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The Australian Defence Force and contested space

Malcolm Davis

August 2019

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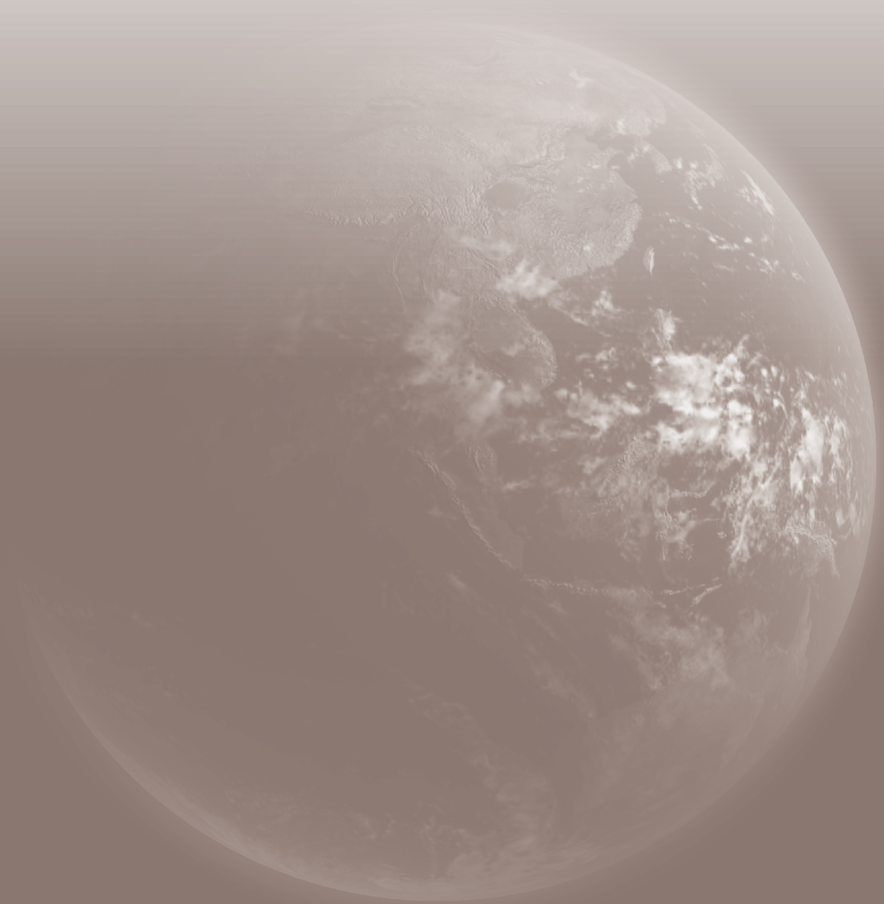

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EXECUTIVE SUMMARY

This ASPI Strategy paper explores the evolving threat posed by counterspace capabilities that are now appearing in the armed forces of major powers, notably China and Russia. Those capabilities are designed to deny access to vital space support that's essential for Australia and its allies in information-led joint warfare.

The paper considers the steps Australia needs to take in policy formulation and, by extension, capability development to meet this growing challenge. We must preserve freedom of access to space for our national interests and to support our armed forces.

Chapter 1 provides an overview of the importance of the space domain and examines how Australia uses and depends on space capabilities. This dependency spans joint and coalition military operations of the Australian Defence Force (ADF). The chapter explores both the space segment (the satellites in orbit) and how the ADF uses space, as well as the ground segment, and policy dimensions of space for the ADF.

Chapter 2 examines how the space domain is changing, using the 'contested, congested and competitive' model as a basis for analysis out to the 2028–2035 period. I consider the implications of major-power counterspace developments in detail. I also consider the implications of advances in space access and the reducing cost of accessing space from 'Space 2.0', which emphasises the commercial space sector over state-run space programs, for the future development of counterspace.

A key finding is that, while states such as China are developing a full suite of counterspace systems, they're likely to emphasise new approaches to counterspace operations that would enable 'grey zone' actions in orbit through dual-use capabilities, 'soft kill' systems and ground-based counterspace systems over traditional antisatellite weapons that generate clouds of space debris. China is developing the ability to rapidly attack US and allied (including Australian) critical space infrastructure prior to or at the outset of a future military conflict, in what amounts to the risk of a 'space Pearl Harbor' that would be designed to leave the US and its allies deaf, dumb and blind. Such an outcome would severely erode the ADF's ability to undertake information-led joint, integrated and coalition operations.

Chapter 3 considers how Australia should respond to the growing challenge of the emerging counterspace threat and a contested space domain. I recommend the development of a Defence space policy that's clear and coherent as a starting point, formulated by a government commission comprising a panel of experts drawn from Defence and the ADF and subject-matter experts and organisations outside of government. That policy has to focus on how Australia can make a more substantial contribution to developing a credible extended space deterrence posture, in which the ADF and Australia directly contribute to boosting space resilience via the augmentation, disaggregation and reconstitution of space capability.

Australia can't remain a passive observer and can do more to burden-share in orbit rather than only providing what the late Desmond Ball referred to as 'a suitable piece of real estate'. We must fully leverage the emerging potential of Australia's space industry sector and engage with the Australian Space Agency to acquire a sovereign space capability. Realising the vision of Australian satellites being launched on Australian launch vehicles from Australian launch sites, regularly and responsively, should be a key goal to strengthen Australia's contribution to building extended space deterrence with the US and other key partners across the Indo-Pacific region.

Chapter 3 also explores the potential case for Australia to develop its own counterspace capabilities as part of a deterrent posture and argues that we should hold open the option of developing soft-kill ground-based counterspace capabilities, such as electronic warfare, jamming and spoofing,[1] laser-dazzling and cyberattack capabilities. Such a step would complement the growth of the ADF's offensive and defensive cyberwarfare capability and would not violate current international space law. It would be done within an extended space deterrence context and contribute towards burden-sharing in orbit.

Chapter 4 concludes the analysis with specific capability recommendations emerging from this policy review. It reinforces the importance of Space 2.0 as a means for acquiring a sovereign space capability, emphasising that Australia can build its own space segment to complement US-provided high-end space capabilities in a high–low mix. Such an approach emphasises the need for a sovereign space launch capability for the ADF as an entirely new type of capability that contributes to the ADF's ability to burden-share in orbit. It highlights the importance of exploiting Australia's growing commercial space industry sector to provide capability for Defence, not only in satellite development but also in sovereign space launch capability, and greater investment in research and development of breakthrough technologies such as fully reusable space launch. I also recommend greater investment in an expanded network of space situational awareness (SSA) infrastructure, and support for a space-based SSA approach.

The chapter reiterates the need to explore a ground-based counterspace capability proposed in Chapter 3 and recommends the creation of new organisational structures within Defence to promote new policy and strategy development and to build a joint cadre of space expertise. It emphasises greater engagement with the Australian Space Agency as a means to best harness the emerging skills and capabilities of Australia's space industry sector to contribute to a more significant Australian defence space capability.

INTRODUCTION

> **The influence of space power upon history is already substantial and growing … [I]t has the potential to yield decisive advantage.**
>
> **—Professor Colin S Gray, 1998**

The end of the second decade of the 21st century is marked by the increasing prospect of major-power military conflict as the Western alliance system, led by the US, comes under increasing threat from rising and returning authoritarian peer adversaries, specifically China and Russia. Those states are challenging the US-led rules-based international order that's kept the peace (or at least prevented major-power warfare) since 1945. The shift towards a new era of major-power competition means that the international security outlook facing Australia in 2019 is the most precarious it's been since the end of the Cold War in 1991.

Most significantly, Australia finds itself on the front line of a new era of intensifying strategic competition between a rising China and the US, the outcome of which will determine the future stability of the Indo-Pacific region.

What's previously been seen as a distant adjunct to geopolitical rivalries—the space domain—is now a key operational environment in future major-power competition and possibly war. China's modernisation of the People's Liberation Army (PLA) continues to emphasise development of space capabilities as a key enabler for the 'informatisation' of its forces (US DoD 2019). Informatisation is the gathering, analysis and dissemination of information through networked systems of systems to wage informatised local war with a maritime focus at long range from the Chinese mainland. Space is crucial to the PLA's approach to integrated joint operations, directly supports PLA anti-access/area-denial capabilities and enables the long-range projection of Chinese military power in far seas and oceans. For China, space is recognised as a new centre of gravity, where 'whoever is the strongman of military space will be the ruler of the battlefield; whoever has the advantage of space has the power of the initiative' (Harrison et al. 2019:11).

China is promoting the rapid development of its space capabilities to support its terrestrial forces, while at the same time developing a comprehensive suite of counterspace capabilities that are designed both to deter threats to its own space forces and to deny space to its opponents. China recognises US dependency on space capabilities as an Achilles' heel—that is, as both a source of strength and a vulnerability. Denying the US and its allies access to space support would render them deaf, dumb and blind and unable to fully exploit their traditional advantages in information-led warfare.

Meeting this challenge demands greater cooperation to preserve Western access to critical space capabilities, including increasing burden-sharing in orbit. Australia is already a key partner for the US in preserving space security and stability, but we must step up to do more in this increasingly important role.

The Trump administration has made clear in its 2018 National Defense Strategy that maintaining strong alliance relationships is vital, and Australia's defence and security relationship with Washington is closer than ever (US DoD 2018). It's clear that the US isn't about to make a 'China choice' and grant Beijing a sphere of influence at the expense of its own interests or those of its key allies. However, the National Defense Strategy also makes it clear that the US expects its allies to burden-share to a greater degree in countering a rising China, and ensuring regional security and stability more generally, noting that 'we will provide allies and partners with a clear and consistent message to encourage alliance and coalition commitment, greater defense cooperation, and military investment' (US DoD 2018:9).

Australia's *2016 Defence White Paper* notes that the roles of the US and China, and the relationship between them, will continue to be the most strategically important factor in the Indo-Pacific region, but it also highlights other risks (DoD 2016a:2.14). The need to preserve the rules-based international order—itself under challenge from China and Russia—and the threat posed by transnational terrorist networks add to a deteriorating security outlook (DoD 2016a:2.19–2.27). To accentuate the risks, the Western alliance system that stood united during the Cold War is now eroding through a combination of uncertain leadership by the US under President Donald Trump and growing divisions within the societies of democratic states. As the challenge grows, the West is faltering (Dibb 2019).

Our immediate neighbourhood in the Southwest Pacific, as well as Papua New Guinea and Timor-Leste, faces growing security risks emerging from fragile social and economic structures, weak governance and the mounting threat posed by long-term climate change (DoD 2016a:2.35, 2.62–2.70). There's also a strong push by China to gain political influence in those states through debt-trap diplomacy, potentially leading to a Chinese forward military presence at dual-use ports and air bases. Such a development—if realised—would fundamentally transform Australia's strategic circumstances for the worse (Dobell 2018).

Historical concerns about the possibilities of tension with Indonesia have receded, and Canberra's positive defence relationship with Jakarta continues to deepen. The *2016 Defence White Paper* notes that 'Australia and Indonesia share many common security interests including a shared maritime border, a commitment to combatting terrorism, promoting peace and stability in our region and working to strengthen the regional security architecture' (DoD 2016a:2.82).

Most importantly, the White Paper highlights Indonesia's and Australia's common interests in pursuing a good relationship, noting that:

> a secure Indonesia is in Australia's interests and its growing military capabilities will offer Australia and Indonesia opportunities for more effective cooperation to respond to regional challenges, including terrorism, transnational crime such as people smuggling, and humanitarian disasters. (DoD 2016a:2.83)

As is the case with the Southwest Pacific, China is seeking to use soft power to gain influence across Southeast Asia in a manner that divides and weakens ASEAN and enables a greater forward Chinese strategic presence via its bases in the South China Sea (Shambaugh 2018, Heydarian 2017).

Far from being at 'the end of history' that was predicted at the end of the Cold War, we're in a period of intensifying strategic competition. Our critical alliance with the US and geostrategic location in the Indo-Pacific region mean that, in an intensified era of strategic competition between the US and a rising China, we're very much on the front line of that contest. There are other challenges and risks, but all are dwarfed by the prospect of intensifying US–Chinese competition. Within this emerging competition, the ADF is a key partner to the US military across all domains, including the space domain. This paper seeks to explain how we can do more to burden-share with the US in orbit and ensure our freedom of action in space.

Space is a war-fighting domain and, while the ADF doesn't seek to weaponise space, it does seek to set the conditions to ensure its access to this critical environment. Although space is a global commons—much like the oceans or cyberspace—it isn't a sanctuary that sits placid and serene, untouched by terrestrial geopolitical rivalry and conflict below. Space has been militarised since the dawn of the space age, and satellites have been used to support a broad range of terrestrial military tasks, notably nuclear command and control, since the early 1960s. Over the decades, the role of space has spread into other military tasks, with more ubiquitous satellite communications, advanced intelligence, surveillance and reconnaissance capabilities and, from the 1980s, global navigation satellite systems (GNSSs) such as the US Global Positioning System (GPS). As the technology of space has matured, the dependency of military forces on space capabilities has expanded, and more states are investing in such capability as a force multiplier. The growing dependence of terrestrial military forces on space support has incentivised the development of counterspace capabilities. Antisatellite (ASAT) weapons aren't new, and both the US and the Soviet Union were developing different types of ASAT capabilities throughout the Cold War. However, the US never operationally deployed such capability, and the Soviet Union had only a limited deployment of its ASAT systems from the 1970s.

The winding down of Cold War tensions and the role of arms control meant that counterspace development was practically stillborn by the late 1980s and remained largely moribund through to the early 21st century. China's test of an ASAT device in January 2007 fundamentally changed the debate over counterspace and brought the importance of such systems back to the forefront. The event overturned assumptions in Western states that they would have unchallenged access to space capability in warfare. With the accelerating counterspace programs that are now emerging in China and Russia, including the operational deployment of ASATs by China, and with the development of more sophisticated co-orbital and soft-kill counterspace capability underway, space is now moving from being militarised towards becoming weaponised.

The Australian defence policy community identified the potential risks of counterspace capability in the *2016 Defence White Paper* (DoD 2016a:52, 87), which stated:

> Some countries are developing capabilities to target satellites to destroy these systems or degrade their capabilities, threatening our networks. (para. 2.53)

and then went on to note:

> Satellite systems are vulnerable to space debris, which could damage or disable satellites, and advanced counter-space capabilities such as anti-satellite missiles, which can deny, disrupt and destroy our space-based systems. (4.15)

Since then, there's been broad policy consensus in Australia's defence policy community that the 21st-century space domain is 'contested, congested and competitive'. Space is 'contested' as ASAT weapons and other forms of counterspace capability, including soft-kill measures, emerge in the military forces of potential future adversaries. Space is 'congested' as a result of the rapid increase in manmade objects such as satellites and the growth of space debris, which act to complicate space operations and increase the risk of collisions in orbit. The use of some ASAT systems adds to the potential for congestion. Space is 'competitive' due to the increasing number of space actors—both nation-states and commercial entities—that are enjoying greater access to lower Earth orbits at lower cost largely due to the 'Space 2.0' transformation (Davis 2018a). This trend of access is potentially extensible into other orbits over the coming decades.

