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The PLA’s anti-ship cruise missile threat to Australian and allied naval operations

Dr Sam Goldsmith
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About the author

Dr Sam Goldsmith is the director of Red Team Research, has a PhD on Australian defence industry innovation and has published through the United States Naval War College with the title *U.S. Conventional Access Strategy: Denying China a Conventional First-Strike Capability*.

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Cover image: Combat systems operators and electronic warfare sailors manning consoles in the operations room onboard HMAS Anzac. Photo: Defence image library, online.
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Executive summary

‘Vampire Vampire Vampire’—three words that would send shivers down the spine of any ship’s captain. This is because ‘vampire’ is the US military’s brevity code for a hostile anti-ship missile.

Typically, advanced anti-ship cruise missiles (ASCMs) have long ranges and advanced guidance systems and in some cases might incorporate stealthy design features, decoys and countermeasures to assist the missile in successfully penetrating sophisticated air defence systems.

Ever since the 1995–1996 Taiwan Strait crisis, the People’s Republic of China has heavily invested in its multibranched armed forces—the People’s Liberation Army (PLA). For over two decades, the PLA has consistently acquired, developed and surreptitiously obtained new technologies and capabilities, including a prodigious array of increasingly sophisticated ASCMs, such as the supersonic sea-skimming YJ-12 ASCM, which has a range around 400–537 kilometres. YJ-12 variants can be launched from bombers, surface ships and land batteries. The PLA has also invested in capabilities to sustain ASCM maritime strike operations even under high-intensity battle conditions against a technologically advanced power such as the US; for example, land-based C4ISR (command, control, communications, computing, intelligence, surveillance and reconnaissance) networks, passive defences such as hardened air bases, plus active defences such as surface-to-air missiles.

In any regional war, the PLA would likely execute combat operations under its ‘counter-intervention strategy’, which aims to leverage its anti-access/area-denial (A2/AD) capabilities for maximum asymmetric effect to deter, deny or defeat US and Allied forces from intervening over a range of territorial disputes in the Western Pacific. ASCMs form part of the PLA’s broader A2/AD capability toolbox, which also includes naval assets such as submarines, air assets such as fighter squadrons, land assets such as theatre ballistic missiles, and cyber capabilities.

The PLA’s ASCM capability generates four serious challenges for Australian and Allied naval forces. First, ASCMs will be difficult to detect because of their low signatures, and sea-skimming ASCMs will be detected by a surface ship’s radar only when they pop up over the horizon. Second, countering ASCMs will be difficult because of high speeds, manoeuvrability, swarming technology plus the possibility of decoys and countermeasures to help penetrate surface ships’ anti-air defences. Third, ASCM raids might saturate anti-air defences and either sink ships or leave ships with severely depleted missile magazines. Fourth, terrorist groups have previously accessed PLA ASCM technology; in the past, PLA ASCM technology has been sold to Iran and then on-sold to Hezbollah, which attacked an Israeli warship with ASCMs in July 2006.

The PLA’s ASCM threat is very significant because existing Royal Australian Navy (RAN) surface ships have small air-defence missile magazines, and even future surface ships that are planned to begin arriving around 2033 won’t rectify the fleet-wide shortfall of vertical launching system (VLS) missile cells. The RAN’s eight Anzac-class frigates have eight VLS cells each, and the three Hobart-class destroyers have 48 VLS cells per ship. The Anzac frigates will remain in service until around 2044 and the Hobart destroyers even longer. Even when the future Hunter-class frigates begin to arrive around 2033, each ship will only pack a punch of 32 VLS cells. This means that the RAN surface fleet won’t begin to receive moderate numbers of VLS cells until after 2033, which might be too little, too late, given that there’s the very real risk of a regional war occurring between 2020 and 2030.
While the RAN waits for the future Hunter-class frigates to arrive, what else can be done to radically improve the survivability of deployed RAN taskforces against the sprawling and increasingly sophisticated ASCM threat spectrum?

The answer is that any solution should consider tackling four critical issues:

- deeper fleet magazines
- the disaggregation of expensive crewed surface combatants into smaller, cheaper and expendable uncrewed assets
- efforts to break the PLA’s ASCM kill-chain by disrupting, denying or destroying critical capabilities that would be needed to execute successful ASCM strikes
- employing long-range ordnance to engage in offensive air and missile defence operations, principally by targeting enemy ASCM launch platforms.

