sensors on the ground.

Australia is a big country and the effect of precision farming in this country alone could be huge. But when you scale that effect globally, the opportunities to transform global industries—maritime, emergency services, agriculture, transport, logistics and environment—are extraordinary.
As we’ve seen with recent debates around technological advancements that were born in the digital age, their potential impact was only realised in hindsight. For some, the real awakening came almost a decade after the initial development of these new technologies.

I’d argue that when it comes to the next industrial revolution, businesses won’t have the privilege of hindsight if we don’t work rapidly to keep up with the growing presence of devices in our daily lives.

Without the infrastructure in place, businesses working with data will fail to keep up, and educational institutes will lack the expertise to train workers for current and future jobs. This isn’t a risk we can afford to take. For Australia to become a leader in IoT, we must have a space infrastructure to allow us to thrive.

Now is the time to put in place the societal and physical infrastructure to build the world of the future, one that is currently being driven by an exciting venture into space.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/space-2-0-building-australias-strategy-space/

The Australian Space Agency: rhetoric and reality
Brett Biddington, 27 April 2018

In September 2017, the Minister for Education and Science, Senator Simon Birmingham, announced that the Australian government would establish a space agency in 2018. The announcement was made to the global space community at the opening ceremony of the 68th International Astronautical Congress (IAC2017) in Adelaide.

Australia had a space agency from 1987 to 1996. Called the Australian Space Office (ASO), it was established by the Keating Labor government. Shortly after the Howard Coalition government came to office in 1996, the ASO was axed. The ASO and associated programs failed for numerous reasons, not the least of which was the ambivalence shown by Defence towards the office and its responsibilities.

The question now is whether the new agency will fare any better. There are three causes for optimism:

- There’s bipartisan support for the new agency.
- There’s much broader community awareness of the dependence that we all have on secure and assured access to services and data provided by satellites.
- Defence is engaged and supportive.

A reasonable expectation is that the agency will be funded and staffed to perform a series of essential tasks. It may also be funded and staffed to perform some discretionary tasks as well. The essential tasks relate to governance and regulation, nationally and internationally. They include:

- administering the Space Activities Act
- providing a degree of coherence and explicit coordination to the Australian government’s own investments in space capabilities
- representing Australia’s space interests at international forums devoted to space matters, including the UN Committee on the Peaceful Uses of Outer Space.

Four discretionary tasks that the agency might perform are:

- support for domestic space industry development in both upstream (space) and downstream (ground-based) elements
- support for space science and engineering research
- promotion of STEM education programs, using space topics as a learning vector
- development of public outreach programs that promote a better understanding of the outer space environment and of Australia’s interests and activities among the broader public.
The extent to which the new agency does involve itself with these matters will be a test of the real priority accorded to space matters, beyond the rhetoric and commitments made at IAC2017 by the government.

The agency is essential to the development of a domestic industry, but on its own will not be sufficient. Industry, including large companies, will need to step up and invest, and that won’t happen unless companies can see a path to profit within a reasonable period of time.

In recent years several small companies seeking to engage in upstream space activities have been founded in Australia. They’re taking advantage of technological changes, including the miniaturisation and commoditisation of electronics, sophisticated software, and new materials and manufacturing techniques to develop niche products and services. The commercial success of these companies will be determined by the extent to which they are successful internationally. The Australian market may nurture their development but isn’t large enough to ensure long-term and sustained success.

Furthermore, space companies seeking to develop technologies in Australia may well find their access to export markets limited by Australia’s export regulations, which are restrictive where space technologies are concerned. Export facilitation may become one of the most important roles of the space agency in support of the Australian space sector if the sector is to flourish.

Australia’s space engagement since the 1940s has been shaped by the country’s geography (location, size and population distribution), and tied to national security interests. Initially, Australia established Woomera to support the ambitions of the United Kingdom to develop long-range missiles. Since the 1970s Australia has hosted ground stations that support missile early-warning and intelligence gathering satellites vital to the security interests of the United States. More recently, Australia has installed ground-based sensors at North West Cape that contribute to the space debris monitoring system of the United States.

Defence and national security interests, at the heart of which is Australia’s alliance relationship with the United States, will be the dominant policy driver for Australian space activity for the immediate future. The bulk of the Commonwealth’s space investments are in Defence, notably a $3–4 billion investment in space-based remote sensing announced in the 2016 Integrated Investment Program.

The Australian Defence establishment is seeking to understand outer space both as a domain from which to influence maritime, land, air and cyber warfare, and as a warfighting domain in its own right. To acquire knowledge and understanding, even before contemplating space operations, Defence is making modest investments in cubesats. A civilian program is a helpful adjunct to these activities.

Australia’s geography will continue to be attractive and important as a location for ground stations from numerous nations, including the United States. Although Australian relations with China and Russia are presently strained, both may seek to install ground infrastructure in Australia in support of their space activities in future.

Ukrainian groups are known to be interested in an Australian launch site, and Brexit may also lead, in time, to closer cooperation with the United Kingdom on space projects. These possibilities may present opportunities for Australia to exercise middle-power influence in the space domain in its own interests and those, more broadly, of the global rules-based order.

Space technologies and capabilities are profoundly ‘dual use’. The new agency, by promoting civil and commercial opportunities, will establish a basis for defence-related space capabilities for the foreseeable future. There’s a risk that the potential of so-called ‘Space 2.0 technologies’ will be overstated by some who would put them at the core of an emergent Australian space sector. New jobs and innovation in the Australian market are more likely to occur downstream in the data processing and application domains than in the upstream satellite segment, which is where Space 2.0 technologies are concentrated. As a consequence, the new agency may face a significant challenge in managing expectations.

The most immediate challenge, however, will be to find a cadre of women and men who have the standing, connections, skills and knowledge to turn the rhetoric of the Minister’s announcement at IAC2017 into reality.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/australian-space-agency-rhetoric-reality/
Space 2.0—why it matters for Australia’s defence
Malcolm Davis, 30 April 2018

Some key events are looming in the nascent Australian space sector. Following the announcement in October 2017 regarding the Australian Space Agency, government is set to provide details about this new organisation, including its charter and funding.

The government is also studying findings of the 2017 Review of Australian Space Industry Capability, and this will likely guide the formulation of new policies and direct funding to stimulate this growing sector of the economy.

With these important developments in mind, if Australia is to seek a more meaningful role in space, then it’s important to get the right business model. In a recent ASPI Strategy paper, I strongly promoted the concept of ‘Space 2.0’ as the best path forward for Australia.

Space 2.0 has transformed the global space sector. Its growing emphasis on the ‘small, cheap and many’ in terms of satellite design challenges the traditional approach of relying on a smaller number of large, expensive and increasingly vulnerable satellites that must operate in an increasingly challenging and crowded space domain.

Space 2.0 emphasises much more cost effective and responsive space launch capabilities, best epitomised by Elon Musk’s SpaceX that now regularly launches reusable rockets. It’s about innovation by new companies in opening up new uses of space, such as the ‘internet of things’, the establishment of mega-constellations of small satellites to support a global ‘broadband in the sky’ (making NBN obsolete in a few years), or new uses of commercial earth observation to support rapidly developing economies.

Space 2.0 suggests a path for Australia that’s both affordable and can be developed locally. It also undermines the traditional justification for total dependency on foreign providers of space capability.