Western military forces (and those of our adversaries) are highly dependent on space systems to undertake military operations effectively. The ADF couldn't fight an information-based war that's fast and precise, and that minimises the risk of casualties among its forces and civilian populations, if it were to lose access to space systems. Instead, it would be forced to revert to a more basic industrial-era approach, which would bring higher casualties, prolonged hostilities and greater risk of defeat. We must learn from Viscount Bernard Montgomery of Alamein, who referred to the importance of gaining and sustaining control of the air, noting, 'If we lose the war in the air, we lose the war and we lose it quickly' (US DoD 2017:I-1). The same is true for the importance of ensuring and maintaining access to space.

In the past, Australia has accepted a high degree of dependency on the US for the provision of its space capability. Our lack of political will and awareness contributed to insufficient funding to develop our own space segment, such as space launch and satellite manufacturing infrastructure. Until recently, the cost of space technology was beyond our reach. Our most significant Defence space investment to date was in the joint production and operational partnership with the US centred on investment in the sixth Wideband Global SATCOM (WGS) satellite. Not only did this provide us with a proportional access to the WGS constellation, but we now host ground segment infrastructure supporting the WGS, and a significant ADF communications workforce embedded across the US Department of Defense. Similarly, for narrowband satellite communications, Australia and the US both benefit from sharing space segment capacity, the ADF contribution being capacity from its hosted payload on the IS-22 satellite (CASG 2014). That ground segment is still vital, and the space situational awareness component of Australia's military space cooperation under the Combined Space Operations (CSpO) Initiative is another important contribution to the US–Australia alliance.

But we can do more.

This report examines how the ADF can better ensure continued access to the space domain as it develops future capability and shapes its future force structure (Blain, n.d.). The report contributes to that process by examining the nature of the emerging space domain and considering future capability options for the ADF to ensure that it can continue to access this vital region and the essential capabilities within it.

CHAPTER 1

Why maintaining space access matters

Australia's reliance on space power for defence and national security purposes is very clear. The ADF depends on the full range of space capabilities to undertake essential tasks, ranging from the 'defence of Australia' mission through to joint expeditionary operations either independently or as part of coalitions.

Without access to space support, the ADF's ability to mount modern information-based joint and integrated military operations would be severely curtailed—it would be rendered deaf, dumb and blind—and the potential risks in our use of military power would rise. Rather than exploit information and a knowledge edge for gaining advantage over an adversary, the ADF would be forced into a more industrial-era contest of attrition, in which costs in friendly and collateral casualties would rise, and risks of failure at the tactical level could translate into defeat at the strategic level. The loss of access to space capability would rob the ADF of a means to fight war and conduct other military operations in a manner most conducive to likely success.

The ADF Joint Doctrine document ADDP 3.18, *The operational employment of space*, highlights the benefits offered through access to the space domain for the ADF in terms of 'space effects' that 'have permeated all aspects of Australian military planning from the strategic to the tactical level of conflict and impact the full range of military operations' (DoD 2010:1.40).

It notes that intelligence, surveillance and reconnaissance (ISR) satellites:

> have allowed Australia to observe its region in an unencumbered and timely way while the persistence of satellite coverage has allowed it to note long term trends in specific areas of interest. Information from ISR satellites has allowed Government to make informed decisions and shape its responses to a variety of environmental, economic, diplomatic and national security issues … High bandwidth satellite communication systems have allowed reliable, immediate and long-range dissemination of information while PNT [positioning, navigation and timing] satellites have allowed the military to accurately track the position of forces (including Blue Force Tracking) involved in an engagement and to accurately direct guided munitions. (DoD 2010:1.41–1.42)

An updated edition of ADDP 3.18 reiterates those points and notes that:

> the operational effectiveness of Defence is critically dependent on assured access to … space capabilities, without which the capability of Defence would be severely degraded. Defence's reliance on space capabilities will continue to increase, resulting in a growing demand for military and commercial space services and products, as well as space capabilities that are owned and operated by the Government or industry. (DoD 2016b:1.6)

It makes clear that without access to space the ADF wouldn't have the benefits of space power through the military use of space, including *global access and perspective* that enables a wide swathe of the Earth to be continuously observed from certain orbits; *persistence* through long-lived satellites in high orbits that can provide space support; and *precision* that delivers 'unprecedented levels of accuracy in the delivery of weapons, space-based mapping, and access to many Earth observation activities, including weather predictions, intelligence collection and communications network and transaction timings' (DoD 2016b:1.35).

Above all, space power provides two fundamental benefits that can't be enjoyed through any other type of military power. The vantage point of Earth orbit for satellites can give us a global perspective and persistent support while facilitating pervasive awareness, and space ensures better force integration across multiple domains within the joint and coalition battlespace to create maximum military effectiveness.

Understanding Australia's approach to space

The starting point for understanding Australia's approach to space is to examine the space segment and the key roles of space support provided by satellites. The first essential capability is satellite communications (SATCOMs). Although ADF operations within Australia can exploit national and military–strategic communications networks via landline or seabed cable, the ADF emphasises joint expeditionary operations as a key task, and those operations depend on space capability.

Satellite communications

Regional and expeditionary deployed forces are reliant on SATCOMs for both intra- and inter-theatre exchange of command and control, combat support and logistics information. As the ADF evolves towards becoming a fifth-generation force, this reliance will be amplified, particularly because of the high bandwidth demands of modern network-centric operations, the proliferation of uninhabited systems that are controlled via satellites, and the increasing distances between weapon systems and platforms beyond the range of tactical communication systems.

Australia doesn't yet build and launch its own satellites. Instead, we rely on formal agreements with allies and commercial partners (DoD 2016b:2.16). For example, we've provided the funding for the construction, launch and operation of the sixth WGS satellite—one of 10 that currently make up the WGS constellation (Deagel 2007, Davies 2015). In exchange for Australia's investment, the WGS memorandum of understanding (MoU) gives us 'assured access' to roughly 10% of the WGS capacity of a 10-satellite constellation (commensurate with the investment), including the embedding of 16 Australian Cooperative Project personnel in military organisations in the US under the WGS program. Five of the 10 WGS satellites are within view of Australia, providing a high level of redundancy across Australia and the surrounding region.

Australia also has access to Defence-owned payloads aboard the Optus C1 and Intelsat IS-22 commercial satellites, which provide the ADF with control of its own SATCOMs payloads, as opposed to depending on allied military satellites. Our arrangements with Intelsat General for IS-22 facilitated our ability to establish another MoU with the US for sharing ultra-high frequency (UHF) SATCOMs; in that arrangement, the US derives UHF capacity over the Indian Ocean from IS-22 in exchange for UHF capacity to Australia over the Pacific Ocean and globally.

Optus C1 is the predecessor to UHF arrangements for IS-22 and the UHF MoU with the US as well as the WGS; Optus C1 operates in the X-band, the military K_a-band and UHF but has a much smaller capacity than is provided by its successors.

Optus C1 was due to be decommissioned in 2020; however, Defence has extended the satellite's operational life of type by further contracting with Optus Satellite to operate it in an inclined state, extending its operation out to 2027 and beyond.

However, the capabilities available now from WGS and the UHF SATCOM arrangements will ultimately be replaced by new ADF SATCOM capabilities to form the Australian Defence SATCOM System (ASDSS) under program JP9102 from the mid- to late 2020s (Hose 2018). Under JP9102, the ASDSS will 'enable the Joint Command and Control of deployed Joint Task Forces through resilient and responsive communications beyond the range and capacity of other systems … from the mid-2020s onwards' (Brown & Hose 2019).

In considering the future shape of ADF SATCOMs, establishing future capability isn't just about physical hardware in the form of satellites and the ground segment. Australian SATCOM capability is divided into four segments: the space segment; the ground segment, which controls the operations of the satellites; a control segment, which manages the overall SATCOM system and is run from HMAS Harman, just outside of Canberra; and finally the user segment based around terminals within specific ADF platforms in the air, on and under the sea, and on land.

Filings

Equally as important as the four segments are filings, which are international legal approvals from the International Telecommunication Union for permission to operate in a portion of the telecommunications spectrum. In particular, it's important for Australia to gain and maintain precedence in filings to ensure that other nations must coordinate with us, rather than for us to be subject to the interests of other states, including potential adversaries such as China and Russia. The issue of filings will become ever more important as the expansion of the use of SATCOMs gains pace due to the introduction of 5G and the 'internet of things' and the growth of mega-constellations of satellites in low Earth orbit (LEO).

Gaining precedence in filings means that a state has up to three years to place a satellite in a specific location in space (normally in geostationary orbit, or GEO) before that location is given to another actor. To sustain precedence, a state already occupying that location must replace a satellite that's reached the end of its life within three years or lose precedence. Once precedence is lost, it's almost impossible to regain.

The issue of filings affects future capability planning as much as it's about ensuring freedom of action in space. In the case of Australia's access to the Optus C1 satellite, which was launched and activated in 2003, Australia has three filings across three bands: X-band (from about 8 GHz to 12 GHz), military K_a-band (from 27 GHz to 40 GHz) and UHF (300 MHz to 1 GHz). To maintain precedence in filings, Defence has extended the life of type of Optus C1 by changing its inclination in GEO and reducing the fuel used, while giving Defence more time to prepare future SATCOM capabilities under JP9102. Failure to do so would see either Russia or China take the GEO slot—the filing—occupied by Optus C1, and Australia would lose precedence to either of those two states, requiring coordination with, and permission from, Moscow or Beijing for operating ADF SATCOMs.

Positioning, navigation and timing

Positioning, navigation and timing (PNT), via GNSSs such as the US GPS, is just as important. The systems support precise navigation and manoeuvre in the battlespace, as well as enabling networked command and control of forces by managing data networks within the battlespace. PNT via GPS is also integral to guiding many weapons employed by the ADF.

ADDP 3.18 notes:

> In the military context, space-based PNT services provide precise positioning information for use by receivers which can be either hand-held or embedded in larger equipment. In addition to aiding ground-based positioning and navigation, PNT information is a critical enabler for the delivery of numerous types of precision-guided munitions (PGMs) including aircraft missiles, naval gunnery and land-based artillery shells. Synchronous timing provided by space-based PNT services is also a vital element of many military communication and information systems. (DoD 2016b:2.27)

Of critical importance is the timing component of PNT, which is essential to the functioning of modern digital command and control networks. Without accurate timing, information and data can't be sent across those networks, and this means that the effective functioning of the ADF would erode rapidly. The timing component is also essential beyond a defence and national security context and is critical to the functioning of modern information-based economies, stock markets, the internet and telecommunications.

Given the importance of PNT and the risk posed by deliberate interference with the provision of that essential capability, the ADF is focused not only on accessing and exploiting GPS, but also on developing an ability for 'navwar'—counternavigation warfare operations. Navwar:

> encompasses various offensive, defensive and support activities to ensure unimpeded availability of PNT information, and when necessary, deny PNT information to an adversary. Navwar is a cross-domain and cross-operational area capability enabled by taskable space systems, using the electromagnetic spectrum, civil–military unity of effort, and alternate sources of PNT information. (DoD 2016b:1.37)

Navwar incorporates aspects of international law and rules of engagement, an ability to track the jamming of GNSSs, and the development of procedures and capabilities to mitigate GNSS jamming that aren't solely dependent on GPS to function, and also by hardening command and control systems against GPS jamming. A key Defence project is JP9380, which seeks to understand GPS use across the ADF and look at commercial solutions to jamming threats (Brown & Hose 2019, Osley 2018). Both SATCOM and PNT systems are the responsibility of the Joint Capabilities Group.

Intelligence, surveillance and reconnaissance

The ADF also depends on ISR satellites through the Australian Geospatial-Intelligence Organisation (AGO) to support operations by ensuring timely and accurate understanding of the battlespace, including understanding of friendly and adversary deployments and the movements and activities of an adversary, and to directly support the planning and execution of military operations and the targeting of precision weapons.

Australia currently lacks its own ISR satellites and depends on the provision of space-based ISR through allied systems, notably US National Reconnaissance Organization systems, and also uses commercial imaging satellites to supplement military capabilities when necessary. AGO also uses satellite imaging to produce highly accurate geospatial data and mapping to support defence operations.

The *2016 Defence White Paper* and its accompanying Integrated Investment Plan highlighted the importance of accessing space-based ISR and, from June 2017, Project DEF-799 was established to improve Australia's space-based ISR over two phases. In Phase 1, Australia will establish a network of ground facilities and has signed agreements for more timely access to commercial imagery satellites (Pyne 2017; DoD, n.d.). Phase 2 will consist of a two-year study into costs and options for Australia to acquire its own space-based ISR capability from the late 2020s, with a budget of $4–5 billion (Brown & Hose 2019; DoD, n.d.).

In addition to the three key space support tasks—SATCOMs, PNT and space-based ISR—satellites perform other critical tasks for the ADF. Meteorological support has been one of the earliest military roles of satellites since the dawn of the space age, but increasingly satellites perform a variety of other environmental monitoring roles as well, including oceanographic monitoring and monitoring of the space environment in relation to space weather (DoD 2016b:2.55–2.65).

The ground segment

These capabilities in the space segment (sometimes referred to as 'upstream') are useless without ground facilities to manage their operations. The ground segment (or 'downstream') is equally as important. Certainly, it's in the ground segment where Australia has traditionally focused on acquiring sovereign capability, along with developing the regulatory environment to manage data and ensuring the provision of skilled personnel.

Satellite management facilities (tracking and satellite command and control facilities) are critical elements of space support, as they provide essential management and control of satellites in space and ensure that the satellites provide timely and accurate data to terrestrial users. They include the joint facilities at Pine Gap and North West Cape, which not only contribute to the critical mission of nuclear deterrence but also support US and allied global military operations by facilitating space-based ISR to terrestrial forces (Beazley 2017, Blaxland 2017).