In the short term, the RAN could exploit proven military-off-the-shelf technology upgrades to its existing surface ship fleet. Options include using the Evolved Sea Sparrow Missile Block II, retrofitting ships with launchers to support the Rolling Airframe Missile Block II, using new hypervelocity projectile rounds in the existing five-inch naval guns, and potentially fitting embarked helicopters with an appropriate air search radar to detect hostile ASCMs at greater ranges.

In the medium term, the RAN could introduce a mix of crewed and uncrewed assets to deepen fleet magazines and underpin offensive and missile defence operations. It might consider acquiring a batch of more capable guided missile destroyers from the US or Japan. The RAN could introduce a class of large unmanned surface vehicles to carry a variety of payloads, including strike-length Mk-41 VLS cells, innovative naval gun rounds to defend against ASCMs, high-power radio frequency weapons, as well as jammers and lasers to blind or dazzle electro-optical and infrared satellites. It could consider introducing small unmanned aerial vehicles, unmanned surface vehicles and unmanned undersea vehicles or high-altitude airships—to be fitted with sensors for detecting hostile ASCMs and enemy ASCM launch platforms. The RAN could also consider introducing a large unmanned combat aerial vehicle with a very long range, high endurance and high payload capacity to provide deployed RAN task groups with a replenishable mobile magazine of anti-air, anti-ship and anti-submarine ordnance for neutralising enemy ASCM launch platforms.

In the longer term, the RAN could introduce long-range platforms and systems to help break an adversary’s kill-chain. Options might include ‘magazine ships’ fitted with large numbers of air and missile defence interceptors and long-range strike missiles, a force of B-21 Raider long-range stealth bombers, antisatellite weapons and offensive cyberattack capabilities.

The problem faced by the RAN is that the current fleet is unlikely to meet the ASCM threat spectrum of today, let alone the ASCM threat spectrum of the 2030s and 2040s. Nor does the future RAN battle force appear sufficient to meet a dystopian future in which the PLA Navy will be the world’s largest navy. An even greater concern is that the ADF doesn’t possess the very long-range strike capability that would be needed to make any substantial contribution in a high-intensity regional war against a technologically advanced and sophisticated adversary.

Australia has been caught napping at the wheel. Ten years ago was the time for change, but now wholesale changes are well overdue. Decades of unchallenged US strategic primacy have arguably shielded Australia from the consequences of complacency and chronic underinvestment in Australia’s national defence. The problem is that US strategic primacy is being actively contested, if not visibly eroded.

Australia faces a bleak future, and the window for expediting effective countermeasures is rapidly closing. There’s good reason to believe that a bipartisan parliamentary inquiry might be a valuable exercise to educate the Australian public as to what a regional war against a nuclear-armed major-power adversary might look like and how it would affect the Australian way of life. The government might also consider commissioning a bipartisan and independent review of Australia’s defence capabilities to be run by a security-cleared, experienced and eminent Australian—‘Dibb Review 2.0’.
Introduction

Since 1995–1996, China’s People’s Liberation Army (PLA) has been developing a lethal array of missiles for land-attack and anti-ship applications.¹ The current PLA arsenal includes a range of different ordnance types, including cruise missiles, ballistic missiles and hypersonic boost-glide missiles.² However, this paper focuses on the threat posed by anti-ship cruise missiles (ASCMs), particularly to Royal Australian Navy (RAN) combatant assets. Future papers will look at other aspects of the PLA threat spectrum.