The business paradigm of Space 2.0 is akin to the business model of Silicon Valley and smartphone development. In the same way that mobile devices have rapidly evolved on a three-year cycle, Space 2.0 rides the wave of Moore’s Law, allowing smaller satellites to continuously exploit new technology to do more, at less cost, and benefit from the rapid refresh of technology and innovation. This phenomenon is occurring now, and it means the next decade will see the global satellite and space launch industry going through a rapid transformation.

Australia’s space agency must be savvy enough to identify, understand and surf that wave, rather than be left behind by choosing an increasingly outmoded Space 1.0 business model that is risk averse, slow to innovate and heavily regulated. Rather than be a ‘NASA down under’, the new space agency must instead let the private sector lead and fully support the rapid growth of Space 2.0 start-ups.

These can provide new services ‘downstream’ (the ground segment) to the end user, be it government, commercial companies or the private individual. They can also offer Australia the chance to begin developing its own sovereign space segment (‘upstream’), including satellites and ultimately, a sovereign space launch capability.

Getting the right approach is also vital for Australia’s defence and national security. Space is contested, congested and competitive, and a traditional Space 1.0 approach is increasingly incapable of responding to these challenges.

Space is contested because peer adversaries such as China and Russia are developing a suite of counter-space capabilities, including co-orbital and direct ascent anti-satellite weapons, as well as ‘soft kill’ counter-space capabilities based around electronic warfare, cyberattack and, potentially, directed-energy weapons.

Investment in or reliance upon the traditional approach of a smaller number of large, expensive satellites makes it easier for an adversary to threaten vital space capabilities quickly, and that could result in a sudden and catastrophic loss of space support. Conversely, the use of disaggregated space capabilities using large numbers of smaller, cheaper satellites that can be quickly
reconstituted makes it harder for an adversary to threaten a decisive counter-space attack, and reinforces deterrence and
dissuasion against such a threat.

Space is congested because of a growing amount of space debris that increasingly threatens to choke vital orbits and places vital
satellites at risk. There’s an urgent effort to find ways to clear space debris, and Australia plays a significant role in monitoring such
debris using ground-based space situational awareness.

As Space 2.0 is all about rapid innovation, finding a timely solution to space debris would suggest tapping the thinking of
commercial space actors to find new ways to solve this problem.

Space is competitive because Space 2.0, while opening up space to Australia, also allows the proliferation of militarily relevant
space technologies to a broader range of state and non-state actors in a manner that boosts their prospective military
capability. In doing so, our military–technological edge is eroded and the traditional market dominance of space powers is being
challenged. To mitigate risk, Australia needs to effectively compete in the global space sector. We can’t do that by embracing
outdated thinking.

With this challenging environment in mind, the space agency needs to develop effective space policy that isn’t just focused on
space science, or on supporting civilian space industry, but also manages the nexus between defence and civilian space activities.
Defence must be well inside the tent, rather than kept at a distance.

Firstly, the agency should consider the nature of Space 2.0 and how the ADF can exploit it, and also explore how our adversaries
might use it against us. Secondly, the space agency has to be bold, and not simply re-establish a traditional emphasis on the
ground segment in key defence missions. It’s time to do more than more of the same.

With this in mind, a key early policy debate in the new agency should be about how Australia can best contribute to deterring
and dissuading counter-space threats. Australia’s current activities in space surveillance should be the starting point for this
debate, which will encompass how Australia contributes to developing disaggregated space systems, and how it can best support
reconstitution of space support to key partners.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/space-2-0-matters-australias-defence/

Space: supporting intelligent decision-making in Australia
Naomi Mathers, 31 May 2018

The ability to make intelligent decisions is supported by access to timely, reliable, superior information. Access to superior
information gives businesses a competitive advantage and provides a strategic advantage to defence.

Space is an increasingly important source of information. Satellite systems support communication; positioning, navigation and
timing (PNT); and earth observation. This space-derived data is then combined with other data sources to deliver value across a
wide range of industries.

How do we ensure that Australia has access to the data that best serves our needs and gives our companies and defence the
strategic advantage we desire?

This is a complex question and one that the new Australian Space Agency has been tasked to answer. Any response must span all
three satellite applications and consider the needs of government, industry and defence.

Our ability to deliver and use superior space-derived information is related to our infrastructure and skills. It relies on our ability
to develop a user community that understands the sector’s needs, understands the strengths and weaknesses of the various
solutions, can provide the requirements for new solutions, and can integrate new solutions into their existing operations.
The most mature commercial market for satellite data is communication. Since the government first invested in infrastructure back in 1979 through AUSSAT Pty Ltd, the sector has grown to more than 21 companies active in commercial satellite communications (Communications Alliance). Optus Satellites now has more than 30 years’ experience in commercial satellite operations and employs more than 150 people in space-related roles. It currently operates five Optus satellites, two NBN satellites and 94 ground stations, hosts a payload for defence and has supported more than 90 international missions.

The future needs of the sector are being supported through groups like the Institute for Telecommunications Research and the development of optical communication systems at the ANU, UNSW and the University of Western Australia.

We’re also seeing the emergence of companies using small satellites. Myriota is deploying a network of low-power microtransmitters that transmit a narrow bandwidth signal to a constellation of small satellites in low-earth orbit. Optus and Myriota both use satellite communications platforms, but they serve different and complimentary markets. With high power and high bandwidth, Optus can deliver persistent video and internet services, whereas Myriota provides a low-cost solution to assist users to monitor distributed assets.

In the 2018–19 Budget, the government announced a $260 million investment in SBAS (Satellite-based Augmentation System), PNT infrastructure and Digital Earth Australia. The investment in SBAS and PNT will improve location accuracy in Australia from 10 metres to 10 centimetres, laying the foundation for the next generation of autonomous systems for agriculture, mining, aviation and more.

Australia doesn’t have any earth observation satellites. We access low- to medium-resolution imagery from satellites such as the ESA Copernicus and USGS Landsat constellations through intergovernmental agreements. The investment in Digital Earth Australia makes this archive available to government departments and industry free of charge, providing users with 10-metre-resolution optical imagery every five days.

Australia accesses high-resolution imagery through commercial arrangements with international providers. This gives us access to high-resolution optical and radar satellites from multiple countries on an as-needed basis.

However, Australia is the only OECD country, and one of few countries in the Asia–Pacific, that doesn’t have direct receiving stations for these systems. Without the ability to downlink data in Australia, we receive imagery six to 24 hours after submitting a request (compared to 20 to 40 minutes with direct downlink), pay higher costs, and can’t directly task the satellites.

Australia has access to broadband communication, and with the investment in SBAS we’ll have high-precision positioning. But due to a lack of infrastructure, our access to high-resolution earth observation data is slower and more expensive than other countries’ and we can’t directly task these satellites. If it was entirely a commercial decision, industry would invest in the infrastructure, but as with communications and positioning infrastructure, the benefactors are government, defence and commercial companies across multiple industries.

There are some exciting examples of how these systems are being used. The Australian Maritime Safety Authority uses Satellite AIS (Automatic Identification System) to track ships. exactEarth’s recent move from a constellation of small low-earth satellites to hosted payloads on more than 60 Iridium Next communications satellites will make it possible to track ships with a latency of less than one minute. Many Australian companies, including Geospatial Intelligence...
Pty Ltd, integrate AIS data, high-resolution radar and optical imagery, and other data sources to develop products and services for customers that need high-quality information quickly. With access to a ground station in Australia, this could include search and rescue.