A key role for Australia is SSA through space surveillance. The *2016 Defence White Paper* emphasised the importance of SSA by re-announcing (from previous white papers) that:

> In cooperation with the United States, Australia is strengthening its space surveillance and situational awareness capabilities. At the centre of this work is the establishment of the space surveillance C-band radar operated jointly by Australia and the United States, and the relocation of a United States optical surveillance telescope to Australia. Both assets will be located at the Harold E Holt Naval Communications Station near Exmouth in Western Australia. The radar and telescope will increase our capacity to detect and track objects in space, including space debris, and predict and avoid collisions. (DoD 2016a:4.16)[2]

US–Australian cooperation in SSA is managed under a partnership that incorporates sites as part of the global Space Surveillance Network, as well as No. 1 Remote Sensor Unit, which also operates JORN (the Jindalee Operational Radar Network), supports operations at the C-band radar and the space surveillance telescope, and participates in the Space-based Infra-Red System through an Australian mission processor (DFAT 2010, RAAF 2019:62). Australia's Southern Hemisphere location allows Australian SSA facilities—both government and commercial—to contribute to a global awareness of space traffic activity and a better ability to identify and respond to the risks posed by space debris and to understand potential counterspace threats.[3]

It isn't just Defence joint facilities that can contribute to the SSA mission. Commercial companies, such as EOS Space Systems, and the Space Environment Research Centre undertake the SSA task with space debris mitigation in mind (Bennett 2019, EOS 2019). The Australian Space Agency's new Civil Space Strategy reiterates SSA and space debris monitoring as a national civil space priority area (ASA 2019).

As noted above, SATCOMs also have a ground segment to exchange the large volumes of communications traffic between the satellites and terrestrial networks. Similarly to sharing the space segment, current Defence SATCOM is scoped to share ground segment infrastructure, such as the Combined Communications Gateway Geraldton (C2G2) to service satellites over the Indian Ocean (CASG 2017). On the east coast of Australia, Defence has invested almost a quarter of a billion dollars in a significant capability in the Kapooka Military Area capable of anchoring traffic from three significant multi-band WGS certified dishes.[4] C2G2 and Kapooka represent only a portion of the SATCOM ground segment. In 2017, the then Minister for Defence remarked that 'The Kapooka ground station will operate in conjunction with a satellite ground station in Western Australia to provide Defence with the level of wideband satellite communications, capacity and survivability needed in the future.'[5]

Governance and diplomacy

Australia's approach to space is divided among a panoply of groups across the Defence Department and the single coordination authority of the Australian Space Agency within the Department of Industry, Innovation and Science. Space governance is a key area in which streamlining and flattening of command hierarchies is urgently needed, particularly within Defence. There are many actors spread across a variety of policy and capability roles within Defence and an equal number of groups at the operational level within Headquarters Joint Operations Command (HQJOC) and extending into the Chief Information Officer Group with Satellite Communications Operations. What's needed is a consolidation of groups and roles to develop a new body—akin to US Space Command within the US Air Force—that leads to coherent and coordinated space policy development, capability management and operations reinforced by space capability acquisition.

ADDP 3.18 notes that 'ADF space capabilities are sourced and managed by a range of departments and are applied at various levels within Defence' (DoD 2016b:4.9–4.17). The Chief of Joint Capabilities is the capability manager for SATCOM as well as PNT. The Chief of the Air Force is responsible for air and space awareness, which includes 'space mission assurance and space situational awareness through intelligence derived from space-based intelligence, surveillance and reconnaissance capabilities'.

A key body is the Defence Space Directorate within the Joint Capabilities Group. The directorate undertakes international engagement with the US and other partners, facilitates training for the development of a skilled Defence joint space cadre, and advises Defence decision-makers on space-related capability development issues.

Doctrinally, there are also four main capability-specific Defence space working groups (focused on defence SATCOM, ISR, PNT and SSA), which report to the Defence Space Coordination Group within the Chiefs of Service Committee.

A key aspect of Australia's military space activities is ongoing high-level policy and technical support for US and allied space needs through the CSpO Initiative, which:

> afford[s] participating nations an understanding of the current and future space environment, an awareness of space capability to support global operations, and a military-to-military relationship to address challenges. (Pellerin 2014)

The CSpO Initiative, signed on 23 September 2014 in Ottawa, includes the US, Australia, Canada and the UK and focuses on the development of combined space operations, including SSA, force support, space launch and re-entry assessment, as well as on contingency operations. The initiative will see all partners share information on satellite orbits, work together on new methods to mitigate SATCOM interference, ensure GPS accuracy, and provide space weather data (Cheng 2014). Its goal is to 'enhance the resilience of space operations, and share the burden of conducting them, [and] collectively promote the responsible use of space through coordinated diplomacy'.[6]

The CSpO Initiative is built on three tiers of cooperation, collaboration and integration, determined by partner nations' 'capacity and willingness to share, their national security priorities, and their current level of integration in Joint Space Operations Centre (JSpOC) activities' (Pellerin 2014). Increasingly combined space operations among CSpO partners will allow timely and accurate warnings and assessments of threats to space capabilities, support to national users as well as joint and coalition forces, and an ability to protect and defend space capabilities. Overall, these goals work towards strengthening safety, stability and security in space, which aligns with a key goal of the Obama administration's National Space Policy released in 2010.

Alongside the activities of CSpO, the Australian Space Operations Centre (AUSSpOC) at HQJOC's Air and Space Operations Centre provides space awareness operations coordination for the ADF and support to allied forces, in conjunction with the US Combined Space Operations Center (CSpOC) and other allied space operation centres through the Global Sentinel program. The AUSSpOC provides 'timely and accurate space awareness support and advice to operations, exercises and activities across Defence, in cooperation with local and international military, government and civil organisations' (DoD 2016b:4, 18). Specifically, the AUSSpOC provides:

> analysis of satellite vulnerability reports for force elements in training or as deployed on operations and exercises; warning reports of space debris re-entry over areas of interest and liaisons with EMA [Emergency Management Australia]; monitoring of the impacts of space weather forecasts on operational space capabilities; dissemination of space situational awareness advice; and liaison with the US CSpOC. (RAAF 2019:83)[7]

Contrast this complex web of groups and bodies with the establishment of the Australian Space Agency, which manages Australia's civil space activities. The agency was announced at the International Astronautical Congress in Adelaide on 25 October 2017 and formally established on 1 July 2018 (DIIS 2018a, 2018b). It was established after a review of Australia's space industry capability published in March 2018 (DIIS 2018c). The agency isn't a 'mini-NASA down under' that manages an end-to-end taxpayer-funded space program. It doesn't build rockets and launch satellites. Instead, the Australian Space Agency's key role is to transform and grow a globally respected Australian space industry by:

> providing national policy and strategic advice on the civil space sector; coordinating Australia's domestic civil space sector activities; supporting the growth of Australia's space industry and the use of space across the broader economy; leading international civil space engagement; administering space activities legislation and delivering on our international obligations; and inspiring the Australian community and the next generation of space entrepreneurs. (DIIS 2019)

The Australian Space Agency has an important role in the coordination of space policy at the whole-of-government level, including coordination with Defence (ASA 2018). The main mechanism for coordination is the Space Coordination Committee, which functions as an interdepartmental committee and meets once per quarter. The agency engages primarily with the Strategic Policy Division within Defence, as well as the Defence Industry Policy Division and CASG. The goal of this engagement is to work with Defence to ensure that the space agency's activities support the space industry, are aligned and complementary at the whole-of-government level, and are to the benefit of Australia.

With this framework of space capabilities and organisational arrangements in mind, we now need to understand the challenges facing Australia in ensuring freedom of action in space and, specifically, the challenges posed by emerging counterspace capability. The emerging counterspace capabilities appearing in potential future adversary states—notably China and Russia—will demand that current space capabilities and space governance arrangements be reviewed and updated. The systems and policy arrangements noted above were established in a period when the space domain was largely benign. That the nature of the space domain has changed—and become much more contested, congested and competitive—is very clear. Defence must adapt to this new reality, which means that capability to preserve access to space and to deter threats must be acquired. As the space environment shifts from a benign, uncontested domain to a war-fighting domain, Australia's approach to the military use of space must also evolve if it's to remain relevant and effective.

CHAPTER 2

The contested space domain through to 2035 and beyond

It's worth restating that the space domain at the end of the second decade of the 21st century is 'contested, congested and competitive'. That message is vital to reinforce when thinking about the military nature of space. To underplay or dismiss that key message would be to promote a myth of space as a peaceful commons and leave Western states woefully unprepared for real challenges that are now emerging from authoritarian peer adversaries. Certainly, space is now a 'centre of gravity' in modern information-based warfare and a source of power and strength (Pollpeter et al. 2015). The critical nature of the space domain, and capabilities within that domain, mean that in future war directing power, energy and force against that domain, to deny it to an opponent while preserving friendly access, could generate strategic outcomes and rapid success on terrestrial battlefields.

Space is fast becoming a war-fighting domain in its own right.

This contrasts with previous decades, when space systems were seen primarily as an adjunct capability to operations in the traditional air, sea and land domains, and the presumption was that they would remain untouched by warfare below. However, China's test of an ASAT on 11 January 2007, which created a massive debris field, reawakened a focus on ensuring access to space and on the threat posed by adversary counterspace capability—a threat that had lain dormant since the Cold War. China's ASAT test was a warning shot that transformed the debate about the importance of and role of space and ended the comfortable assumption that US military forces—and those of its allies—would always have uninterrupted access to space capabilities, and thus be able to fight war in a manner most conducive to their success.

The growing importance of information systems, the essential need for command and control, ISR and PNT satellites, and the role that space plays in facilitating information-led operations accentuate the incentive for adversaries such as China and Russia to threaten the US's and its allies' satellites prior to or at the outset of a military conflict in order to deny them access to critical space systems. The result would be the US and its allies, including Australia, being unable to fight a 'Western way of war' that's fast and precise and seeks to gain and maintain a knowledge edge over an opponent as a key means to a quick victory.

Space is going to become even more contested between now and 2035 as adversary counterspace capabilities mature. China and Russia are both developing a suite of counterspace capabilities, including:

- direct-ascent antisatellite weapons (DA-ASATs) designed to be launched from the Earth and physically destroy a target satellite through kinetic or explosive mechanisms
- co-orbital ASATs that can manoeuvre close to a target satellite and then either destroy it through collision or disable it via a soft-kill mechanism such as electronic warfare or physical interference
- terrestrial counterspace capability, such as satellite uplink and downlink jamming and spoofing techniques, laser-dazzling and, ultimately, cyberattack.

China and Russia are the most advanced in capability development and have undertaken organisational reform, such as the formation of the PLA Strategic Support Force (PLASSF) in 2015 to manage space operations, and are developing conceptual thinking for space warfare (Pollpeter et al. 2017). For example, from 2010, China has operationally deployed DA-ASATs for targeting LEO-based satellites (Coats 2019). It's seeking to have the means to deploy other counterspace capabilities, including, potentially, the means to threaten US and allied satellites in GEO. It has undertaken the operational testing of co-orbital technologies, including mounting 'rendezvous and proximity operations' that demonstrate potential application in ASAT roles. The threat isn't just limited to major powers such as China and Russia. As counterspace technologies mature, the nature of some types of counterspace systems, such as jamming and spoofing systems, as well as cyberattacks, makes them more likely to proliferate to other state and non-state actors over the period through to 2035, expanding the counterspace threat facing the US and its allies.

If 'space power', as defined by the RAAF's *Air power manual*, is 'the total strength of a nation's capabilities to conduct and influence activities to, in, through and from space to achieve its objectives', then counterspace is the use of space weapons and space-weapons-related technology systems to interfere with a state's ability to exploit space power by disabling, degrading or destroying its satellite systems and satellite ground facilities, or denying access to space capabilities (APDC 2013:5.5). Both Australia and the US define counterspace in terms of offensive counterspace and defensive counterspace; their view is that counterspace integrates offensive and defensive operations to attain and maintain the desired control of and protection in and through space (CELC 2018, DoD 2016b:3.16). ADDP 3.18 states:

> Space control supports freedom of action in space for friendly forces. When necessary, it also supports defeat of adversary efforts to interfere with or attack friendly space systems and negates adversary space capabilities. The components of space control include offensive space control (OSC) and defensive space control (DSC). OSC [includes] measures taken to prevent an adversary's ability to interfere with or attack friendly space systems. DSC includes measures taken to preserve the ability to exploit space capabilities via active and passive actions, while protecting friendly space capabilities from attack, interference or unintentional hazards. (DoD 2016b)

Australia has to a large extent copied US counterspace doctrine rather than developing its own, so the Australian perspective is essentially the same as the US one. In work for the US's Secure World Foundation, Brian Weeden and Victoria Sampson refer to 'space control' as 'a set of capabilities or techniques that are used to gain space superiority', and they suggest that space superiority is the ability to use space for one's own purposes while denying it to an adversary (Weeden & Sampson 2019:xv). They also point to Chinese conceptual thinking on space control and space superiority, the latter of which Chinese analysts define as 'ensuring one's ability to fully use space while at the same time limiting, weakening and destroying an adversary's space forces' (Weeden & Sampson 2019:1-21).

The consequences of an effective offensive counterspace campaign against Australia would be severe. The ADF would be forced to rely purely on terrestrial capabilities for vital tasks. In some cases, such as secure global communications, timely ISR, and PNT, there would be no adequate or complete substitute, resulting in a very significant diminution of the ADF's overall military effectiveness.

Beyond the immediate military implications, any loss of access to space would severely affect Australia's national economic wellbeing and prosperity and, by extension, potentially our social stability.

In 2015, Wing Commander Darin Lovett noted that:

> The integration of spatial reference services [i.e. GPS] into societal subsystems is truly staggering. In just one application, precise positioning in agriculture has led to the automation of crop harvesting—a quantum leap in technology that brings industrial age capabilities of mechanisation into the knowledge age. Other examples include electronic switches, cargo movement, traffic safety, logistics tracking, just-in-time logistics, precision agricultural harvesting, and remotely piloted vehicles. Studies suggest modern societal systems would collapse as soon as three days after the spatial reference system was degraded, or as far out as 30 days. Whether the former or latter, the message is clear—space dependence underpins modern society. (Lovett 2015:74)

The logistical effects of a day without space would be immense, potentially disrupting the timely movement of critical goods (including food) to markets, but there would also be severe economic consequences as well as interruptions in communications. Once again, GPS is the critical node in the network. Its precision timing service is essential to the stability of stock markets and banking, the effective functioning of the internet, the functioning of air traffic control networks, and the availability of mobile phone communications, as well as in ensuring that essential services such as electricity are available to civilian populations (Tullis 2018, Holden 2012, Fernholz 2017). GPS jamming and spoofing are emerging as a key component in the suite of counterspace capabilities within reach of adversaries, and the low-tech nature of such systems makes them easier to proliferate to non-state actors, including terrorists (RNTF 2016).

What follows is a survey of key types of counterspace capability developments and a consideration of their operational implications.