The 1995–1996 Taiwan Strait crisis became an inflection point in the PLA’s trajectory and has driven the PLA’s military modernisation plans and war-fighting doctrine.³ The crisis highlighted the inability of the PLA to deter, blunt or, if necessary, defeat US force projection capabilities in the Western Pacific, and particularly US Navy carrier strike groups.⁴

The PLA also drew lessons from the 1982 Falklands War, the 1991 Gulf War, Operation Allied Force in 1999 and possibly Soviet doctrine from the Cold War. The PLA has studied the 1982 Falklands War as an example of how an inferior air force might disproportionately affect a technologically superior naval force.⁵ The 1991 Gulf War highlighted the US’s mastery of integrated command, control, communications, computing, intelligence, surveillance and reconnaissance (C4ISR) technologies and techniques, long-range strike missiles, air power supported by tankers, plus space assets for navigation and intelligence.⁶ Serbian responses to NATO bombing campaigns during Operation Allied Force in 1999 highlighted the importance of passive defences such as dispersion, decoys, camouflage, concealment and hardened structures.⁷ Operation Allied Force also highlighted the importance of cruise missiles and probably spurred the PLA’s accelerated acquisition, development or both of such missiles.⁸ The PLA’s military modernisation began to take shape around a concept of ‘three attacks, three defences’.⁹ The three attacks refer to offensive stealth aircraft, cruise missiles and helicopters.¹⁰ The three defences refer to defensive measures to reduce the effectiveness of an adversary’s precision strikes, electronic warfare and reconnaissance.¹¹ It’s also possible that the PLA drew lessons from Soviet doctrine that aimed to neutralise NATO air bases and US Navy aircraft carriers with long-range anti-ship missiles.¹²
The PLA is China's multi-branched armed forces: branches of the PLA include the People's Liberation Army Army (PLAA), the People's Liberation Army Navy (PLAN), the People's Liberation Army Air Force (PLAAF), the People's Liberation Army Rocket Force (PLARF) and the PLA Strategic Support Force. Since the 1995–1996 Taiwan Strait crisis, the People's Republic of China (PRC) has rapidly transformed the PLA into a modern force, furnished with large volumes of technologically sophisticated combat capabilities.

In particular, the PLA has made significant strides in terms of the quantity, variety and technological sophistication of its domestically produced land and anti-ship strike missiles. In 2005, the US Department of Defense assessed that the PLA's objective for ASCMs was to improve their range and speed. By 2009, the PLAN was deploying the Chinese-manufactured YJ-62 ASCM aboard its Luyang II-class guided missile destroyers. By 2015, the PLAN was fielding its newly developed YJ-18 ASCM aboard its Luyang III-class guided missile destroyers, Type 055 class guided missile cruisers and various submarine classes.

The PLAN continues to extend its strike range with more and increasingly sophisticated domestically produced ship, submarine, and aircraft-deployed ASCMs, with the exception of a few legacy missiles imported from Russia in the 1990s and early 2000s.

The PLA's military modernisation has been underpinned by four key methods: foreign technology imports, reverse-engineering, foreign knowledge exploitation and clandestine technology capture. Although not all of those methods may have been used to develop the PLA's ASCM capability, it's important to understand the range of collection techniques that the PRC has exploited in the past and may very well have been used in the cruise missile domain. The PRC's short-term objective was to rapidly improve the combat power of the PLA, with the long-term objective of fielding a technologically advanced domestic defence industry with the capability to service the PLA's future military capability requirements.

The pace of indigenous [Chinese] ASCM [anti-ship cruise missile] research, development, and production—and of foreign procurement—has accelerated over the past decade.

The PRC's long-term goal is to create an entirely self-reliant defense-industrial sector—fused with a strong civilian industrial and technology sector—that can meet the PLA's needs for modern capabilities. However, the PLA still looks to import foreign equipment, technologies, and knowledge to fill some critical, near-term capability gaps and accelerate its modernization.

Foreign technology imports have been critical to enabling the PLA's rapid rise as a modern military force. Initially, the PRC imported Russian technology, such as ASCMs, to rapidly upgrade the combat power of the PLA, but has since broadened its scope. For example, the PRC acquired two Sovremenny-class destroyers that were fitted with the Russian SS-N-22 Sunburn ASCM. However, the PLA has broadened its scope, and Russian scientists embedded
in the Chinese defence industry have provided the PRC with significant technical assistance. The PRC also imported HARPY anti-radiation loitering missiles from Israel in 2001, and Israel assisted the PLA with maintenance in 2003. However, neither Russia nor Israel has sold its most advanced weapons systems to the PRC. Furthermore, the PLA’s military modernisation has benefited from the importation of dual-use and military technologies from European states including Britain, France, Italy and Germany. For example, the PRC acquired Spey Mk-202 engines from Britain in 2001 for use on the PLA’s FB-7 fighter-bomber. Another example is French and Italian technical assistance for a new Chinese helicopter.