This is an exciting time for the space industry as miniaturisation and improved computer processing are driving down the size, weight and cost of satellites and opening new possibilities for constellations of small satellites. However, the laws of physics still hold. The performance of these satellites is limited by the size of the instrument, the available power, the on-board storage, and the ability to launch and replenish constellations. Small satellites won’t replace large satellites, just as satellites won’t replace aerial observations, but a range of options are emerging that deliver greater capability and efficiency for users.

The real power is in the integration of multiple sources of information. Australia has an opportunity to become an intelligent customer and a sophisticated user. We can develop our own systems where the market doesn’t meet our needs and draw on all the available technologies to deliver a competitive advantage for businesses, and a strategic advantage to defence.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/space-supporting-intelligent-decision-making-in-australia/

How it started—Australia’s early days in space at Woomera
Malcolm J. Phillips, 2 May 2018

In the late 1950s, the relevance of space to many Australians was made clear by the launch of Sputnik 1 from the Soviet Union. In the next several years after the 4 October 1957 launch from the Baikonur Cosmodrome, the US and Europe developed similar space launch capabilities.

While the US created the National Aeronautics and Space Administration (NASA) and chose to go to the Moon, in Europe, the already active Blue Streak ICBM program was the basis for Britain and France agreeing in 1961 to join in the development of a multinational space launch program. This was known as the European Launcher Development Organisation (ELDO). Belgium, West Germany, Italy and The Netherlands also joined.

ELDO sought to develop a multi-stage launch vehicle, first named ELDO 1 and later renamed EUROPA-A. That vehicle consisted of the British Blue Streak first stage, a French second stage and a German third stage, with Italy developing a satellite as the payload.

The launch site for the missions was to be in Australia, at the Woomera Missile Range. Britain and Australia had used the range for military weapons testing since 1947. The EUROPA-A launch complex would be the one that had already been developed for the British Blue Streak project.

The Woomera Test Range was the only land-based test range left in the Western world capable of testing the next (or what is now termed the ‘fifth’) generation of weapons systems within a fully instrumented, land-based, specialised test and evaluation range. That redefined the future role and strategic importance of the Woomera Range Complex within Australia’s long-term Defence requirements.

ELDO began in June 1964 with the first launch of the EUROPA-A vehicle. That test successfully launched the EUROPA-A’s first stage. Two more similar launches of the first stage were completed in the next nine months.

With confidence building that a multi-stage vehicle could reach orbit, seven more launches were attempted. Two launches in 1966 with dummy second and third stages were successful. The following year, two launches with powered second stages and dummy third stages were attempted. However, both of those launches suffered second-stage separation malfunctions.

The final three flights were carrying satellites for the first time and had all stages active. None succeeded: in the first two launches, the third stage exploded, and the final launch didn’t achieve a suitable orbit to deploy the satellite.

After that, ELDO stopped launching from Woomera and developed a new launch site in French Guiana in South America.
Other programs continued work at Woomera. One of the landmark events was the launch of an Australian satellite, WRESAT, in November 1967 using a spare Redstone vehicle. Australia became the third country after the US and Russia to launch its own satellite.

Another success occurred in October 1971 when a UK satellite was launched from Woomera on the British Black Arrow. Weapons Research Establishment also tested the Turana target drone for the Navy out of Woomera, and also from Jervis Bay.

The global enthusiasm for satellites and the realisation that it was the lifeline to everything from weather monitoring to the emerging world of the internet led to the search for a continuing mission for Woomera.

One company that saw such an opportunity was Kistler Aerospace in the US. It had a two-stage reusable launch vehicle in development that could be reused 100 times. However, the company had problems in securing the US$1 billion in funds it needed for the project, despite receiving US$100 million from Northrup Grumman, and didn’t set up its program at Woomera.

The story of Woomera and missed opportunities in missile testing and space initiatives can be linked to the lack of political awareness of where this technical field was headed. From the beginning, the political will to take advantage of Woomera’s potential was muted. Voters saw little reason to prioritise funding to expand the facilities at Woomera or the programs using them, or to seek out new ways to use Woomera to further Australian space activities.

However, more recently Woomera has been ‘re-discovered’ by over 60 private start-up companies eager to implement their own space launch programs. Yet Defence is resisting calls to open up Woomera to commercial space activities because of sensitive military research and development occurring at the location.

The Turnbull government announced at the International Astronautical Congress in Adelaide last year that it would again launch a national space agency. That makes Australia the second-last OECD member to have its own.

So it would seem that, belatedly, both private industry and government are realising the importance of space as a sector of national development and growth. In that regard, there are unique capabilities inherent in the Woomera Range. The challenge for the federal government is to figure out how it’s going to balance military and civilian use within the facility.

Time will tell if—this time—the opportunities are realised.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/started-australias-early-days-space-woomera/

ADF space operations: re-focusing the military lens
Darin Lovett, 29 March 2018

‘Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.’

Giulio Douhet, The command of the air, 1921

Giulio Douhet was an early devotee of air power who championed command of the air as a necessary precursor for operations on land or at sea. While his prophetic ideas were vilified initially and resulted in his military court-martial, they eventually led to the recognition of air as a unique operational domain.

Today a comparable transformation is occurring in the way the Australian Defence Force and its allies view the space domain. Gone is a public policy narrative that espouses space as a sanctuary. It has been replaced by a more realist view—where it’s feared that space will now be contested, degraded and operationally limited.

The US, currently the world’s dominant space power, is wrestling with new strategy to address its perceived Achilles’ heel: an exquisitely engineered, aggregated and frangible space enterprise that underpins its techno-centric style of warfare.
Due to Australia’s reliance upon US space-derived services, any fragility in the US space enterprise portends a dark cloud for our own security. However, an opportunity exists for Australia to develop its own strategy for the space domain, helping deter bad actors while playing to our strengths.

Since Sputnik first ventured skywards in 1957, space has been a contested domain. As far back as 2001, the US Space Commission warned of a ‘Space Pearl Harbor’, and made major recommendations to enhance space security. Subsequent US commissions reinforced the need for change and unity of effort, but to little or no effect. But now a plethora of new entrants, disruptive technologies and congestion are driving the evolution of a new space security agenda.

In December 2017, the US established its inaugural four-star Joint Force Space Component Commander, with operational command for all joint space forces. This novel restructure parallels similar centralised roles in the air, maritime and land domains. Douhet would be pleased.

Simultaneously, the US has shifted from benevolently encouraging coalition participation to seeing allies as essential in preserving space as a global commons. Australia, for its part, has made robust efforts to revamp its doctrine, capabilities and approach to space.

A growing Australian Space Operations Centre (AUSSPOC) mirrors the role played by the US Joint Space Operations Command and other allied space operations commands charged with the same mission. Additionally, a fledgling Australian space cadre has effectively doubled over the last five years and continues to grow. Nonetheless, it pales in comparison to the US, which has a space command numbering over 30,000, including thousands of dedicated space career professionals.

Any conflict in space bodes ill for humankind. The characteristics of orbital dynamics entail that any defunct satellite or debris leaves a legacy for a thousand years and beyond. We have challenges, but there are also great opportunities.

Australia’s space security and contribution to security of the commons can be enhanced without the multibillion-dollar premium that funds legacy space capabilities. A whole-of-government strategy may not offer the cachet of large technological projects, but there are a number of avenues we can pursue that offer value for money.
First, space operational doctrine requires development and dissemination. Noting that space hasn’t been through a crucible of conflict like other domains, we can only explore the vagaries of operations through war-gaming and scenario-based simulations. From a national security perspective, problems in space are metaphorically—and physically—far away. Despite the robust Schriever wargame series and other exercises, space operations need intellectual investment and joint exercises to stimulate better understanding.