Direct-ascent antisatellite weapons

The most traditional form of ASATs are DA-ASATs launched from Earth against a target satellite and designed to physically destroy the satellite through kinetic impact or by nearby explosion in a hard kill. This was the type tested by **China** on 11 January 2007 against a defunct Chinese weather satellite in LEO, the Fengyun 1C, at an altitude of 863 kilometres (Weeden 2010). This particular test generated considerable international opprobrium for Beijing, as it was the first ASAT test since the Cold War, breaking an unofficial norm against space weaponisation, and, more significantly, it generated a massive cloud of more than 3,000 pieces of space debris that remains a threat to other space objects in LEO today.

Since 2005, and continuing on from its January 2007 DA-ASAT test, China has undertaken multiple tests of a delivery system for a DA-ASAT. The most significant was on 13 May 2013, when it launched a DN-2 rocket that reached an altitude of 30,000 kilometres—almost to GEO at ~36,000 kilometres. This demonstrated China's potential for DA-ASAT delivery to this vital orbit, which is home to US and allied military communications satellites, and certainly covers other vital satellites in medium Earth orbit (MEO), including the US GPS network (Weeden & Sampson 2019:1-11).

Weeden and Sampson suggest that China has 'at least one, and possibly as many as three' programs underway to develop DA-ASAT capabilities, and that 'Chinese DA-ASAT capability against LEO targets is likely mature and may be operationally fielded on mobile launchers' (Weeden & Sampson 2019:1-8). They note that China's ballistic missile defence (BMD) capabilities for mid-course intercepts could also be used as DA-ASATs against LEO satellites. They argue that China's DA-ASAT capabilities against targets in MEO and GEO are still in development and say that there's not enough information to assess when such capabilities might be deployed operationally.

The 2019 Center for Strategic and International Studies (CSIS) *Space threat assessment* (Harrison et al. 2019) is broadly in agreement with Weeden and Sampson's *Global counterspace capabilities assessment* and was released at roughly the same time. They refer to the US Director of National Intelligence's 2019 worldwide threat assessment, which states that the PLA 'has an operational ground-based ASAT missile intended to target low-Earth-orbit satellites, and China probably intends to pursue additional ASAT weapons capable of destroying satellites up to geosynchronous Earth orbit' (Coats 2019:17). The CSIS analysis notes that:

> A kinetic ASAT attack in GEO could be devastating for the United States and other space-faring nations because the debris it would produce could linger for generations in this unique region of space and interfere with the safe operation of satellites. (Harrison et al. 2019:12)

Weeden and Sampson's analysis (2019:1-12) suggests that this missile could reach operational status between 2020 and 2025. Subsequent Chinese DA-ASAT tests occurred in 2014, 2015, 2017 and 2018 and demonstrated a dual-role mid-course BMD/ASAT capability.

Russia is also developing its own DA-ASAT capability, although key sources suggest that it's some years behind China in developing a DA-ASAT capability against LEO satellites, let alone the more sophisticated delivery of a hard kill against satellites in MEO and GEO (Weeden & Sampson 2019:2-9–2-12). As with China, Russia is exploiting the inherent dual-role potential of mid-course BMD systems to have a secondary DA-ASAT role, at least against LEO-based satellites, with its S-500 missile defence and long-range air defence system. Weeden and Sampson suggest that Russia has two main DA-ASATs: the Nudol missile, which is launched from a ground-based trailer-erector-launcher vehicle and can reach targets in LEO, and the air-launched Kontakt missile, which is designed to be launched from a MiG-31BM Foxhound aircraft and also be targeted against LEO-based satellites.

Neither system is yet deployed, but the Nudol has been tested seven times, most recently in December 2018 (Podvig 2019). Weeden and Sampson also note that there's some consideration for arming Nudol with a nuclear warhead to increase its lethality, including through space-based electromagnetic pulse effects.

The second system—Kontakt—would potentially have the ability to launch surge attacks against a large number of LEO-based satellites over a 24-hour period with little or no warning (Podvig 2013). According to US intelligence sources, Russia seeks to have the Kontakt system ready for operational deployment by 2022 (Macias 2018).

Most recently, **India** tested its own DA-ASAT with a hard-kill capability against a previously deployed Microsat-R target satellite (Davis 2019a). In Mission Shakti, the Indian test on 27 March 2019, a DA-ASAT struck the Microsat-R, which was orbiting at 300 kilometres. Like the earlier Chinese test, the Indian test created a cloud of space debris. Although much of the Indian debris will re-enter the atmosphere more rapidly than the Russian debris due to the lower altitude of the target satellite, a significant portion of it has been thrown up into higher orbits where it's likely to remain for 18 months, increasing the risk to LEO satellites, including the International Space Station (Lewin 2019, Hose 2019).

It isn't clear whether, having demonstrated a DA-ASAT capability, India will continue to develop this into a fully operational system, or whether the test was more for political reasons. Certainly, India was sending a strong message to China, as well as Pakistan, that it won't accept threats to its space capabilities and that it has the ability to strike back and thus deter any ASAT threat that emerges, particularly one from Beijing. The Indian ASAT test also played into domestic politics during an election season after a tense confrontation with Pakistan over the February 2019 Pulwama attack, in which 40 Indian police officers were killed (Davis 2019a). Finally, the Indian test may be placing a marker in emerging discussions over space arms control to ensure that India has a seat at the table in negotiating future agreements.

North Korea also has a potential DA-ASAT capability through employing existing ballistic missile technology as a foundation, but there's broad consensus that, at the time of writing, North Korea hasn't tested or indicated that it's attempting to develop either a direct-ascent or a co-orbital ASAT capability (Harrison et al. 2019:32, Weeden & Sampson 2019:5-1). Given the developmental stage of North Korean nuclear and ballistic missile capabilities, and its limited basis for developing new weapons (it lacks the high-tech military–industrial capacity needed for ASATs and the money to fund advanced technology programs), it seems more likely that Pyongyang will focus on nuclear weapons delivery systems and perfecting the warheads to go on long-range missiles, rather than ASATs. As I note below, however, other approaches to counterspace, including cyberattacks on satellites, may allow North Korea to bypass DA-ASATs and instead emphasise soft-kill methods.

In closing this overview of DA-ASAT systems, I stress that mid-course BMD interceptor missiles have an inherent dual-role capability for both defending against ballistic missile attacks and, potentially, striking satellites in LEO. This was demonstrated by the **United States** on 20 February 2008 in Operation Burnt Frost, when a US Navy Ticonderoga-class guided missile cruiser launched an SM-3 missile to destroy a malfunctioning satellite that was threatening to re-enter Earth's atmosphere in an uncontrolled manner, potentially releasing toxic chemicals over populated areas (Petrucci 2017, Galdorisi 2013). Weeden and Sampson (2019:3-9) highlight that the emerging US BMD architecture, comprising sea-based SM-3 missiles on Ticonderoga-class guided missile cruisers and Arleigh Burke-class guided missile destroyers and ground-based interceptor missiles, can be employed in an ASAT role.

They argue that, given the growth of this architecture, the US is better placed to hold at risk Chinese and Russian satellites in LEO in a future conflict using BMD interceptors doubling as DA-ASATs.

However, it's not at all certain that such an outcome, as implied by Weeden and Sampson, would necessarily emerge. Operation Burnt Frost took months of planning and required specially adapted SM-3s. Every SM-3 tasked for an ASAT role is one less available for a BMD role, and it's likely that the US would place greater emphasis on defending US cities against an adversary's nuclear forces than on shooting down satellites. It would certainly be wrong to imply that, given existing US BMD architecture, this automatically means that the US somehow has superiority over Russia and China in DA-ASAT capability.

Operational implications of DA-ASAT systems

DA-ASAT development has been the traditional path for states seeking to develop ASAT capabilities. However, the effects of hard-kill systems, which employ either kinetic or explosive methods, which in turn generate large clouds of space debris, are making such systems less appealing. Certainly, China and Russia continue to develop DA-ASAT systems, yet there's greater risk in using such capability because physically destroying an adversary's satellites will result in space being denied to all, rather than just to one's opponents. Furthermore, the technology to develop a DA-ASAT capability that targets satellites in higher orbits beyond LEO, notably to attack US GPS and missile early-warning satellites in MEO and communications satellites in GEO, is demanding. China seems to be the most advanced in developing such a capability, but it's some years away from being able to deploy it operationally. If China does eventually deploy a GEO-class DA-ASAT, it's not clear how such a system would benefit Beijing, because an attack in GEO would quickly produce a cascading spread of space debris across the entire GEO belt, destroying Chinese satellites as well as those of China's opponents and third parties. The result would be the denial of GEO to all, potentially for generations.

DA-ASATs thus represent a threat primarily to LEO-based satellites, and notably to the ISR systems that are vital for US and allied forces gaining and sustaining a knowledge edge. Yet the potential for soft-kill systems, together with the possibilities offered by ground-based directed-energy weapons such as lasers, as well as cyberattack, are more likely to be key features in the next decade of adversary counterspace capabilities. As I note in the next section, the dual-role nature of co-orbital systems, which can have legitimate applications for commercial space but can also offer counterspace capability, raises the prospect of grey-zone operations in orbit, while the scalable and reversible effects of soft-kill systems means that more sophisticated co-orbital and ground-based counterspace systems allow the prospect of deniability and anonymity, which are important for hybrid space warfare. It's in these co-orbital and soft-kill systems that China and Russia, and others, are rapidly making progress, and those systems represent the greatest threat to US and allied space access simply because they're more usable.

Co-orbital ASAT, ground-based counterspace and the challenges of grey-zone operations in orbit

The US, China and Russia have all undertaken a range of activities with orbital vehicles that have included close rendezvous and proximity operations (RPOs). RPOs could be explained away as tests of technologies for the emerging on-orbit refuel-and-repair sector of the commercial space sector, or as the use of orbital vehicles for space-based SSA and intelligence gathering. Those are legitimate roles, but RPOs can also be applied in a co-orbital ASAT role.

Unlike DA-ASATs, co-orbital ASAT systems are better suited to non-kinetic kill mechanisms that leave a target satellite intact and avoid creating clouds of space debris. In particular, co-orbital RPOs can exploit electronic warfare, high-powered microwave weapons, jamming or physical interference to generate scalable or reversible effects that can disable, damage and disrupt a target satellite, rather than only destroy it.

The same can be implied for ground-based counterspace systems, such as blinding lasers, uplink and downlink jamming, spoofing, and cyberattacks on satellites, and those capabilities are now appearing as part of the ensemble of counterspace technologies being developed by China and Russia.

Since 2010, China has undertaken a series of demonstrations of co-orbital systems, which Weeden and Sampson have described in detail in their 2019 *Global counterspace capabilities assessment*. While China has claimed that the demonstrations were for civilian applications, they show that Beijing is developing the means to have a co-orbital ASAT capability if it chooses to do so.

On 15 June 2010, China launched the Shi Jian-12 satellite, which initiated changes to its orbital trajectory over a period of weeks through to 16 August to bring it into a close approach with another Chinese satellite, the Shin Jian-06F, which had been launched on 5 October 2008. The closest approach of less than 300 metres was on 19 August (Weeden & Sampson 2019:1-2). As part of these manoeuvres, the two satellites gently bumped into each other.

In 2013, China deployed three satellites (Shiyan 7, Chuangxin 3 and Shi Jian-15) on what it described as a test of on-orbit maintenance (Weeden & Sampson 2019). From 2013 to 2015, the three satellites made a series of manoeuvres that were RPOs with each other and with another Chinese satellite (Shi Jian-7). Shiyan 7 was equipped with a robotic arm, while Chuangxin 3 carried a space surveillance sensor.

In 2016 China launched the Aolung 1 satellite, which was described as an 'advanced debris removal vehicle' and was equipped with a robotic arm, which raised concerns that it was a covert co-orbital ASAT.[8] Certainly, the idea that this spacecraft was for legitimate debris-removal purposes is open to challenge, given the sheer volume of space debris and the number of such spacecraft that would be needed to reduce it significantly.

A much more significant event was the launch of the Shi Jian-17 satellite, which, after being launched on 3 November 2016, demonstrated four RPOs in GEO between November 2016 and April 2018 (Clark 2018). This was followed by the Tongxin Jishu Shiyan (TJS-3) satellite, launched on 23 December 2018, which also demonstrated RPO capabilities for GEO.

The Chinese RPO activities in GEO are significant. First, they're being promoted as entirely legal commercial activities. Certainly, they do fit the types of operations that would be associated with on-orbit refuel and repair, which would require close approach and ultimately docking, or at least grappling using a remote manipulator system similar to the one on Aolung 1. They would also be consistent with space-based SSA and intelligence-gathering tasks. This is something the US has done in the past with its XSS-10 and XSS-11 satellites, and also probably does with the much more advanced X-37B spaceplane (Davis 2016).[9] So China and Russia, which has also experimented with co-orbital RPO capability (Weeden & Sampson 2019:2-4–2-8), can legitimately perform commercial and civil tasks in space, but that capability can be quickly retasked for co-orbital ASAT roles if necessary. Weeden and Sampson note that:

> While the known on-orbit activities of SJ-12, SJ-15, SJ-17, and TJS-3 ... did not include explicit testing of offensive capabilities or aggressive maneuvers, it's possible that the technologies they tested could be used for offensive purposes in the future. One potential offensive use would be to get a radio-frequency jammer close to a satellite, thereby greatly amplifying its ability to interfere with a satellite's communications. (Weeden & Sampson 2019:1-8)

Weeden and Sampson (2019:1-8) argue that the slowness of co-orbital RPO manoeuvres means that the 'warning time of such a close approach would likely be at least hours (for LEO) or days (for GEO) unless the attacking satellite was already in a very similar orbit'. The slowness of co-orbital ASATs, and the uncertainty over whether a satellite or vehicle will be performing a legitimate commercial task (on-orbit servicing) or will suddenly be employed in an ASAT role, open up the prospect for grey-zone actions in orbit. This is a much more likely scenario for the employment of counterspace capabilities before or at the outset of a major-power conflict than the very visible use of DA-ASATs, which would be quickly and publicly attributed to one state.

For example, China could reasonably declare that it has an interest in pursuing a commercial on-orbit refuelling-and-repair capability as part of the civil side of its space program. This would be a legitimate business using a new technological means to extend and renew satellites in orbit, upgrade them, or repair them when necessary, and certainly on-orbit repair-and-refuel is emerging as a potentially lucrative part of the commercial space sector globally. China could test the technologies of such a capability under a commercial guise, while at the same time perfecting the means to develop military co-orbital ASATs that employ the same RPO close approach and docking manoeuvres as would a civilian or commercial activity. Just before or at the outset of a conflict, China could then rapidly transition such a commercial capability to a military role as co-orbital ASATs. This would be consistent with language from the PLA Academy of Military Science, which in a recent report on space warfare argued that China, 'whilst doing all it can at the strategic level to avoid firing the first shot', would 'strive to attack first at the campaign and tactical levels in order to maintain the space battlefield initiative, and that the intent should be to conceal concentration of forces and make a decisive large-scale first strike' (Pollpeter 2019:6, Jiang & Wang 2013:44).