The direct acquisition of foreign weapons and technology … [has] enabled China to develop and produce advanced weapon systems, such as missiles, fighter aircraft, and warships.

—Office of the Secretary of Defense, 2008

China acquires dual-use, export controlled technology by applying for licenses through the US Department of Commerce. The majority of China’s imports have traditionally been electronic and materials processing and test, inspection, and production equipment.

—Office of the Secretary of Defense, 2020

The PRC has also used reverse-engineering in order to realise benefits for the broader Chinese defence-industrial base. The PRC already has a track record of reverse-engineering foreign technology, such as US Firebee drones that were captured during the Vietnam War. In 2006, the Chinese reverse-engineered the SA-10 anti-air missile system that was previously acquired from Russia, in order to produce a domestic variant. In 2019, it was reported that the PRC might attempt to reverse-engineer the imported Russian S-400 air and missile defence system. Indeed, reliance on Russian technology imports was intended only as a temporary measure to establish a self-sufficient high-tech Chinese defence industry.

China is actively seeking foreign weapons and technology, primarily from Russia and states of the former Soviet Union, to fill near-term capability gaps. In the long term, however, Beijing seeks to establish a wholly indigenous defense industrial sector.

—Office of the Secretary of Defense, 2006

The PRC has also exploited foreign knowledge to rapidly develop and expand its domestic defence industrial base. Around 2006, it was reported to be exploiting joint ventures, foreign investment and repatriated Chinese students in order to gain unauthorised access to both dual-use and military technologies. In 2007, the US Department of Defense noted that the PRC was repatriating Chinese nationals with overseas experience and training back to China. In 2011, the department noted that the PLA was exploiting companies and research institutes with Chinese Government links to access advanced foreign dual-use technologies, under the guise of research or business collaboration frameworks. In 2018, the PRC was recruiting foreign skilled and experienced people to work in China in order to ‘fill technical knowledge gaps’. One of those foreign recruitment programs was the ‘Thousand Talents Program’, which gave priority to skilled people typically of Chinese ethnicity.

[T]wo authoritative PRC journals recommended an increase in the use of overseas ethnic-Chinese scientists to transfer foreign technology. The journals endorsed building databases of such overseas scientists, tasking them with research of interest to Beijing, and maintaining secrecy through the use of intermediaries and third countries. Recruitment through intermediaries was recommended to avoid complications due to policies and sensitivities of the targeted nation.

—Office of the Secretary of Defense, 2002

The PRC leverages foreign investments, commercial joint ventures, mergers and acquisitions, academic exchanges, the foreign experience that students and researchers from the PRC gain from studying in foreign nations … to increase the level of technologies and expertise available to support military research, development, and acquisition.

—Office of the Secretary of Defense, 2021
Clandestine technology capture has been and continues to be a very significant enabler of the PLA's rapid military modernisation: typically, this pathway involves the deliberate targeting of sensitive and classified technology. Between 2000 and 2006, the US Immigration and Customs Enforcement agency 'initiated more than 400 investigations involving the illicit export of US arms and technologies to China'.44 By 2011, the PRC had moved into the wholesale espionage business by recruiting foreign nationals for the purpose of harvesting classified technology and extremely sensitive technology.45 For example, in August 2010, Noshir Gowadia, a naturalised US national, was convicted for assisting the PLA develop a low-infrared-signature cruise missile.46 In January 2012, Yang Bing was extradited from Bulgaria to the US for attempting to export military accelerometers, as used in guided missiles, to the PRC.47 In July 2012, naturalised Canadian national Zhang Zhaowei was indicted for attempting to illegally export gyroscopes, as used in missile guidance systems, to the PRC.48 In March 2013, Chinese national Liu Sixing was sentenced to 70 months jail by a US federal court for illegally transporting to the PRC stolen files that covered the design and performance of missile guidance systems.49
Current PLA ASCM capability

PLA ordnance and launch platforms

The PLA deploys a wide range of technologically advanced and lethal ASCMs, not all of which are listed here. Current PLA ASCMs have long ranges, offer supersonic speeds, fly as low as five metres and can approach targets from multiple axes. The YJ-12 and YJ-18 are newer breeds of PLA ASCMs. By contrast, the YJ-62 and YJ-91 date back to 2008, and the YJ-83 dates back to 2004. Table 1 summarises some key PLA ASCMs.