Second, continued integration between allies is required, moving beyond the Five Eyes community (Australia, Canada, New Zealand, the UK and the US) to encompass new entrants. Australia can utilise its regional position to build a multinational framework that also contributes to space security, as was suggested in ASPI’s recent report on Australia’s future in space, or to our space commons. Improvements rarely occur unless like-minded partners collaborate.

Third, broad policy options must be developed to guide government and industry decision-makers when it comes to space security. There are glaring holes in areas such as diplomacy, military response, policy and law.

Finally, a culture of space-mindedness is essential across all domains, and expertise from ethicists to engineers is required. The development of an interdisciplinary space cadre would expand from space operators presently stemming from a traditional air combat heritage to include intelligence, legal, engineering, policy and planning backgrounds.

Clausewitz once warned that ‘there can be no question of a purely military evaluation of a great strategic issue, nor of a purely military scheme to solve it’. Our present space power strategy is discordant, blurred as it is by a purely military lens.

A strategy integrating the broader elements of space power—government, military, industry and academic—would enhance Australia’s contribution to safeguarding this critically important domain.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/ADF-space-operations-refocusing-military-lens/

Three ways to improve our deterrence posture in space

Todd Harrison, 11 April 2018

From the beginning, space has been a contested domain and a warfighting domain. The first test of an anti-satellite weapon—the launch of a Bold Orion missile from a US bomber—occurred in 1959, just two years after Sputnik.

Throughout the Cold War, both the United States and the Soviet Union developed and tested a variety of anti-satellite weapons capable of holding each other’s satellites at risk. Thankfully, none of these kinetic weapons were used in anger, but the threat was ever-present. What has changed is our confidence in the ability to deter attacks against our space systems.

During the Cold War, national security space systems were protected by the cloak of nuclear deterrence because space was primarily used to support nuclear forces. But today, Australia, the United States and other allied nations use space to support operations across the full spectrum of conflict, from counterterrorism operations to high-end combat against a near-peer adversary.

Space gives allied military forces global reach, power and influence. But this dependence on space creates a vulnerability because our space systems aren’t protected across the full spectrum of threats. Conflict that begins or extends into space, particularly if it becomes kinetic, won’t end well for anyone.

Our primary focus should therefore be to deter conflict in space. There are three main areas where we can do more to improve our deterrence posture in space.

First, we need a clearer understanding and articulation of the thresholds for escalation in space, especially at the lower end of the spectrum of conflict. Ambiguous escalation thresholds can invite ‘grey-zone aggression’ in space, as we’re seeing occur in other domains today. Adversaries are probing at the seams and finding ways to advance their own ambitions without triggering direct, overt conflict with the United States.
What’s different about space is that we have little history to draw upon, and few widely accepted norms of conduct, to serve as reference points. It’s therefore in our interests to work with international and commercial partners to establish sensible norms of conduct and to abide by them.

Another complicating factor is that adversaries can use methods of attack against space systems that are difficult to detect and attribute, and that may have reversible effects. Examples include cyberattacks, as well as jamming and attacking systems with lasers. It’s nearly impossible to deter an attack if you can’t attribute the source of the attack or know with confidence that the effects being experienced are in fact malicious.

We can’t establish clear and credible thresholds without the ability to detect and attribute threats to our space systems in a timely manner. Australia plays an important role in providing space situational awareness and environmental monitoring for allied nations. Because of its geographical location, it can see parts of the sky that can’t be viewed from the United States or Europe.

A second area where we should focus more effort is the development of innovative space capabilities. The world is in the midst of a renaissance in commercial space, but it’s difficult to take advantage of these advances in commercial space technology if our militaries are tied to sclerotic acquisition policies. The cadre of space personnel—both civilian and military—needs to grow in numbers and be given more opportunities to deepen their space expertise so they can more effectively interface with industry and navigate the labyrinth of military acquisition processes.

The combined space cadre of the United States, Australia and other allied nations is relatively small, and it’s difficult to effectively and efficiently manage such a small workforce. Allied nations should therefore combine resources and develop a fully integrated joint education and training curriculum and expand opportunities for joint operational assignments.

A third and final area that needs more attention is the problem of communicating thresholds and capabilities. While certain aspects of our national security space systems must remain secret to be effective, too often the US military and intelligence community default to over-classification. Much of this is a cultural issue—the legacy of a time when space was primarily the domain of two superpowers and much of what occurred in space was opaque.

Times have changed, but our culture of secrecy hasn’t kept pace. Secrecy invites suspicion among our allies and partners and does little to deter our adversaries. The over-classification of information inhibits the ability of the US government to work with international partners and commercial firms, both of which can play an important role in improving the resilience of US national space systems. And just as important, over-classification is effectively an overhead tax on space activities, adding complexity and time to everything.

Another way to improve the communication of thresholds is to be more explicit with commercial space operators about how attacks on their systems will be treated. Without such clarity, commercial space operators may not be willing to accept the risks of doing business with the government in the event of a crisis.

One approach to consider is an indemnification program for commercial satellite operators (including international firms) that would cover losses incurred due to a conflict, in exchange for a commitment by these firms to prioritise US and allied government customers in a crisis. This isn’t something the United States can or should do alone—the participation and input of allies like Australia is essential to creating a credible and reliable working relationship with the commercial satellite market.

In conclusion, much remains to be done to improve our deterrence posture in space for the wide range of threats we face today. Australia and the United States have a long and rich history of working together in space on civil, military and commercial space programs. Building upon this legacy of successful cooperation, we can help ensure that space remains a peaceful domain that benefits all of humanity.

While there’s no guarantee that all adversaries can or will be deterred from attacking space systems, every effort should be made to raise the costs and reduce the benefits of doing so.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/three-ways-improve-deterrence-posture-space/
A capability conflux: on military space, cyber and autonomous modernisation

Greg Rowlands, 23 May 2018

‘The most important skill, which underlies all creativity and all scientific discovery, is the ability to find links between ideas that are seemingly unconnected.’

Theodore Zeldin

While at first glance space technology, cybersecurity, and robotics and autonomous systems (RAS) may seem to be focused, individual disciplines, they’re in fact inextricably linked and interdependent. This tapestry of systems is sewn together with a shared technological thread. The common thread is a network or, in communications engineering terms, the channel.

Each discipline is at a different stage of maturity and all feature growth trajectories with a myriad of latent technical pathways whose limits are bounded only by physics, imagination and the paradigm’s nature. The paradigm in this case is in relation to the future autonomous modernisation of the Australian Army, which was raised at recent public forums.

When it comes to acquiring smart military drones and robots in an era of machine-learning–enabled hacking and ‘Turing-like’ quantum code-breaking risks, proceeding carefully to avoid pernicious outcomes is warranted.

Much has been said about the fourth industrial revolution and artificial intelligence–fuelled hyperwar, but the magnitude of the capability implications is only just being recognised. Therefore the temptation for an organisation with finite resources to generate mass with machines is compelling. The foundations already exist given that unmanned aerial systems are already in service and, usefully, a cyber squadron is being established.

Moreover, in its 2016 Defence White Paper, the Australian government recognised the continuing expansion of space-based and space-enabled capabilities over the next 20 years, so space surveillance projects are in the acquisition pipeline to strengthen Defence’s awareness of space. To that end, Australian Defence sovereign space capabilities are being progressively enhanced through access to allied and commercial space-based capabilities.