Such a posture is broadly consistent with the PLA's Active Defence Strategy, which Beijing describes as 'strategically defensive but operationally offensive', noting that China 'may conduct defensive counterattacks by responding to an attack *or striking pre-emptively to disrupt an adversary's preparations to attack'* (US DoD 2019:15; emphasis added).

The 2013 edition of the *Science of military strategy*, one of China's foremost publications on PLA military thought, states how Active Defence translates to space warfare:

> Only when another state conscientiously infringes upon China's space rights and interests and causes harm to national security, may China implement space deterrence against the enemy and launch a counterspace attack. In the space domain, what China still follows is the principle of we will not attack unless we are attacked. (Pollpeter & Ray 2016:251)

Yet it isn't clear exactly how China determines when or if a state 'infringes upon China's space rights and interests and causes harm to national security' or, indeed, what to China constitutes 'an adversary's preparations to attack'. MT Fravel, in analysing Chinese military strategy in the *Science of military strategy*, suggests that Chinese thinking is that it won't 'fire the first shot but will use offensive actions to achieve defensive goals' (Fravel 2016:52). There's ample scope for a liberal interpretation of what constitutes a threat to China to justify the development of the types of counterspace capability noted above, which would allow Beijing the opportunity to exploit grey-zone operations in orbit and establish the means to strike pre-emptively to disrupt an adversary's preparations to attack. Although China maintains an 'Active Defence' strategic posture, that posture is by nature offensive in its execution at the operational and tactical levels. The US and its allies shouldn't make the mistake of assuming that China won't exploit grey-zone counterspace activities prior to or at the outset of a future military conflict.

Ground-based counterspace technologies

China could best exploit ground-based systems, such as laser-dazzling, uplink and downlink jamming and spoofing, and cyberattacks to complement co-orbital ASATs such that the combination of the covert positioning of co-orbital ASATs plus the employment of ground-based interference could deliver a classical 'Pearl Harbor in space' counterspace campaign just before or at the outset of a conflict, in a manner that's consistent with the intent suggested above.

This approach, rather than reliance only on DA-ASATs designed for the physical destruction of targets, seems a more likely path for future adversary counterspace campaigns and conceptual thinking and expands the spectrum of potential counterspace threats facing the US and its allies, including Australia, over the coming decade and beyond.

Reinforcing the grey-zone phenomenon risk, the ground-based counterspace technologies mentioned above add potential degrees of anonymity and deniability for counterspace operations that a state could exploit before or at the outset of a military conflict. The PLASSF's responsibilities cover both space and network operations, including electronic warfare operations. A 2015 RAND Corporation report on the role of the PLASSF argues that China's approach to counterspace—'space attack and defense operations'—seeks to achieve superiority within a certain period of time and within a certain location, and that ground-based counterspace would form a 'third leg' of China's capability for space attack and defence (Pollpeter et al. 2015:9).

Cyberattacks on satellites are emerging as an important future counterspace capability. A key 2016 Chatham House report argued that satellites are vulnerable to cyberattack, both directly and indirectly, through ground stations or through the supply chain of satellite technology (Livingstone & Lewis 2016). Although military satellites are often hardened against cyber-intrusion, commercial off-the-shelf satellites used by military forces are often not. The very character of cyberwarfare and computer network operations means that states can exploit this form of power without necessarily incriminating themselves, they can do so well before a declaration of war or an outbreak of overt military hostilities, and the nature of cyber threats allows them to be insidiously planted inside critical systems in a dormant state. Cyberattacks on satellites might begin not on the day of war breaking out, but months or even years beforehand when malicious code is slipped into critical components on a commercial production line, and be carried out by undeclared cyberforces acting on behalf of a state.

The Chatham House report lays out a number of potential attack methods that could use cyber means:

- jamming, spoofing and hacking attacks on communication networks via space infrastructure
- attacks on satellites, targeting their control systems or mission packages, perhaps taking control of a satellite to exploit its capabilities, shut it down, alter its orbit, or 'cook' or 'grill' its solar cells through deliberate exposure to damaging levels of radiation
- attacks on ground infrastructure, such as satellite control centres, associated networks and data centres, leading to potential global cascading effects on critical information infrastructure and networks (Livingstone & Lewis 2016:9–10).

The nature of cyberwarfare suggests some important risks for maintaining access and freedom of action in space for the ADF.

First, the potential for this type of counterspace attack is open to a much broader range of international actors, including non-state actors such as international terrorist networks like al-Qaeda and Islamic State, and potentially even would-be teenage hackers seeking a new challenge. It isn't a challenge that's relevant only to high-intensity inter-state warfare scenarios. The ADF will need to think about, and plan for, how cyberattacks on satellites can be a factor in a full range of lower intensity scenarios, including within Australia's regional neighbourhood, such as operations in the Southwest Pacific.

Second, cyber techniques and technologies, together with uplink and downlink jamming and laser-dazzling, allow scalable and reversible effects and can also play an intelligence-gathering role through the monitoring or theft of information passing through a satellite or via a ground station. They can also be employed to spoof a satellite to generate false information to an opponent in a deception campaign. The potential for coercion, hostile intelligence operations and strategic information warfare through cyber operations against a state's space segment must be a real concern.

Third, a key advantage of using cyber capabilities to mount counterspace operations is their low cost. They can be quickly acquired through a broader offensive and defensive computer network operations program, or be open to non-state actors that need only computers and a good understanding of hacking to develop capabilities that could be effective, at least against non-hardened commercial satellites. The footprint of cyber capabilities for counterspace is minimal compared to that for traditional counterspace capabilities, such as DA-ASATs. There's no need for rocket technology, advanced spacecraft technology, highly visible testing and equally visible debris clouds. Detecting the development of such a capability is therefore highly challenging for intelligence organisations, and there's little or no possibility of preventing the development of such a capability if a state or non-state actor chooses to acquire it. The technology isn't challenging to develop—unlike DA-ASAT or co-orbital ASAT—and it can be combined with other low-cost counterspace capabilities such as jamming and spoofing capabilities that can be employed across all levels of warfare, from the tactical battlefield through to the strategic level.

Fourth, cyberattacks on satellites can more readily leverage advances in the civil sector, including rapid developments in artificial intelligence, to develop highly potent counterspace capability (Zinatullin 2018).

Space 2.0 and counterspace

The counterspace threats of the next decade are emerging against a broader context of transformational change in the global space sector through the rapid growth of commercial space technology and the 'Space 2.0' paradigm, which are currently optimised for LEO (Davis 2018b). This approach consists of a paradigm shift towards 'small, cheap and many' in satellite design, in contrast to the building of large, complex and expensive satellites that are beyond the reach of all but the major space powers. The Space 2.0 paradigm of rapid progress, innovation and transformational change also applies to the launch—and recovery and reuse—of reusable rockets now being flown commercially by SpaceX in an approach soon to be followed by other companies.

Space 2.0 technologies include small satellites and 'CubeSats'; on-orbit manufacturing; on-orbit refuelling and repairing; and innovations in space launch techniques. Together, they'll make it easier for a broader range of state and non-state actors to access and utilise space for both peaceful and military means, including, potentially, for counterspace roles (Davis 2018b). The next decade is also likely to see the growth of 'mega-constellations' of small satellites to provide transformation space services for terrestrial users, including 'broadband in the sky' from thousands of LEO-based satellites; pervasive Earth-observation services; and a space-enabled 'internet of things'. The rapid growth of mega-constellations and our increasing dependency on these new space services will increase the potential consequences of counterspace use in a future military conflict, which include a 'day without space' (the sudden catastrophic collapse of critical information and logistics services in modern globalised societies) and the potential for rapidly growing space debris threats (Harris 2019).

The key principle underpinning Space 2.0 is the leading role of the commercial sector over government-run space activities. Commercial companies developing smaller and cheaper satellites and exploring rapid spiral development cycles enabled by reducing costs produce a rapid refresh of technology that leads to more rapid innovation. This contrasts with the Space 1.0 model of a government-run, taxpayer-funded, end-to-end space program (such as those run by NASA or the European Space Agency) that's risk averse, slow to change and expensive and doesn't embrace innovation.

It's Space 2.0 that's now leading and transforming global space activities in the 21st century.

That's a very positive development for humanity's long-term future in space, as it makes possible the achievement of some ambitious 'big space' goals, including the colonisation of the Moon and Mars and the exploitation of space resources to establish self-sustaining and expanding space-based infrastructure, which is vital if humanity is to become a true space-faring civilisation.

However, it also brings risks. Space 2.0's paradigm can be equally applied to developing counterspace capabilities. The reduction of costs to access and use space through reusable rockets and small satellites and the leveraging of commercial space actors open a quicker and cheaper path for the ultimate development of ASATs for major powers and minor powers alike. CubeSats can be designed to provide useful services to terrestrial users, but they can also be useful co-orbital ASATs if equipped with the right payload, such as a close-range jamming system. The rapid transformation introduced by 'fourth industrial revolution' technologies, including additive manufacturing (3D printing), automation, robotics and advanced assembly line processes, means that satellites can be manufactured quickly (Erwin 2018).

Space launch is also changing. NASA persists with its fully expendable Space Launch System, which is years behind schedule and billions of dollars over budget and will cost approximately $1 billion per launch, in contrast to SpaceX's Falcon Heavy, which is partly reusable and costs as little as $90 million per launch (Wall 2018, NASA 2018, Reisinger 2019). The trends towards reusability and reduced cost will continue as rocket technology evolves and as commercial actors such as SpaceX, Blue Origin and others, now including Chinese companies, emphasise either fully or partly reusable launch capabilities (Jones 2019). Perhaps epitomising the next phase of space launch, the UK's Reaction Engines is developing the SABRE (synergistic air-breathing rocket engine), which could make spaceplanes a reality, providing rapid response and quick turnaround for payload delivery into space by the 2030s (REL 2018).

There'll be a commercial need for this capability, as next-generation mega-constellations for the 'internet of things', 'broadband in the sky' and pervasive Earth-observation networks demand rapid production and equally rapid deployment on low-cost reusable launch vehicles (Harris 2019). The same manufacturing process for developing civilian mega-constellations can quickly churn out low-cost ASATs, given political will. After all, defining 'ASAT' exactly is challenging when a $10,000 CubeSat crashing into a multi-billion-dollar ISR satellite generates the same effect as a much more expensive and complex DA-ASAT, such as that tested by China in 2007.

The Space 2.0 revolution and 'new space' are opening up new types of space capability, from on-orbit servicing, on-orbit manufacturing and responsive space access to, in the future, lunar and asteroid mining and the use of *in situ* resources for manufacturing goods in orbit. In considering where this may be headed, some key trends need to be highlighted.

First, the cost of accessing and using space for benign or malign purposes is dropping, and there's an accelerating proliferation of Space 2.0 technologies. In 2019, China and Russia are the two key counterspace threats in terms of traditional ASAT technologies; however, by 2035, the spread of space technology that can be applied in an ASAT role, whether in space or from the ground, will mean that the number of potential counterspace powers will grow rapidly.

Second, states will increasingly seek to avoid ASAT and counterspace capabilities that generate large amounts of space debris. The emphasis will be on soft kills with rapid, scalable and reversible effects, along with a requirement for deniability if not outright anonymity. Key capabilities of the space battlefield of 2035 will be directed-energy weapons, cyberattacks, advanced electronic warfare and ubiquitous jamming. Space war may happen at the speed of light, as satellites go dead without warning.

Third, Space 2.0 capabilities in reusable launch may evolve towards even lower cost and more responsive space access, including the potential application of hypersonics-related technologies for aero-spaceplane capabilities—although that will remain limited to major space powers. This will open up new and unique types of counterspace capability for states such as China and the US to rapidly project force into space, through space, and from space against targets on the Earth.

Fourth, the application of Space 2.0 technologies will see the rapid growth of commercial mega-constellations in LEO, and they won't remain limited solely to US companies. In the same way that Chinese commercial space companies are taking their first steps to follow the path of SpaceX, China will seek to exploit mega-constellations for its own civil and military purposes (Jones 2018). Space is congested now; by 2035, it's likely to be far more so.

Fifth, the astrostrategic canvas upon which we now consider the issue of counterspace and space warfare will expand beyond GEO out through cislunar space to the Moon. The US is aiming for a human return to the lunar surface by 2024, although it's uncertain whether it can do it by then (Berger 2019). China is certainly now talking about 'taikonauts' on the lunar surface 'within the next ten years'.[10] The Chinese see the Moon and the region around it as being strategically important in terms of China's 'space dream' (Davis 2019b, 2019c). In recent testimony to the US–China Economic and Security Review Commission, General James Cartwright made clear that the US needs to shift its gaze and mindset beyond its traditional LEO–GEO focus and emphasised the potential risks of major-power competition in cislunar space (Cartwright 2019). The Moon and the cislunar region are astrostrategic high ground from which an adversary could oversee and if necessary control the critical LEO to GEO region, as well as regulate access to the Moon. With a return to the Moon being a key step in the next phase of human space activity in the 2020s, a key component will be commercial competition for access to resources and wealth. That competition won't occur in a manner that doesn't affect the national interests of states.

The growing counterspace capabilities of peer adversaries such as China and Russia and the proliferation of potential counterspace technologies to other hostile actors, including potentially non-state actors, mean that Australia can no longer simply assume that our access to space is assured. In a contested, congested and competitive space domain, our access is certain to be challenged and, potentially, denied.

The ADF must therefore plan for fighting through a contested space environment to achieve operational success. This will demand an understanding of the emerging counterspace threat and how it will evolve through to 2035. A key factor will be the rapid growth of commercial space and Space 2.0 technologies, which is leading to a ‘democratisation’ of space access that can be used both for peaceful purposes but also potentially by adversaries with malign intent.

Space law as a solution?

Are there legal mechanisms that Australia can promote to reduce the risk posed by the types of emerging counterspace capabilities noted above? How might we exploit ongoing multilateral forums and ‘strategic space diplomacy’ to reduce the potential threat of space weaponisation?

The foundational document on space law is the 1968 Outer Space Treaty (OST), to which Australia is a signatory state (UNOOSA 2019). The OST bans the deployment of weapons of mass destruction in space but doesn’t ban the development, testing or deployment of other weapons in space or their use against targets in space. It also bans the use of the Moon and other celestial bodies for military purposes.

However, the OST was negotiated and signed in a different era, when space was accessible solely by the major powers, there was no such thing as Space 2.0 and the commercial space sector simply didn’t exist. The technology of counterspace capabilities has moved on considerably from Cold War systems, and the challenge of dual-use technologies such as co-orbital ASATs and ground-based soft-kill counterspace capabilities make it much more difficult to verify and monitor space arms control agreements, or even define what constitutes a space weapon (Davis 2018c).