Table 1: Key PLA anti-ship cruise missiles

<table>
<thead>
<tr>
<th>ASCM model</th>
<th>Range</th>
<th>Launch options</th>
</tr>
</thead>
<tbody>
<tr>
<td>YJ-12</td>
<td>400–537 km</td>
<td>Bomber</td>
</tr>
<tr>
<td>YJ-12A</td>
<td>400–537 km</td>
<td>Surface ship</td>
</tr>
<tr>
<td>YJ-12B</td>
<td>400–537 km</td>
<td>Land battery</td>
</tr>
<tr>
<td>YJ-18A</td>
<td>537 km</td>
<td>Surface ship</td>
</tr>
<tr>
<td>YJ-18A80</td>
<td>537 km</td>
<td>Submarine</td>
</tr>
<tr>
<td>YJ-62</td>
<td>400 km</td>
<td>Surface ship</td>
</tr>
<tr>
<td>YJ-83J</td>
<td>180 km</td>
<td>Surface ship</td>
</tr>
<tr>
<td>YJ-83K</td>
<td>200 km</td>
<td>Fighter-bomber</td>
</tr>
<tr>
<td>YJ-91</td>
<td>50 km</td>
<td>Air-launched</td>
</tr>
</tbody>
</table>
Current PLA ASCM capability

Figure 1: PLA H-6 bomber with ASCM payload


The PLA’s latest YJ-12 ASCM has a range of around 400–537 kilometres plus a terminal speed around Mach 2.5. The YJ-12 ASCM combines the YJ-91’s supersonic terminal phase of flight speeds with the YJ-62’s range by using subsonic transit speeds. The PLA deploys the YJ-12 from its naval aviation H-6J maritime strike bombers, each of which carries a payload of six YJ-12 ASCMs. The PLA’s naval aviation H-6G bombers can also carry four YJ-12 ASCMs each. The PLA also fields the YJ-12A ship-launched variant and the YJ-12B ground-launched variant: YJ-12B ASCM batteries are already deployed on Chinese outposts in the South China Sea. Planned upgrades to the Russian-built Sovremenny-class guided missile destroyers will allow the ships to carry the Chinese YJ-12A.

Figure 2: PLA YJ-18 anti-ship cruise missile

The PLA’s YJ-18 is a supersonic, sea-skimming, long-range ASCM that’s vertical-launch compatible, has a speed of Mach 2.5 to Mach 3.0 for the final 40 kilometres to target, and has a total range around 537 kilometres (Figure 2). The PLA deploys the long-range and supersonic YJ-18A Luyang III-class guided missile destroyers (Figure 3) and Renhai-class guided missile cruisers (formerly known as Type 055; Figure 4). The YJ-18 is also deployed from Song-, Yuan- and Shang-class submarines: the Shang class or Type 093 is a nuclear-powered attack submarine.

Figure 3: PLA Type-052D Luyang III-class destroyer

Source: Department of Defence, online.

Figure 4: PLA Type-055 Renhai-class cruiser

The PLA fields the older YJ-83 ASCM aboard frigates, corvettes, Houbei-class (Type-022) missile patrol boats (Figure 5) and JH-7 fighter-bombers.80 PLAN frigates and corvettes carry the YJ-83J ASCM, which has a range of around 180 kilometres.81 Houbei-class missile patrol boats carry eight YJ-83 ASCMs.82 The JH-7 fighter-bomber carries four YJ-83K ASCMs plus two air-to-air missiles—the YJ-83K has a range around 200 kilometres.83

Figure 5: PLA Type-022 Houbei-class missile patrol boat

Other PLA ASCMs include the YJ-62 ASCM as used aboard Luyang II-class guided missile destroyers with a range of 400 kilometres.84 The PLA also uses the YJ-91 Chinese-made air-launched missile, which has both anti-ship and anti-radiation variants.85 The YJ-91 has a range around 50 kilometres.86