However, the following scenario illustrates why space, cyber and RAS should ideally feature as an integrated strategy in the context of a militarised autonomous future:

Troops emerge from a landing craft accompanied by humanoid robot avatars. These avatars are unarmed, but carry ballistic shields, mine detectors and first aid equipment. Soldiers in Australia employ ‘telexistence’ to digitally port themselves into the robot avatars (T-RAV). This enables connected soldiers in Australia to interact with human soldiers in the landing craft via their T-RAVs’ real-time audio-visual and haptic sensor data relay. The avatars are controlled via small satellite (smallsat) links from Australia. These strategic links are protected by machine intelligence cyber software, quantum computer processing and digital hologram keys to mitigate hacking threats.

T-RAVs conduct high-risk support tasks, such as mine clearance, casualty evacuation or building entry. They also protect humans under enemy fire by using their ballistic shields in ‘Greek phalanx’ or ‘Roman testudo’ formations. Then as the landing operation unfolds, high-altitude surveillance drones transmit imagery via satellite data links to Canberra. Furthermore, the smallsats were launched from the Northern Territory before the mission after multiple coalition satellites ceased functioning. It was later revealed that the coalition satellites were jammed by electro-disruption devices secretly placed in co-linear orbits or were hacked with malicious cyber machine intelligence.

This potential futures narrative highlights several themes. Firstly, Defence is resolutely building expeditionary capability, so global reach supported by satellite networks for command and navigation, including joint drone coordination will be enduring.

Secondly, with increases in RAS operating at strategic distances and evolving threats to coalition space systems, Australia will benefit from an agile space capability to reliably support autonomous modernisation. Fortuitously, Australia is already working
closely with allies and partners to ensure such capabilities underpin the Australian Defence Force’s operational effectiveness. This effort is well received by allies who recently invited military space partners to contribute more.

Finally, it illuminates the network as an enterprise-level vulnerability, which is why concurrent development of machine intelligence-optimised cybersecurity underpins resilient space capability and reduces autonomous modernisation risks.

The common theme with disrupted coalition satellites in the scenario is that they were in the same orbit for years and didn’t have current cyber-intrusion defences in their system code or hardware. But tactical satellite launch via commercial space facilities from Australia enabled rapid smallsat insertion into selected orbits to support human-machine teaming. Australia’s imagined space capability also permitted smallsat deployment with recent cryptographic security measures engineered into them.

Accordingly, smallsats with both low signatures and leading-edge cyber protection enabled a more resilient space system to support the mission. It’s noteworthy that constellations of smallsats are considered more resilient than large traditional satellites because smallsats are difficult to detect and target.

Thus robust space architectures could become increasingly important as the internet of military things will evolve with more complex network nodes when RAS capabilities are introduced.

So an ‘evolution of autonomy’ will require increasingly more bandwidth, including potent ‘antidotes to attenuation’ and network speed to overcome the ‘inevitability of latency’.

Therefore a growing inventory of military platforms, including autonomous systems with multipath propagation links, will require space communications engineering efforts to configure an enterprise channel. The value proposition is that enhanced space assets could create secure, scalable and high-speed networks—or a global digital cloud (GDC)—especially in areas without fixed or deployed terrestrial communications infrastructure. Moreover, an expeditionary space-enabled network may provide strategic spectrum for responsive drone control and navigation at scale.

GDC could also deliver technology growth pathways for high data-transfer rates among increasingly sophisticated robotic systems with a ‘big-data’ security challenge.

Hence acquisition of enhanced space systems, including access to allied and commercial capabilities, in parallel with cyber and RAS modernisation, will develop a holistic space capability system. This integrated capability approach might avoid high re-engineering costs and mitigate potential RAS operating limitations in the future.

Consequently, systems design for a fifth-generation army must reconcile an emerging conflux of capability with space, cyber and autonomous modernisation. Optimal national security outcomes could depend on it.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/a-capability-conflux-on-military-space-cyber-autonomous-modernisation/

Balancing the risks and rewards of space
Richard Harrison, 8 June 2018

Recent years have seen an explosion of optimism around our ability to reach and exploit space, with a multitude of benefits apparent across all aspects of human endeavour. However the paradigm of ‘Space 2.0’ offers both risks and rewards, and shouldn’t be viewed as an unalloyed good.

The rapid and uncontrolled exploitation of new opportunities without consideration of potential consequences has the potential to aggravate the already congested and competitive character of the space environment, with risks to both Australia’s national interests and the long-term survival of the global commons of outer space.
Firstly, the sheer number of potential satellites planned will tax existing collision deconfliction and traffic management structures. On current forecasts, the number of active satellites will increase in the next decade, from approximately 1,800 to a number approaching 10,000. Within this range, a number of ‘mega-constellations’ are proposed, each containing thousands of satellites. Much of the explosion in numbers is forecast to occur within a fairly constrained orbital regime, within 1,000 kilometres of the surface of the earth.

Such developments may quickly overtake the current means of space surveillance, which is based around the independent verification of orbits by agencies like the US Space Surveillance Network, and in the future the US Department of Commerce. Increasingly, the best source of orbital information will be the operators themselves, which will require new ways of exchanging and verifying such data. Once exchanged, agreed norms of orbit maintenance and deconfliction measures will need to be established between operators. Additionally, the real-time monitoring and adjustment of constellations within a congested environment will drive a level of system autonomy currently unseen in current operations.

Added to this, the increasing miniaturisation of spacecraft—exemplified by the growth of ‘cubesats’—will challenge the ability of existing surveillance systems to track and identify objects in orbit. The distribution of missions across multiple satellites has meant a steady reduction in object size, while modular construction techniques will make more satellites appear alike to external ground- and space-based observers.

Miniaturisation and modularisation offer twin challenges—first the ability to detect and track objects, and second to characterise these objects and associate them with an owner-operator. For example, the bulk of the manifest for the record-setting launch of 104 satellites on an Indian PSLV rocket in February 2017 comprised essentially identical cubesats, which caused identification challenges when they separated from the booster.

These challenges drive a requirement for active identification methods, similar to the radio transponders used by aircraft. However, unless they’re motivated by an understanding of the benefits of ‘best practice’ space operations, owner-operators seeking to prioritise payload space on their spacecraft might treat such measures as being of secondary importance.

Finally, the shrinking costs of entry into space operations enable a range of new players with little or no experience to push the boundaries of missions, orbits and spacecraft design. This newfound access requires the space community to answer not only the question of ‘Can we do it?’, but also ‘Is it a good idea?’

Missions such as the crowd-funded ‘Kicksat’—which planned to dispense ‘chipsats’ the size of credit cards (while short-lived, these were essentially untrackable by existing surveillance sensors)—raise the issue of the bounds of reasonable operations in space. In a similar vein, the recent launch of US satellites (on an Indian launcher) that had been denied FCC approval to operate highlights at best gaps in current regulation, and indicates at worst a ‘Wild West’ mentality among some of those hungry to exploit new opportunities.

In combination, these challenges have the potential to place at risk the safe operation of other spacecraft, and by extension entire orbital regimes. As demonstrated by the accidental collision between an Iridium spacecraft and a...
decommissioned Russian surveillance satellite, damage to the space environment has the potential to remain a factor for many years to come. With a significant increase in the number of space objects, the risks of cascading consequences from one mistake (the so-called ‘Kessler Syndrome’) are also enhanced.

This isn’t to say that we should discourage space activities. Australia should take advantage of the opportunities presented by space, and where possible reduce the barriers to entry. But such measures should be tempered by sufficient regulation and norms of behaviour to minimise environmental risks, and to maintain the long-term viability of space operations. Thus, the management of space within Australia will need to not only consider the industrial aspects of space, but the safe operation of orbital missions.