This isn’t to imply that the OST is worthless. It’s the foundation of modern legal mechanisms and normative structures to constrain space weaponisation and to preserve, to the greatest degree possible, stability in space. However, it needs to be updated to address the potential risks in a more contested, congested and competitive space domain and be made more relevant to the Space 2.0 paradigm. In particular, an updated OST, or an OST complemented by side agreements to address legal and regulatory gaps that have emerged since it came into effect, needs to better manage the opportunities and risks of the rapidly growing commercial space sector.

Two other agreements—the Convention on International Liability for Damage Caused by Space Objects (1972) and the Convention on Registration of Objects Launched into Outer Space (1976)—contribute towards building a regulatory framework. They can and should be strengthened to address the growing number of space actors, both state and non-state, and the challenge of grey-zone activities and the dual-use technologies implicit in co-orbital and ground-based counterspace systems.

Efforts within the UN’s Committee on the Peaceful Uses of Outer Space and the UN General Assembly’s Committee on Disarmament to develop new legal measures to prevent space weaponisation are also underway. In recent testimony before the US–China Economic and Security Review Commission, Brian Weeden noted that the draft Treaty on the Prevention of the Placement of Weapons in Outer Space (PPWT), sponsored by China and Russia, was submitted to the Committee on Disarmament in 2008 and resubmitted in 2014. The updated treaty was rejected by the US. Weeden (2019) stated the reasons given for the US’s rejection as:

> the lack of a definition of a space weapon, lack of a verification mechanism, and no restrictions on the development and stockpiling of anti-satellite (ASAT) weapons on the ground. This … would allow a nation to develop a readily deployable space-based weapons break-out capability should it decide to withdraw from the PPWT. [Furthermore] terrestrially based ASAT systems, not weapons in space [were seen to be] the most pressing current threat to outer space systems, and the PPWT did not ban any of them.

The PPWT has been consistently promoted by China and Russia, through the UN General Assembly Committee on Disarmament and despite opposition by the US, as a basis for the prevention of an arms race in outer space. This has included promoting it in meetings of groups of government experts on space security, which included Australians.

The continued promotion of the PPWT as a basis for a legally binding agreement to prevent a space arms race undermines chances for achieving a deal that's able to be verifiable and that makes real progress towards rolling back the development of counterspace capabilities.

Beyond formal intergovernmental diplomacy, two Track 2.0 efforts are also underway, and Australia is playing a key role in both:

- The *Woomera manual* project, led by the University of Adelaide and the University of NSW—Canberra, seeks to 'develop a manual that objectively articulates and clarifies existing international law applicable to military space operations' (UoA 2018).
- The *Manual on international law applicable to military uses of outer space* (MILAMOS) project, led by McGill University in Canada but also including Australian participants, seeks a similar outcome (McGill University 2019).

Both projects essentially seek to create new norms and a rules-based order in space that precludes space weaponisation and the use of counterspace capabilities and to explain how existing international law applies to space.

The current failure of formal intergovernmental dialogue to lead to new legal mechanisms, strengthened norms or even attempts at space arms control, and the existence of Track 2.0 efforts such as Woomera and MILAMOS, highlight that there are no hard legal constraints on space weaponisation or the development and testing of counterspace capabilities. For Australia, this has two implications.

First, Australia has an opportunity, which we should pursue, to take on a more significant and visible role, starting with Track 2.0 efforts such as the *Woomera manual* and moving into intergovernmental negotiations, to boost the prospects for space arms control. Such an approach would seek to identify and highlight emerging counterspace threats, such as those emerging from China and Russia, and promote legal constraints, arms control agreements and international norms to constrain such threats from further development.

Second, the absence of legal mechanisms and the weakness of international norms against space weaponisation, while generating risk for Australia, also give Australian defence planners political flexibility in considering capability responses. In considering developing Australian means to deter adversary counterspace use, wise capability choices can be made without violating international legal agreements.

Australia should play a full and visible role through strategic space diplomacy to promote international engagement and discussion to manage risks and strengthen dialogue in a manner that may facilitate the development of new legal and normative measures that erode the benefits of counterspace capability (Handmer 2018). Such strategic space diplomacy can be strengthened through credible space deterrence, which I discuss in the next chapter.

With these factors in mind, and with the clear evidence presented in this analysis of a growing potential counterspace threat to the US and its allies' space capabilities, how should Australia respond in policy and capability choices through to 2035?

CHAPTER 3

Evolving Australian space policy to respond to rapid change and increasing challenges

The US is now moving to respond to the emerging counterspace challenge that's coming principally from China and Russia. Australia must quickly and visibly align its emerging space policy with steps being taken by the US. The Defence organisation needs to explore the following steps in responding to the growing counterspace threat if Australia is to maintain freedom of action in space through to 2035.

Space deterrence

The US response to Chinese and Russian counterspace capabilities will be primarily based on building credible 'space deterrence' against threats to US space architecture posed by adversaries' use of counterspace as a means towards space superiority through offensive and defensive space control (Harrison et al. 2017, CELC 2018). Australia should seek to play a full and engaged role in contributing to the development and day-to-day delivery of space deterrence as part of a coalition activity. We already contribute substantially by providing facilities and by direct involvement in SATCOM and SSA missions, but we can do more through exploiting emerging sovereign space capabilities now appearing in our nascent civil space industry sector.

As I discuss below, a key part of space deterrence is built on strengthening the resilience of US and allied space-based ISR and PNT architecture in the face of counterspace threats. This is primarily achieved through two approaches. The first is *augmentation and disaggregation*, which involves distributing space segment architectures across greater numbers of smaller, cheaper satellites, and having the ability to rapidly deploy additional satellites before a conflict in order to complicate an adversary's counterspace campaign planning. The second approach is to ensure an ability for *rapid reconstitution.* Although more applicable to LEO capabilities, reconstitution constitutes deterrence by denial and requires a demonstrated ability to rapidly launch replacement satellites, thus helping to ensure the capability of friendly forces. Both, acting together, generate doubt in the adversary's mind about the likely success, and therefore the wisdom, of a counterspace campaign. These measures are already encompassed within ADF doctrine under defensive space control through protecting space capabilities from attack and preserving space capabilities (DoD 2016b:3.16).

ADDP 3.18 also talks about offensive space control, which 'includes measures taken to prevent an adversary's ability to interfere with or attack friendly space systems'. Measures include 'prevention' through whole-of-government approaches to deter the use of counterspace capability by an adversary, as well as 'space negation', which is a military response that includes 'active defensive and offensive measures to deceive, disrupt, degrade, deny or destroy an adversary's space capabilities' (DoD 2016b).

Australia lacks the ability to undertake space negation, but we can expand our ability for defensive space control through augmentation, disaggregation and reconstitution, and in doing so fully utilise our sovereign space industry to support defence tasks.

The starting point towards that goal must be the development of a clear and coherent space defence policy. Australian doctrine as stated in ADDP 3.18 essentially replicates US counterspace doctrine. What's missing is a unique Australian defence space strategy or policy that meets the requirements of closer cooperation with the US and other partners within the Five Eyes group—such as through the CSpO Initiative—and capability planning and acquisition to ensure Australian freedom of action in space.

Extended space deterrence and ADF space policy

Australia lacks a definitive declaratory defence space strategy or policy. Certainly, the *2016 Defence White Paper* and the accompanying Integrated Investment Plan highlight the importance of space capability and specifically emphasise the growing role of SSA, as well as noting investment in future projects such as DEF-799 (ISR) and JP9102 (satellite communications). They also highlight the challenge posed by space being contested, congested and competitive, noting the risks posed by space debris and counterspace threats (Davis 2018a: 10–12, DoD 2016a:4.14–4.16, DoD 2016c: 1.21–1.24). But that's as far as it goes, and the complex web of decision-making bodies hasn't contributed well to developing a formal space strategy.

Following the February 2016 release of the White Paper, Defence's Strategic Policy and Intelligence Group released policy advice in June 2016, which noted that Defence must be able to continue operations and win in a contested, degraded and operationally limited space environment and protect Australia's access to space (Davis 2018a). Written at a time when the debate over Australia's future in space was just getting started—there was no space agency, the government was reticent about supporting the space industry and the very conservative and over-cautious 2013 Satellite Utilisation Policy (DIISRTE 2013) was still influencing decision-making—the report pulls its punches. It continues to emphasise dependency on the US, but acknowledges that this creates risk. It, too, highlights the growing threat of counterspace capability, stating that, 'as some nations increase their use of space and develop and test counterspace technology, it will become important for Defence to have the ability to monitor and protect our interests in space through a spectrum of responses'.

Stepping beyond this superficial treatment of space policy, an early goal should be to create an updated formal Australian defence policy for space. This should be done by a panel of experts commissioned by government, including Defence officials, ADF personnel, subject-matter experts and organisations outside of government that are recognised as influential in the defence and strategic policy debate.

The policy must recognise the challenges posed by China's counterspace capabilities up front and call for Australia to press China on its development of a suite of those capabilities. It should identify new approaches to arms control in space that Australia can lead on, bringing together Track 2.0 efforts such as the *Woomera manual* project with government participation in bodies such as the UN's Committee on the Peaceful Uses of Outer Space and efforts by the Australian Space Agency towards international outreach to ensure that Australia plays a more visible role internationally on space policy issues.

The policy should recognise and emphasise the importance of space for the ADF, given our dependency on space systems for waging information-led joint and coalition operations. It shouldn't focus only on a distant horizon but recognise short-term risks. If we had to fight somewhere in the Asia–Pacific region in the next few years, and our access to space was contested by a major-power adversary, how could we mitigate risks and ensure that the ADF and coalition partners could prevail even in high-intensity operations? In particular, the policy must recognise the risks of losing access to space, given that space systems are the critical enablers of multi-billion-dollar capability investments. With that investment in mind, space systems are the critical enabler for the future ADF and require much higher priority in the way Defence manages space issues. A smattering of groups and individuals scattered across the Defence organisation, and within the ADF, raises the risk of incoherent approaches to space that don't advance an agenda towards a true Australian defence space policy.

That means ADF space policy needs to be lifted in profile and brought to senior-level attention on a more consistent basis. For that to happen, the ADF needs not only a skilled joint space cadre, akin to a new organisation within Defence with core responsibility for space policy, management, capability development and operation, but also a senior officer of 3-star rank and a senior public servant of Deputy Secretary rank as 'champions of space'.

After these preliminary steps, Defence's space policy should evolve with ongoing counterspace threats in mind and embrace a role focused on space deterrence and burden-sharing in orbit. The objective of a deterrence-focused ADF space capability would be to convince a major power, such as China, to not use counterspace capability against the US and its allies, including Australia, by raising the prospective costs and risks associated with such use and reducing the probability of it being militarily effective.

Australia currently lacks any means whatsoever to independently deter the use of counterspace capabilities against its space systems. As with nuclear deterrence, we continue to rely on the US for 'extended space deterrence', but that isn't a one-way transaction, and Australia can and should do more alongside the US in space to deter Chinese and Russian counterspace threats. Extended nuclear deterrence implies the threat of retaliation in the event of an adversary's use of nuclear weapons against the US or its key allies. In space, a concept of extended space deterrence could imply the prospect of retaliation against an opponent's space capability through offensive space control, as well as the goal of blunting or making ineffective an opponent's counterspace offensive through an approach of 'deterrence by denial' and through defensive space control.

Although US counterspace doctrine explicitly refers to a range of options for offensive space control that suggest counterspace capabilities, it hasn't yet committed to the operational deployment of dedicated offensive and defensive space control capabilities. The decision to do so will be up to the current or a future US administration and decision-makers in the US Department of Defense.

This will demand assurance that demonstrates that Australia can respond to an attack in space; deterrence credibility through maintaining effective space systems; and communication of such a posture to any potential adversaries (Harrison et al. 2017:21–22). If Australian space deterrence strategy is modelled after extended nuclear deterrence, an attack on Australian space assets would bring a quick retaliatory response from the US's offensive space control capabilities, although one designed to minimise the risk of generating space debris. As I have noted, as concepts of space warfare evolve and counterspace technology matures for all actors, an emphasis, backed by agreed legal measures and potentially by future arms control agreements, should be on banning ASATs that rely on the physical destruction of a target through a kinetic kill. As I discuss below, Australia's role would be to blunt the effectiveness of such an attack by contributing directly towards boosting space resilience.

China might be tempted to 'kill the chicken to scare the monkey' by coercing Australia through implied or actual counterspace operations against our space systems, but it should be confronted with a reality that any limited use of ASATs, even in a grey-zone action against a US ally such as Australia, would bring a swift retaliation against its own critical space capabilities, imposing an unacceptable cost and a risk of escalation.

This approach demands a clear declaratory policy agreed between Australia and the US; an increasing capability for SSA that's directly supported by Australian SSA facilities; and close coordination between the US and Australia through the CSpO Initiative in formulating such a space deterrence policy. In particular, Australia and the US must agree on a set of operational principles for dealing with prospective grey-zone operations in orbit by China or Russia and, in coming years, potentially by other adversaries, in the light of the proliferation of space capability that will happen via the Space 2.0 paradigm.

It also demands space resilience, which is where Australia can play a much more active role and which has specific capability development implications for the ADF.

Space resilience and deterrence by denial: augmentation, disaggregation and reconstitution

Strengthening the resilience of space capabilities to make it more difficult for an opponent to effectively use counterspace systems to deny access to space is an area where Australia can and should step up to embrace a more visible, expansive and active role. Space resilience can be achieved through the augmentation of space capabilities in a prelude to a conflict and through the disaggregation, where possible, of key space architectures. Rather than relying on small numbers of large, complex and expensive satellites to provide critical space support, space resilience and deterrence by denial can be better achieved by embracing a 'small, cheap and many' paradigm of larger numbers of small satellites, complemented by fractionated constellations of CubeSats. These types of capabilities can be developed and manufactured locally by the Australian space industry, in the same way that other satellite-manufacturing companies are now manufacturing satellites on a production line basis to support the deployment and operation of mega-constellations. By augmenting and also disaggregating our critical space systems, it's a much more challenging and complex task for an adversary to use counterspace capabilities to deliver a decisive blow—a 'Pearl Harbor in space'—than would be the case if we continue to rely on smaller numbers of large and expensive satellites.