The exploitation of new opportunities in space has the potential to significantly benefit many aspects of Australian society. However, like all the other global commons accessed by humanity, there are always risks to accompany the potential rewards. As space becomes more congested and competitive, it behoves us to manage our responsibilities properly to ensure that space remains a source of prosperity into the future.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/balancing-the-risks-and-rewards-of-space

Inspiring the next generation of space professionals
Geoff McNamara, 1 June 2018

To make a case for a scientifically literate population in a country that has just announced the creation of its own space agency is about as necessary as convincing people we need reliable sources of food, water and electricity. Clearly, we need to have a steady flow of people with sufficient science, technology, engineering and mathematics (STEM) skills to support industry. The source of those STEM professionals? Our schools.

Many of us born in the 1960s, were inspired by a steady diet of Apollo space missions and (quality) science fiction, and so were naturally drawn into the sciences. These days, we need to remain technologically literate at all levels and in all occupations or face the consequences. It’s no longer only a personal choice but also a national imperative. We must inspire generations of scientists and engineers. The question is, how?
The key is to increase engagement between high schools and the STEM community. The importance of schools is often simply overlooked by scientists and engineers. While ‘outreach’ by universities and government facilities is exceptional, there needs to be long-term one-on-one engagement between professionals and (targeted) young students, giving those students opportunities to work on extended projects in science and engineering.

Science Mentors is one program that addresses that need. It partners individual students with STEM practitioners in academia, government and industry. Students are guided through six-month projects by a mentor in the student’s preferred branch of science. The student and mentor design and perform an experiment that culminates in a formal, referenced and refereed report on the student’s findings.

Students learn valuable skills, such as how to gather data and state their hypothesis and how to state in mathematical terms the theoretical underpinning of their projects as well as to reference their own data or a reliable source in everything they write. In short, they’re made accountable for their claims.

The program targets students from Year 9. If we wait until students are in Year 12, it’s usually too late. By Year 11, most students have decided on their university degree and have chosen the courses necessary to gain entry.

After 10 years of development, Science Mentors caters for fields ranging from genetics to geology, physics to pharmaceuticals, and even rocketry. Experiments are typically done at the student’s school, though in some cases students attend week-long sessions at a university or an industrial laboratory because their projects require specialised equipment. The program began at Melrose High School in Canberra, but it’s about to be rolled out across the Australian Capital Territory. Currently approximately 100 scientists and engineers from academia, government and industry support the program.

Until two years ago, one branch of science was missing: astronomy. Then, the best a student could expect was to be plonked in front of a computer to download someone else’s astronomical data for analysis. This was frustrating. So I designed an astronomical teaching facility, which was funded by Denis and Vee Saunders, and hosted by ANU’s Research School of Astronomy and Astrophysics.

As the project developed, others donated equipment, expertise and time. The result is the McNamara-Saunders Astronomical Teaching Telescope (MSATT), which currently caters for a dozen student projects.

MSATT’s design is an important example of the philosophy behind Science Mentors. During the design phase, people asked if the telescope would be automated so that the kids could use it from school. That made as much sense to me as asking students to learn to bushwalk using the internet. I wanted the kids under the stars, in the dark and cold, choosing, attaching and calibrating whatever instrument was needed to work with the telescope. I wanted them to own the data, a principle common to all Science Mentors projects.

The results have been terrific. Here’s one example: a 14-year-old Year 9 student measured one of nature’s fundamental constants. I remember the look on her face as she sat in front of the small whiteboard in MSATT’s dome looking at her final answer: 323.906 537.7 m s⁻¹ (she was in Year 9, and we hadn’t covered significant figures yet.) That look was one of the most memorable expressions I’ve ever seen.

That number—her measurement of the speed of light—resulted from her observations of eclipses of Io, one of Jupiter’s moons, made over several months in 2017. It’s accurate to within about 8%.

She used the same data to calculate the mass of Jupiter, arriving at a result within 0.1% of the accepted value. That’s not bad for a 14-year-old who had never attempted such a thing before.

MSATT students are now learning lunar, planetary and deep sky imaging, photometry, spectroscopy and visual observation methods such as those used to determine the speed of light. There’s so very much more that can still be done, however. MSATT is one telescope: we need more facilities like it, including some for radio astronomy. We have the dreams; now we need commitment.
Science Mentors isn’t original. It’s based on the age-old apprenticeship model—which is simple, inexpensive and highly effective. It shows kids that STEM is hard work, yes, but also rewarding, substantial and fun.

That is critical because if we don’t nurture and inspire students today, we won’t have anyone to employ in our new space industry tomorrow.

And what of the young girl who calculated the speed of light by looking skyward? Not content with finding one of nature’s fundamental constants, she’s now learning planetary imaging in preparation for the 2018 opposition of Mars, an event that presents a fantastic opportunity to study the atmospheric and surface ice behaviour of the planet over four months. Who knows, one day she might even go there.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/inspiring-the-next-generation-of-space-professionals/

How education and outreach can inspire the next generation of space thinkers
Ingrid McCarthy, 6 June 2018

With the announcement of the Australian Space Agency, our space industry can start to focus on the opportunities and benefits that it will bring. No longer will the global space industry be the domain of overseas government agencies and multibillion-dollar budgets. Space is now part of the commercial sector and, as the price of participation falls, Australia will be well placed to be part of that.

Development of a domestic space industry will give Australia better access to the global industry, which is estimated to be worth $1.1 trillion by 2040. Around 10,000 Australians are already employed in the space industry, but many with expertise have left the country in search of work or are working outside of their areas of expertise so that they can stay in Australia. By 2030, however, the industry is estimated to have created around 20,000 high-paying jobs.

What this means is that Australia needs to develop a space industry-ready talent pool. We need well-educated young people with strengths in STEM (science, technology, engineering and mathematics), as well as people working on computer algorithms, space policy and ethics, law and finance. They need to be willing to learn new skills and embrace life-long learning as technology changes and improves.

The report of the review of Australia’s space industry capability, released in March 2018, recognises that we’ll have to work on our space jobs pipeline, both in schools and in the broader community:

**Recommendation 8:** The Government gives priority to strategies that enable: active engagement with Australian schools and the broader community on global space activities; space-related training and education to improve capability; space-inspired STEM outreach; and industry-led research collaboration to underpin the space industry.

Inspiring the next generation of space professionals obviously means that schools, early childhood education and extracurricular activities will play a vital role in engaging children with STEM early and sustaining that interest.

However, many believe that we’re almost at crisis point in our STEM education. Australia has declined in both absolute and relative achievement in science and maths.
Australia’s National Science Statement, released in March 2017, found that enrolments in STEM subjects were at the lowest level in 20 years.

Much is already being done to address these issues, and the space agency will have a role in promoting and coordinating the existing programs and resources, as well as identifying the areas in which there are gaps.

There are many programs that provide STEM course materials for teachers and K–12 students that link to the Australian curriculum and are, or could be, based on what we need for Australian space programs:

- Programs like the Australian Academy of Science’s Science by Doing provide investigative resources for earth and space.
- CSIRO provides activities and teaching resources in its Australian Telescope National Facility division.
- ARC-funded Centres of Excellence ASTRO 3D, CAASTRO and OzGrav are relating their cutting-edge research to programs and resources that help teachers link curriculum content to how space science is being done now.
- Programs like the University of Melbourne’s Telescopes in Schools, ICRAR’s SPIRIT, CSIRO’s Pulse @ Parkes and MSATT allow students to collect astronomical data, drive telescopes and complete astronomy projects before they reach university.

There are also many programs that strengthen the connection that young people have to space and give them more awareness of the breadth of career options that will be open to them, inspiring them to work towards a rewarding career:

- The YMCA Canberra Space Squad shows the best that Canberra has to offer for a career in space to students in Years 7–9.
- The National Youth Science Forum connects Year 11 students to institutions and businesses that are part of the space industry.
- The Royal Aeronautical Society partners with UNSW Canberra to run Cool Aeronautics to introduce schoolchildren (particularly primary-school age) and the public to the world and people of flying, aerospace engineering and space.
- The Australian Youth Aerospace Association runs the Rocket Project to showcase both the theoretical and practical applications of modern rocketry.
- The Young ICT Explorers is a competition that encourages school students to create an ICT project.
The space industry jobs of the future will also require 21st-century skills such as entrepreneurship, design thinking, and creative and collaborative thinking. Already there are great programs in place for that, too:

- Questacon’s **Smart Skills Initiative** is a suite of programs that engage young people in innovation, technology and design thinking through hands-on challenges, projects and workshops.
- Origin Energy’s **littleBIGidea** is a competition that focuses on new inventions by kids in Years 3–8.
- Lighthouse Innovation’s **Teen Startup Program** encourages kids to come up with a business idea and learn how to pitch it.
- Programs such as those run out of the **CBR Innovation Network** connect and support entrepreneurs, small and medium enterprises, and researchers through events and workshops.

There are many programs like these around Australia and new ones being created by government agencies, entrepreneurs and not-for-profits. The Chief Scientist has set up the **STAR Portal**, which enables teachers and parents to access all STEM resources and programs in one place. As new programs get developed, they can be added to the STAR Portal.

If we can provide the inspiration and the skills, both in schools and as extracurricular activities through the ‘gateway’ of space, Australia will be in an excellent position to provide the people power needed in the space industry jobs that are about to be created.


### A sovereign launch capability for Australia

**Scott Wallis, 7 June 2018**

A sustainable sovereign launch capability is essential for a strong and vibrant space industry. Without it, Australia lacks an essential component of industry integration and will always have to queue for a ride to space at a time and place not necessarily optimal for our economic or strategic benefit.

Like Australia, no country in Southeast Asia currently has a launch industry despite strong satellite development. Their need—like ours—is growing rapidly.

An Australian launch capability, in addition to supporting local companies, can generate significant direct export revenue. Canadian company Maritime Launch Services is forecasting eight launches per year at a cost of US$45 million per launch. Revenue earned from multiple sites and using different launch vehicles could amount to more than AUS$2 billion per year by 2025.

At least five Australian companies are developing vehicles to vertically launch satellites ranging in size from a few kilograms to hundreds of kilograms. All are seeking opportunities to launch small satellites and deliver the cluster of constellations expected to be deployed by 2025, and then replenish those every five to seven years. Worldwide there is intense competition among established and emerging launch vehicle builders.

New technologies such as the additive manufacturing (3D printing) of rocket engines and other parts could see manufacturing co-located with a spaceport, enabling rapid supply of vehicles—reducing build and transport costs. Recovering rocket stages and then refurbishing or recycling them will further reduce overall launch costs.

‘Horizontal launch’ of satellites from aircraft could be another option to achieve orbit, but aircraft limitations are likely to restrict payloads to small satellites weighing less than 500 kilograms. Another concept is that of ocean launches using floating rockets, an idea being pursued by Ripple Aerospace. A novel concept being developed by 8Rivers is a tube-launched electric rocket that leaves its power supply on the ground.
Forty US-based launch companies will participate in the recently announced DARPA Launch Challenge. Europe and Asia have a similar number of rocket builders. All in all, this is a very competitive industry, which is leading to a significant decrease in the cost to launch.

For Australia, space launches started in the mid-1960s with the launch of the Europa vehicles from Woomera. Twenty years later, governments across Australia looked to re-enter the space race, with sites considered in Cape York and in the Northern Territory at Darwin, Gunn Point, Point Stuart and Nhulunbuy. Since then commercial organisations have investigated establishing spaceports at Christmas Island, Woomera, Rockhampton, Derby, across Australia's southern coast, and at all the Northern Territory locations considered in the mid-1980s.

Today a spaceport and associated range are being developed in Arnhem Land 25 kilometres south of Nhulunbuy by Equatorial Launch Australia. Land has been leased, and agreements have been established with domestic and international organisations for the supply of rockets capable of lifting into orbit payloads ranging from three kilograms to more than 7,000 kilograms. Over the coming years, subject to regulatory approvals, there should be regular launches of satellites and spacecraft to deep space from the Arnhem Space Centre.

Establishing a spaceport requires careful consideration. Cost constraints mean that extant infrastructure needs to include an airport, seaport, weather radar, high-bandwidth global connectivity and mobile phone coverage. Low population densities help to lower risk and insurance costs, while quick access to hospital emergency facilities is required to meet safety requirements. A local skilled workforce can be a base to build supporting industries, but importantly, there's a need for demonstrated support from the community and traditional owners.

Open ocean next to a site is preferred to allow safe flight termination if there’s a malfunction, and for dropping stages in zones away from people. Marine reserves will limit most coastal site options, especially in eastern Queensland. Launch corridors over land are possible, but would require extensive consultation and agreements with governments and land owners over many years. Oil and gas infrastructure also restricts the potential for northerly blast offs from Western Australia and the Northern Territory.

The further a site is from the equator, the less benefit it gains from the earth’s rotation, which imparts increased velocity when launching to the east. To be competitive, higher latitude sites tend to specialise in launching north–south polar orbits, primarily for earth observation.

The equatorial low-earth orbit is a particular orbit of economic and strategic interest for Australia and our allies. Encompassing the equatorial zone between +/- 15 degrees, this orbit covers three billion people in Southeast Asia, most countries in Africa and South America, and many Pacific nations.

From a satellite operator’s perspective, a constellation flying in this zone only needs one-tenth the number of satellites of a similar global constellation—potentially an order of magnitude’s cost savings.

The global space launch market was valued at US$8.7 billion in 2016, and is projected to reach US$27.2 billion by 2025, a 15% compound annual growth rate. Globally this market is very strong, and the strongest projected growth is in the Asia–Pacific region.