Finally, reconstitution of space capabilities is also an important component of space resilience in the event that space deterrence fails to convince an opponent not to use counterspace systems. The ability to have a strategic reserve of small satellites and CubeSats, manufactured locally and able to be launched rapidly on demand, on Australian launch vehicles and from Australian launch sites, means that we can directly support US space capability, plug gaps in coverage and recover from an adversary's counterspace attack. If an adversary understands that its use of counterspace capabilities will only have limited effect, perhaps for only a limited time, and will also raise the risk of retaliation and escalation, that could contribute to changing its risk calculus such that it chooses not to use counterspace in the first place. That's space deterrence.

Having the ability to build, deploy and operate small satellites and to use fractionated constellations and distributed space architecture approaches for large numbers of low-cost CubeSats is the best approach for developing an operational ADF response space capability. This would see the ADF, for the first time, have the ability to directly support deployed forces either undertaking expeditionary operations or engaged in a 'defence of Australia' mission with additional space support on demand. This would be an entirely new type of capability for the ADF in the next decade and would, for all intents and purposes, make Australia a true 'space power'.

As argued in my previous Strategy paper on space policy, small satellites, CubeSats and a Space 2.0 approach are ideal for Australia's needs and approach to space capability (Davis 2018a). Small satellites are more affordable, can be built in larger numbers, and allow Australia to exploit fast development cycles and rapid innovation. Although currently optimised for access to LEO, smaller satellites develop the pedigree in workforce and technologies for payloads to go on larger satellites capable of withstanding GEO transfer. Smaller satellites can exploit the advantages of 'small, cheap and many' compared to being burdened by the 'expensive, complex and few' approach of large satellites costing considerably more. Australia is simply not in a position to develop large, complex satellites, such as are epitomised by the US WGS or its GPS constellation out in GEO and MEO, where such missions must be carried out, but in decades to come the technology may be extensible from Space 2.0 to other orbits. Our space policy must be practical and affordable and make the best use of the emerging space industry sector. The alternative to such an approach would be continued dependency on the US for the provision of space capability, which would reinforce the risk of losing space access in a crisis. A continued dependency on the US—doing what we've done in the past—also does nothing to contribute to growing Australia's space industry sector.

Any future policy development must ensure that Defence makes full use of this sector and works with the Australian Space Agency. Emerging companies are seeking to provide a sovereign space launch capability for Australia, and two viable space launch sites—one in the Northern Territory near Nhulunbuy and one in South Australia at Whalers

Bay—are in the early stages of being established (ELA, n.d.; Southern Launch, n.d.; GST, n.d.; Hypersonix, n.d.; Davis 2019d). The Australian Space Agency's civil space strategy emphasises growth in key national space priority areas, including access to space (ASA 2019).

Australia's emerging commercial space sector can contribute directly to providing capability, whether it's through the mass production of small satellites and CubeSats to support the disaggregation and augmentation mission or by providing rapid space access for the reconstitution for LEO capabilities. A Space 1.0 approach, in which government funds everything, would immediately make a Defence contribution to space resilience in this manner unaffordable. If Australia is to burden-share in orbit through boosting space resilience by disaggregation, augmentation and reconstitution, we can't do it through the traditional defence project approach that's been applied to other key capabilities, such as the Attack-class future submarine or the F-35A Joint Strike Fighter. It needs to be done through public–private partnerships using dependence on and cooperation with the commercial sector to deliver capability.

Should Australia develop a counterspace capability?

The growth of adversaries' counterspace capability does raise the issue of whether the US will ultimately develop and deploy its own counterspace capability for offensive space control. Certainly, the US has demonstrated the potential for a DA-ASAT capability with the 20 February 2008 Operation Burnt Frost intercept of an errant satellite before it could re-enter the atmosphere, spreading toxic substances. The US has also demonstrated an ability to undertake RPOs with co-orbital vehicles using the XSS-10 satellite in 2003 and the XSS-11 in 2005. If it wished, it could develop such technologies, and others, for counterspace roles, and do so reasonably quickly. There are no indications at this time that the US has decided to develop ASATs, and instead its efforts are directed towards boosting space resilience and enhancing space deterrence. However, the emerging threat posed by hypersonic weapons may see the US deploy a space segment for both sensors and, potentially, interceptors as a means to strengthen missile defence and, as with Operation Burnt Frost and US BMD development in general, there would be an inherent dual-role ASAT potential with such a capability.

To reinforce responsible use of space behavioural norms, Australia doesn't need to envisage deploying DA-ASATs or co-orbital ASATs, even if the US were to eventually do so. Although such weapons aren't prohibited under current legal regimes related to space, there are ongoing efforts within the UN, in which Australia is participating, seeking to constrain or ban ASATs and other space weapons, notably through space law efforts such as the *Woomera manual* project (UoA 2018). More broadly, an Australian ASAT capability would run counter to Australia's support for norms that seek to make space as much as possible a peaceful environment for cooperation. Those norms are not laws—and states (China and Russia) are violating them—but further weakening them would contribute towards weakening the rules-based international order, which would only make it easier for adversaries to erode the order further in order to revise it to meet their own needs.

In arguing against investment in some types of counterspace capability, I have singled out those that generate effect through kinetic hard kill (and thus produce space debris), and that are potentially technologically challenging and financially expensive, such as co-orbital ASATs. Australia should, however, retain the option to develop electronic warfare, jamming and spoofing, and directed-energy weapon (laser-dazzling) capabilities, as well as potential applications of cyberattack and defence for defensive space control tasks as part of future ADF capability.

A key requirement of deterrence is the ability to generate costs against an opponent and to communicate that reality to the opponent. Certainly, Australia can make a valuable and necessary contribution towards a 'deterrence by denial' strategy alongside the US and with other partners without having any form of offensive counterspace capability. However, having a soft-kill ground-based counterspace capability—or a potential capability that could be quickly deployed operationally if needed—would strengthen our ability to contribute to space deterrence by raising potential costs to an adversary and increasing the risk associated with the use, or threat of use, of counterspace against us. It would also reinforce our ability for independent and self-reliant space defence if we need to lead a regional coalition or act in our own defence without necessarily relying on the US.

The decision to develop soft-kill ground-based counterspace capability must be considered to be sensitive. Australia would need to frame such a choice firmly in the context of deterrence and burden-sharing and as a response to adversaries' counterspace developments that are far more expansive and provocative. Australia has developed sophisticated cyberwarfare capabilities, which include both defensive and offensive capability (Hanson & Uren 2018). At the time of its development, the decision was controversial, yet the ADF and the Australian Government had to respond to dramatic changes in how warfare was fought, which included cyberwarfare as an integral part of modern military operations. The future will see space as a contested, congested and competitive war-fighting domain, and the ADF and the government should be ready to make the same adjustment to the emerging reality. A ground-based counterspace capability for the ADF to deter an opponent from using counterspace, support for key allies and enhanced ADF defence self-reliance are logical steps, given the emerging threat of a contested space domain in coming years.

CHAPTER 4

Conclusion and recommendations

From the notion of Australian burden-sharing in orbit to a greater degree through embracing a new role of space deterrence, some key capability development recommendations follow, which Defence should now consider acting on in the Defence Capability Assurance Program.

The current program for acquiring future space capability for the ADF is based on the eventual acquisition of new satellite capability. Two key projects are DEF-799 Phase 2, which will potentially give the ADF a space-based ISR capability, and JP9102, which will deliver enhanced SATCOMs (DoD, n.d.; Ziesing 2018). Until those projects deliver, Defence will continue to rely on existing architecture, including US-provided systems such as WGS and US-provided and highly classified space-based ISR capability.

As I noted in my previous ASPI Strategy paper, released in February 2018, the rapid growth of Australia's space sector and the standing up of the Australian Space Agency open up new opportunities for Defence to leverage new space capability using a Space 2.0 approach (Davis 2018a). The growth of counterspace capabilities and the need to develop an Australian ability to contribute to space deterrence will make government and commercial partnerships even more important.

With the Space 2.0 paradigm firmly in mind, Australia should look to take the following broad space policy and capability steps to ensure freedom of action in space.

Adopt Space 2.0: small, cheap and many

The Defence organisation can and should examine how augmentation and disaggregation will influence key projects, such as DEF-799 and JP9102, as well as other future capability. A multi-tier structure or 'high–low' mix might emerge as a logical choice, whereby Defence might buy, off the shelf, large high-end satellites from a foreign provider, but then complement that capability with low-end locally developed small satellite and CubeSat capabilities to maximise resilience and complicate an adversary's ability to employ counterspace capability effectively. Embracing a Space 2.0 paradigm is critical if Australia is to effectively develop new space capability and ensure space support for terrestrial forces. A 'small, cheap and many' approach reduces many of the risks posed by counterspace, contributes to resilience, and better provides for maintaining freedom of action in space. It also contributes more broadly to national space capability development through Defence investment in the commercial space sector.

Launch from here

The ADF can't contribute effectively to space resilience in partnership with allies if it's totally dependent on foreign powers and commercial space launch actors overseas. Defence must examine how to acquire, through the commercial sector, a sovereign operationally responsive space capability that can launch Australian satellites on Australian launch vehicles from Australian launch sites at short notice. Such a capability would not only contribute to space resilience and deterrence but would be an entirely new type of capability for the ADF that transitions Australia into becoming a true space power that can conduct and influence activities to, in, through and from space to achieve its national objectives.

Invest in game-changers

Investing in the commercial space sector's success will directly assist Defence's space capability development in the longer term and for broader tasks beyond maintaining freedom of action in space. The potential offered by the rapid transformation of the global space sector brought about by Space 2.0 could open up radically new types of capabilities for Defence in the future. In particular, transformational change in space access through systems such as hypersonics-related technologies—an area in which Australia is a research leader—could allow Defence to take on a larger and more ambitious space role alongside the US and other partners in coming decades.

Boost space situational awareness

To deliver credible space deterrence, Defence must invest in expanding and enhancing SSA, including SSA from the ground. This can be complemented by establishing more comprehensive space-based SSA that can also strengthen US and allied defences against emerging threats such as hypersonic weapons. There's no reason why Australia couldn't contribute elements of the space segment for space-based SSA with locally developed satellites launched on locally developed launch vehicles from Australian launch sites.

Australia plays an important role in SSA by virtue of our location in the Southern Hemisphere. There needs to be an expansion of Australian SSA facilities and capabilities that could take greater advantage of new technologies with additional ground stations to gain additional coverage of critical orbits and that exploit new technologies to improve 24-hour coverage.

Build a ground-based counterspace capability

Consideration must be given to establishing—or at least beginning to research and develop—a ground-based counterspace capability based on electronic warfare, jamming, laser-dazzling and cyberwarfare within the considerations of responsibly using space. Such a capability should be considered in the context of directly contributing to a credible space deterrence posture and should add to Australia's potential for burden-sharing in orbit. It can also enable us to have an extra capability to directly support regional coalitions and, if necessary, support the ADF when it mounts independent operations.

Set up a new space structure within Defence

Beyond capability development, an essential step must be to establish a new space organisational structure within Defence. The US is establishing new organisational structures within its Department of Defense to cope with a rapidly changing space domain, such as by standing up the Space Corps within the US Air Force as a potential interim step towards a fully independent US Space Force after 2021. New organisational structures can stimulate the growth of a joint space cadre of expertise, which Australia must tap into and ultimately build our own equivalent. We don't need an independent 'space force', but we do need to have a coordinated and coherent approach to formulating joint doctrine, space policy, space capability management and operations. This would be better served by establishing new organisational structures within Defence that concentrate space expertise in one planning body, rather than having disparate activities spread across multiple elements of the ADF and the broader Defence organisation.

Strengthen or build new space relationships

The Defence organisation should be ambitious about building international space security partnerships. The Australian Space Agency's Civil Space Strategy emphasises the importance of international engagement through to 2028, and Defence can and should look to new partners in addition to the US as it develops new space capabilities, including in response to counterspace threats. The agency's strategy document provides a plan for civil space engagement with international partners, and Defence should match this in the military sphere, in particular through the CSpO Initiative MoU. We should also look beyond CSpO to key neighbours in Asia and the Pacific, such as Japan, Indonesia, New Zealand, South Korea and Singapore.

Build in continuous space connectivity

As important as building a sovereign space segment is for the future, it should occur alongside the expansion of the essential ground segment. This includes not only ground facilities for satellite control and management, but also the establishment of a Defence-wide infrastructure for the expanded use of space capabilities at the operational and tactical levels. Defence units, from the brigade down to the squad and the individual soldier, from the pilot in an F-35A Joint Strike Fighter to the operator of an autonomous unmanned aerial vehicle and personnel crewing a Hobart-class air warfare destroyer's combat information centre, have to be able to 'plug and play' with space to be effective. They have to be able to do so continuously, and that demands a widespread rollout of space connectivity in all defence capabilities, including current and especially future platforms.

The 2020s and beyond are decades full of opportunity for humanity in space. The commercial space sector's moving ahead in leaps and bounds. US plans for a return to the Moon by 2024 will see that high ground opened up for human activity for the first time since 1972, and it's certain that the lunar surface and cislunar space won't necessarily be a US-only domain. China's making it clear that it, too, has lunar ambitions, as do Japan, India and others. The Moon ultimately leads to Mars and beyond, and the potential is there for humanity to achieve the sort of future suggested by the 1968 film *2001: A space odyssey*, in which we're a true space-faring species, expanding across the solar system.

That's a positive and enticing vision, but there are also great risks. States are moving determinedly to acquire the means to deny access to space to others through a range of counterspace technologies. The potential for warfare in space has never been higher, and intensifying China–US military–strategic competition raises the possibility of such a future conflict. For a middle power such as Australia, which is heavily dependent on space not only for its ability to use military power but for its national survival, the growing counterspace threat should be a worrying dark cloud in increasingly stormy skies.

Responding to this challenge must be a matter of increasing urgency for the government.

NOTES

1 In a spoofing attack, a person or program masquerades as another by falsifying data.

2 See also DoD (2016c:1.24).

3 ‘Space situational awareness’, *Pathfinder: Air Power Development Centre Bulletin*, issue 193, February 2013, online.

4 ‘Key tenet of JP2008 realised with satellite ground station contract’, *Australian Defence Magazine*, 10 July 2017, online.

5 ‘Key tenet of JP2008 realised with satellite ground station contract’.

6 ‘The Australian response to potential space warfare’, *Pathfinder: Air Power Development Centre Bulletin*, issue 272, August 2016, online.

7 See also Abbot & Vreugdenburg (2013).

8 ‘China’s new orbital debris clean up satellite raises space militarization concerns’, *Spaceflight 101*, 29 June 2016, online; see also Chen (2016) and Foust (2016).

9 See ‘XSS-11’, *Gunter’s Space Page*, online, and ‘XSS-10’, *Gunter’s Space Page*, online.

10 Xinhua, ‘China to build scientific research station on Moon’s south pole’, *Xinhuanet*, 24 April 2019, online.

REFERENCES

Abbot J, Vreugdenburg M 2013. 'One giant leap', *Air Force*, 7 September 2013, 59(16):12–13.