Key factors driving the growth of the launch market are a rise in space exploration activities, technological advancements to develop low-cost vehicles, and an increase in demand for small satellites and constellations. On 31 August 2017 there were 1,071 active satellites. That could increase tenfold within five years (Table 1).
Table 1: Forecast satellite constellations derived from published sources

<table>
<thead>
<tr>
<th>Company</th>
<th>Satellite numbers</th>
<th>Purpose</th>
<th>Altitude km</th>
<th>Start</th>
<th>IOC</th>
<th>Life Years</th>
<th>Mass kg</th>
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<tbody>
<tr>
<td>OneWeb/OneWorld</td>
<td>648</td>
<td>Global WiFi/LTE/3G</td>
<td>1,200</td>
<td>2018</td>
<td>2022</td>
<td>7</td>
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<td></td>
<td>1,972</td>
<td></td>
<td>1,200</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>720</td>
<td></td>
<td>1,200</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>1,280</td>
<td></td>
<td>MEO</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SpaceX VLEO/Starlink™</td>
<td>4,425</td>
<td>Global comms/5G</td>
<td>1110-1325</td>
<td>2018</td>
<td>2024</td>
<td>100-500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7,518</td>
<td></td>
<td>335-345</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boeing V-band</td>
<td>1,396</td>
<td>Global comms/5G</td>
<td>1,200</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,956</td>
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<td>1,000</td>
<td></td>
<td></td>
<td>5</td>
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<tr>
<td>Telesat</td>
<td>117</td>
<td>Global comms/internet</td>
<td>2017</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LeoSat</td>
<td>108</td>
<td>Global comms/internet</td>
<td>2019</td>
<td></td>
<td></td>
<td>1250</td>
<td></td>
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<tr>
<td>O3b (Other 3b people)</td>
<td>44</td>
<td>Global comms/internet</td>
<td>8,036</td>
<td>2013</td>
<td>2021</td>
<td>700</td>
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<tr>
<td>Google</td>
<td>1,600</td>
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<td></td>
<td></td>
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<td>113</td>
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</tr>
<tr>
<td>Samsung</td>
<td>4,600</td>
<td>Global comms/internet</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sky and Space Global (Australia)</td>
<td>200</td>
<td>Global comms</td>
<td>LEO</td>
<td>2017</td>
<td></td>
<td></td>
<td>Nanosat&lt;10</td>
</tr>
</tbody>
</table>

From 2025, there could be a further rise in deep-space activities associated with off-earth resource extraction. That would produce additional strong demand for efficient equatorial launches of both small and large payloads.

There’s now growing momentum to create a sustainable, flexible and responsive sovereign launch capability that can underpin a globally competitive space industry in Australia.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/space-launch-in-australia/
Australia’s future in space

Peter Jennings, 13 June 2018

When I was the deputy secretary for strategy in the Defence Department, one of the things on my to-do list which never quite got done was to produce a public defence policy for space. Even back in palaeolithic 2009 it was slightly embarrassing that such a policy statement, classified and unclassified, didn’t exist. So many ADF capabilities relied on communications, IT, sensors and emitters that drew on systems operating in or through space. Indeed, wherever Defence links into Australia’s national infrastructure for logistic support, or engages with government decision-makers, or works with friends and allies, our complete reliance on the enabling effects of space systems is matched only by our utter vulnerability to those systems being damaged.

Why was I unable to produce such a policy statement? Looking back, four factors come to mind. One was the sheer number of players across the Defence tribes who felt they had a dog in the space fight. The department’s largest meeting rooms could be packed out with space stakeholders, typically at middle-level ranks, often individuals with very deep passions about the issues. In space, no one can hear you droning on relentlessly. While there were groups with interests big enough to block forward policy movement, the second problem was that no one section of Defence had enough control of space policy to champion change and spur faster policy development.

Third, notwithstanding the ‘critical enabler’ label that was attached to space, Defence’s senior leaders weren’t really galvanised by the issue. Not in the way they could be galvanised about the really big issues like platform acquisition or occupying floor space in the Russell headquarters. Space was ‘niche’—just like cyber used to be. And that was just inside Defence. Beyond the department was, well let’s call it Dimension X: an uncharted world of departments and agencies whose staff didn’t have security clearances (gasp!), bureaucratic decision-makers who were focused on economics (shock!) and politicians who didn’t think space was important (beam me up!). Policy phasers were set to stunned-mullet and had been locked like that for the better part of a generation.

Reading the excellent contributions to this series on Australia and space policy, one is entitled to hope that, in 2018, there are solid grounds to say things have changed for the better. By mid-year we’ll have an Australian Space Agency, which should aim to be the convening point for a national discussion on space policy, as well as a national champion and reasoned advocate for investment in and focus on space. There’s an emerging private-sector space industry and a range of affordable and scalable technology options that lower barriers to entering into space-related business.

Our contributors point to a confluence of technology developments, wrapping together the internet of things, artificial intelligence, autonomous systems and robotics into a slightly scary but very promising field. The good news for Australian entrepreneurs is that it’s smarts rather than scale which can get you into this business. Finally, there are one or two green shoots of hope that our major political parties are seeing the promise of more investment in space. There’s bipartisan support for the new space agency and for sustaining a meaningful defence industry base which will clearly be a central player in space technologies and systems.

A number of contributors, most prominently ASPI’s own Malcolm Davis, point to the reality that space is increasingly contested. In any substantial future conflict between major powers, it’s clear that space and cyber will be two of the earliest theatres of skirmishing as opponents look to disable each other’s military and national decision-making capabilities. In fact, cyber battles will probably occur over access to space and will use space-based communication systems themselves.

So a new factor driving national approaches to space is that all countries are faced with an increasingly stark choice to ‘use or lose’ their interests in space. Australia is acquiring at immense cost a fifth-generation-enabled defence force which, if we’re ever to fight with it, must have assured access to systems that rely on space. The US alliance provides fantastic access to key space systems; however, it could benefit from increased resilience from allied systems designed with it in mind. So a defence policy for space must set out how we’ll ensure that our forces have access to key systems inside our alliance with the United States and alone if necessary. (To give Defence credit, it produced a space policy in 2016—that’s one small step for planning.)
It could all still go wrong, though. First, the industry in Australia is incredibly small. Around 11,000 people are working in space-related businesses. To give you a sense of scale, the Department of Jobs and Small Business reports that 11,300 people worked as service station attendants in December 2017. Slightly more ominously, the same report recorded 11,900 motor vehicle parts and accessory fitters. By analogy it may be the case that our space industry sector is so far below critical mass that it might go the same way as motor vehicle assembly unless a transformative business development can break the industry out of a decaying orbit. Speculation that the Australian space industry will grow by three times its current size by 2030 to be worth $12 billion is just guesswork, although this growth rate doesn’t assume hyper-velocity expansion anytime soon.

I’m also not sure that Defence really has gotten over its tribalism or complacency about space, although I’d be happy to be corrected on this point. It’s one thing to talk the talk about a fifth-generation ADF, but quite another to galvanise delivering the enabling systems that are so space dependent. We are still too focused on platforms, which anyone can see when discussions turn to the number of Joint Strike Fighters or submarines Australia will acquire.

Critically, while many advocates of Australia acquiring space capabilities exist, along with advocates of an Australian space industry, there are very few who are suggesting that they might trade off other spending plans they have to actually acquire real systems with real money in real budgets.

More broadly, Australians have grown used to living in a just-in-time world for energy supply, logistics, power, heating and cooling to the point that it’s only when the lights go out in Tasmania or South Australia that people realise there’s a complex but imminently vulnerable interconnected system of supply and distribution that sets the rhythm of our lives. And so much of this depends on access to and control of space. While our military forces think about the implications of operating in a ‘day without space’, our politicians should ponder what a day or two without space would do for the quality of social harmony in Australia. If satellites go down and there are no others that can provide redundancy and resilience, how long would it take to turn our urban centres into end-of-days theme parks?

But let’s end on a positive note. The arrival of the Australian Space Agency is a very welcome development. Business is buzzing with the potential for expanding space-related work. Defence has never been better equipped with space-enabled platforms and technology. A gaggle of new technologies—from swarming drones to artificially intelligent autonomous systems to dairy herds linked to the internet of things—all push Australia closer to a new and different type of space age. The cost of entry to space has never been lower. More than ever there is promise and excitement in the space business and every opportunity for smart Australians to shape this future.

For print readers, the original piece with live links is at https://www.aspistrategist.org.au/australias-future-in-space/
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