APDC (Air Power Development Centre) 2013. *The air power manual*, 6th edition, Australian Air Publication AAP 1000–D, Royal Australian Air Force, online.

ASA (Australian Space Agency) 2018. *Australian Space Agency Charter*, ASA, Adelaide, October 2018, online.

ASA (Australian Space Agency) 2019. *Advancing space: Australian Civil Space Strategy 2019–2028*, ASA, Adelaide, April 2019, online.

Beazley K 2017. 'Pine Gap at 50: the paradox of a joint facility', *The Strategist*, 30 August 2017, online.

Bennett JCS 2019. 'Space situational awareness in Australia: overview and details of the Space Environment Research Centre', Space Environment Research Centre, 24 January 2019, online.

Berger E 2019. 'High cost, lack of support spell trouble for 2024 Moon landing', *Ars Technica*, 1 May 2019, online.

Blain J, no date. 'Force options and plans', presentation to the Defence Innovation Hub Industry Update, Department of Defence, Canberra, online.

Blaxland J 2017. 'Pine Gap at 50: why controversy lingers and why its utility is enduring', *The Strategist*, 21 August 2017, online.

Brown L, Hose M 2019. 'Defence Force's involvement in space', briefing to Australian Defence Magazine Space Summit, PowerPoint presentation, 30 April 2019.

Cartwright J 2019. *Testimony at hearing on 'China in space: a strategic competition?'*, US–China Economic and Security Review Commission, Washington DC, 25 April 2019, online.

CASG (Capability Acquisition and Sustainment Group) 2014. *Indian Ocean region UHF SATCOM*, Department of Defence, Canberra, December 2014, online.

CASG (Capability Acquisition and Sustainment Group) 2017. *Combined Communications Gateway Geraldton (C2G2)*, Department of Defence, Canberra, August 2017, online.

CELC (Curtis E LeMay Center for Doctrine Development and Education) 2018. Annex 3-14: *Counterspace operations*, CELC, Montgomery, Alabama, 27 August 2018, online.

Chen S 2016. 'Is China militarising space? Experts say new junk collector could be used as anti-satellite weapon', *South China Morning Post,* 28 June 2016, online.

Cheng J 2014. 'Stratcom signs space data agreement with UK, Canada, and Australia', *Defense Systems*, 23 September 2014, online.

Clark C 2018. 'China satellite SJ-17, friendly wanderer?', *Breaking Defense*, 18 April 2018, online.

Coats DR 2019. *Statement for the record: Worldwide threat assessment of the US intelligence community*, Office of the Director of National Intelligence, Washington DC, 29 January 2019, online.

Davies A 2015. 'Australia's WGS communications—what went wrong?', *The Strategist*, 22 September 2015, online.

Davis M 2016. 'Spaceplanes on the high frontier', *The Strategist*, 19 October 2016, online.

Davis M 2018a. *Australia's future in space*, ASPI, Canberra, February 2018, online.

Davis M 2018b. 'Space 2.0—why it matters for Australia's defence', *The Strategist*, 30 April 2018, online.

Davis M 2018c. 'Avoiding a free-for-all: the Outer Space Treaty revisited', *The Strategist*, 16 July 2018, online.

Davis M 2019a. 'Will India's anti-satellite weapon test spark an arms race in space?', *The Strategist*, 29 March 2019, online.

Davis M 2019b. 'China's space mission (part 2): aiming to control the high ground', *The Strategist*, 17 April 2019, online.

Davis M 2019c. 'China, the US and the race for space', *The Strategist*, 10 January 2019, online.

Davis M 2019d. 'Northern Australia's space coast', *The Strategist*, 12 April 2019, online.

Deagel 2007. 'Australia gets access to wideband global SATCOM system', *Deagel.com*, 14 November 2007, online.

DFAT (Department of Foreign Affairs and Trade) 2010. *Australia – United States Space Situational Awareness Partnership AUSMIN 2010*, Australian Government, Canberra, 2010, online.

Dibb P 2019. 'The geopolitical challenge the crisis in the West poses for Australia', *The Strategist*, 17 May 2019, online.

DIISRTE (Department of Industry, Innovation, Science, Research and Tertiary Education) 2013. *Australia's satellite utilisation policy*, Australian Government, Canberra, April 2013, online.

DIIS (Department of Industry, Innovation and Science) 2018a. 'Australian Space Agency launches operations', news release, Australian Government, Canberra, 29 June 2018, online.

DIIS (Department of Industry, Innovation and Science) 2018b. '100 days of the Australian Space Agency', news release, Australian Government, Canberra, 9 October 2018, online.

DIIS (Department of Industry, Innovation and Science) 2018c. *Review of Australia's space industry capability*, Australian Government, Canberra, March 2018, online.

DIIS (Department of Industry, Innovation and Science) 2019. *Australian Space Agency*, Australian Government, Canberra, 1 July 2019, online.

Dobell G 2018. 'China challenges Australia in the South Pacific', *The Strategist*, 2 October 2018, online.

DoD (Department of Defence) 2010. *ADDP 3.18: Operational employment of space*, 1st edition, Australian Government, Canberra, 8 June 2010, online.

DoD (Department of Defence) 2016a. *2016 Defence White Paper*, Australian Government, Canberra, 2016, online.

DoD (Department of Defence) 2016b. *ADDP 3.18: Operational employment of space*, 2nd edition, Australian Government, Canberra, December 2016.

DoD (Department of Defence) 2016c. *2016 Integrated Investment Program*, Australian Government, Canberra, 2016, online.

DoD (Department of Defence), no date. *Defence Project 799: Enhanced satellite ISR capability*, Australian Government, Canberra, online.

ELA (Equatorial Launch Australia), no date. *Australia's first commercial spaceport*, ELA, Melbourne, online.

EOS (Electro Optic Systems) 2019. *Space situational awareness*, EOS Space Systems, June 2019, online.

Erwin S 2018. 'With a new satellite factory in the US, Airbus eyes opportunities in military space', *Space News*, 6 July 2018, online.

Fernholz T 2017. 'The entire global financial system depends on GPS, and it's shockingly vulnerable to attack', *Quartz*, 22 October 2017, online.

Foust J 2016. 'Long March 7 payload raises anti-satellite concerns', *Space News*, 28 June 2016, online.

Fravel MT 2016. 'China's changing approach to military strategy: the science of military strategy from 2001 and 2013', in McReynolds J (ed.), *China's evolving military strategy*, Jamestown Foundation, Washington DC, April 2016.

Galdorisi G 2013. 'US Navy missile defense: Operation Burnt Frost', *Defense Media Network*, 18 May 2013, online.

GST (Gilmour Space Technology), no date. *Gilmour Space*, online.

Handmer A 2018. 'Australia should aspire to be a leader in strategic space diplomacy', *The Strategist*, 31 October 2018, online.

Hanson F, Uren T 2018. *Australia's offensive cyber capability*, ASPI, Canberra, 10 April 2018, online.

Harris M 2019. 'Why satellite mega-constellations are a threat to the future of space', *MIT Technology Review*, 29 March 2019, online.

Harrison T, Johnson K, Roberts TG 2017. *Escalation and deterrence in the Second Space Age*, Center for Strategic and International Studies, Washington DC, 3 October 2017, online.

Harrison T, Johnson K, Roberts TG 2019. *Space threat assessment 2019*, Center for Strategic and International Studies, Washington DC, April 2019, online.

Heydarian R 2017. 'Divided ASEAN hands China diplomatic coup', *Nikkei Asian Review*, 12 August 2017, online.

Holden M 2012. 'GPS attacks risk maritime disaster, trading chaos', *Reuters*, 22 February 2012, online.

Hose C 2019. 'India ASAT debris spotted above 2,200 kilometres, will remain a year or more in orbit', *Space News*, 9 April 2019, online.

Hose M 2018. 'Australian Defence SATCOM System (ASDSS) brief to MilCIS 2018', PowerPoint presentation, 13 November 2018.

Hypersonix, no date. *Hypersonix: developing a sustainable way to get to space*, online.

Jiang Lianju, Wang Liwen (eds) 2013. *Textbook for the study of space operations*, Military Science Publishing House, Beijing, 2013.

Jones A 2018. 'China to launch first Hongyan LEO communications constellation satellite soon', *Global Times*, 13 November 2018, online.

Jones A 2019. 'Chinese firms Space Transportation and Linkspace test reusable launcher technologies', *Space News*, 26 April 2019, online.

Lewin S 2019. 'India's anti-satellite test created dangerous debris, NASA chief says', *Space.com*, 1 April 2019, online.

Livingstone D, Lewis P 2016. *Space, the final frontier for cybersecurity?*, Chatham House, September 2016, online.

Lovett DJ 2015. *Space power for Australia's security: grand strategy or strategy of grandeur*, Air Power Development Centre, 2015, online.

Macias A 2018. 'A never before seen Russian missile is identified as an anti-satellite weapon and will be ready for warfare by 2022', *CNBC*, 25 October 2018, online.

McGill University 2019. *Manual on international law applicable to military uses of outer space*, Montreal, Quebec, 2019, online.

NASA (National Aeronautics and Space Administration) 2018. *NASA's management of the space launch system stages contract*, Office of the Inspector General, Washington DC, 10 October 2018, online.

Osley K 2018. 'Positioning, navigation and timing … a warfighter's perspective!', Department of Defence, Canberra, February 2018, online.

Pellerin C 2014. 'Stratcom, DoD sign space operations agreement with allies', news release, US Department of Defense, Washington DC, 23 September 2014, online.

Petrucci N 2017. 'Reflections on Operation Burnt Frost', *AirPowerStrategy.com*, 5 March 2017, online.

Podvig P 2013. 'Another old anti-satellite system resurfaces', *Russian Strategic Nuclear Forces*, 25 January 2013, online.

Podvig P 2019. 'Nudol ASAT was tested from Plesetsk in December 2018', *Russian Strategic Nuclear Forces*, 6 February 2019, online.

Pollpeter K 2019. *Testimony at hearing on 'China in space: a strategic competition?'*, US–China Economic and Security Review Commission, Washington DC, 25 April 2019, online.

Pollpeter K, Anderson E, Wilson J, Yang F 2015. *China dream, space dream: China's progress in space technologies and the implications for the United States*, US–China Economic and Security Review Commission, Washington DC, 2 March 2015, online.

Pollpeter K, Chase MS, Heginbotham E 2017. *The creation of the PLA Strategic Support Force and its implications for Chinese military space operations*, RAND Corporation, Santa Monica, California, 2017, online.

Pollpeter K, Ray J 2016. 'The conceptual evolution of China's military space operations and strategy', in McReynolds J (ed.), *China's evolving military strategy*, Jamestown Foundation, Washington DC, April 2016.

Pyne C 2017. '$500 million for enhanced satellite capability', media release, Department of Defence, 18 June 2017, online.

RAAF (Royal Australian Air Force) 2019. *Air–space integration*, AFDN 1-19, Doctrine Note series, RAAF, 15 February 2019, online.

Reisinger D 2019. 'Three reasons why the second Falcon Heavy launch is a make or break moment for SpaceX', *Forbes*, 10 April 2019, online.

REL (Reaction Engines Ltd) 2018. *SABRE*, online.

RNTF (Resilient Navigation and Timing Foundation) 2016. *Prioritizing dangers to the United States from threats to GPS: ranking risks and proposed mitigations*, RNTF, Alexandria, Virginia, 2016, online.

Shambaugh D 2018. 'Can America meet the China challenge in Southeast Asia?', *The Strategist*, 23 May 2018, online.

Southern Launch, no date. *Southern Launch*, online.

Tullis P 2018. 'The world economy runs on GPS. It needs a backup plan', *Bloomberg Businessweek*, 25 July 2018, online.

UNOOSA (United Nations Office for Outer Space Affairs) 2019. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, UNOOSA, Vienna, 2019, online.

UoA (University of Adelaide) 2018. *The Woomera manual on the international law of military space operations*, UoA, 2018, online.

US DoD (US Department of Defense) 2017. *Countering air and missile threats*, joint publication 3-01, US DoD, Washington DC, 21 April 2017, online.

US DoD (US Department of Defense) 2018. *Summary of the 2018 National Defense Strategy of the United States of America: sharpening the American military's competitive edge*, US DoD, Washington DC, January 2018, online.

US DoD (US Department of Defense) 2019. *Annual report to Congress: Military and security developments involving the People's Republic of China 2019*, US DoD, Washington DC, May 2019, online.

Wall M 2018. 'NASA's SLS megarocket over budget, behind schedule, report finds', *Space.com*, 10 October 2018, online.

Weeden B 2010. *2007 Chinese anti-satellite test fact sheet*, Secure World Foundation, Washington DC, 2010, online.

Weeden B 2019. *Testimony at hearing on 'China in space: a strategic competition?'*, US–China Economic and Security Review Commission, Washington DC, 25 April 2019, online.

Weeden B, Sampson V (eds) 2019. *Global counterspace capabilities: an open source assessment*, Secure World Foundation, Washington DC, April 2019, online.

Ziesing K 2018. 'Next generation of satcoms under JP9102', *Australian Defence Magazine*, 2 November 2018, online.

Zinatullin L 2018. 'Artificial intelligence and cybersecurity: attacking and defending', *The State of Security*, 10 December 2018, online.

ACRONYMS AND ABBREVIATIONS

ADF	Australian Defence Force
AGO	Australian Geospatial-Intelligence Organisation
ASAT	antisatellite / antisatellite weapon
ASDSS	Australian Defence SATCOM System
ASEAN	Association of Southeast Asian Nations
AUSSpOC	Australian Space Operations Centre
BMD	ballistic missile defence
C2G2	Combined Communications Gateway Geraldton
CSIS	Center for Strategic and International Studies (US)
CSpO Initiative	Combined Space Operations Initiative
CSpOC	Combined Space Operations Center (US)
DA-ASAT	direct-ascent antisatellite weapon
GEO	geostationary orbit
GNSS	global navigation satellite system
GPS	Global Positioning System
HQJOC	Headquarters Joint Operations Command
ISR	intelligence, surveillance and reconnaissance
JORN	Jindalee Operational Radar Network
LEO	low Earth orbit
MEO	medium Earth orbit
MILAMOS	*Manual on international law applicable to military uses of outer space*
MoU	memorandum of understanding
OST	Outer Space Treaty
PLA	People's Liberation Army
PLASSF	PLA Strategic Support Force
PPWT	Treaty on the Prevention of the Placement of Weapons in Outer Space
RAAF	Royal Australian Air Force
RPO	rendezvous and proximity operation
SATCOM	satellite communication
SSA	space situational awareness
UHF	ultra-high frequency
WGS	Wideband Global SATCOM

The Australian Defence Force and contested space