The PLA is developing hypersonic glide vehicle and scramjet technology, both of which could be used to develop a future hypersonic ASCM.87

The PLA is also developing the H-20, which is a new long-range stealth bomber that will carry a payload of conventional or nuclear ordnance exceeding 10 tonnes to a range exceeding 8,500 kilometres, making the H-20 an ideal future launch platform for PLA ASCMs.88
PLA versus American ASCMs

The RGM-84 Harpoon is the legacy ASCM that both the US Navy and Royal Australian Navy (RAN) currently rely on to neutralise hostile warships at sea. The RGM-84 is a subsonic, sea-skimming ASCM that carries a 227-kilogram warhead to a range of around 124 kilometres.89

The answer of the US Navy and RAN to the inadequate range of the RGM-84 Harpoon is the American Long Range Anti-Ship Missile (LRASM). However, even the LRASM might not have sufficient range to match let alone out-range PLA ASCMs.

The American LRASM is a new generation of ASCM that uses advanced design features to penetrate sophisticated enemy air defences and semi-autonomous guidance to find and kill enemy warships, even in denied environments where data from off-board platforms, such as GPS satellite constellations, might be unavailable due to sophisticated adversary electronic warfare.90 The LRASM is a subsonic ASCM that carries a 453-kilogram blast fragmentation warhead and is fitted with a variety of guidance systems including anti-jam GPS, a radio frequency sensor to identify the target enemy warship plus an infrared sensor for terminal guidance to the specific aim point.91 The LRASM is also reported to include ‘countermeasures’ to aid in the penetration of sophisticated enemy air defences as well as the ability to coordinate attacks on enemy targets with other LRASMs.92

The AGM-158C air-launched LRASM variant has an unclassified range of around 926 kilometres and achieved operational capability aboard B-1B bombers in 2018 and aboard F/A-18E/F combat aircraft in 2019.93

The RGM-158C surface-launched LRASM variant is likely to have a range around 740 kilometres and was successfully test fired from the Mk-41 vertical launching system (VLS) at a land-based test facility on 4 September 2013.94 According to Lockheed Martin, integrating the RGM-158C aboard US Navy destroyers and cruisers would require only ‘software modifications to existing launch control systems’.95
Why does the PLA conventional strike range matter?

The PLA’s very long-range ASCM capability has the ability to hold at risk Allied naval warships (US, Australian, Japanese, South Korean etc.) operating across all of the first and second island chains. The first island chain runs from the southern tip of Kyushu in the Japanese home islands to include Okinawa, Taiwan and almost all of the South China Sea (Figure 6). The second island chain starts at the middle of Honshu in the Japanese home islands to include the Northern Mariana Islands, Guam and Palau and stops at West Papua (Figure 7).

Figure 6: 2020 PLA conventional strike ranges

Allied ships operating in the South China Sea could be attacked by PLA YJ-12B ASCM batteries that have been deployed to China’s artificial outposts.98 Allied ships operating in the South or East China Seas could also be attacked with YJ-83 ASCMs launched from PLA Type-022 missile patrol boats.99

Allied ships operating anywhere in the first or second island chains could come under ASCM saturation attacks from PLA combat aircraft. PLA JH-7 fighter-bombers can attack Allied ships with ASCMs at a range of around 1,870 kilometres.100 PLA H-6J bombers can attack Allied ships with ASCMs at a range of around 2,900 kilometres.101 The PLA’s forthcoming H-20 stealth bomber is also a future long-range ASCM launch platform, particularly given the aircraft’s payload of over 10 tonnes and a range that exceeds 8,500 kilometres.102

The PLA’s integration of the YJ-18 ASCM aboard its surface combatants and submarines will theoretically allow it to execute ASCM strikes anywhere in the world. The YJ-18 ASCM is currently carried aboard Type-052D Luyang III-class destroyers, Type-055 Renhai-class cruisers, Song-class submarines, Yuan-class submarines and Type-093 Shang-class nuclear-powered attack submarines.103 It’s worth noting that a PLA Type-052D Luyang III destroyer recently transited through the Timor and Arafura seas, within Australia’s exclusive economic zone (EEZ), between 14 and 18 February 2022.104
Why does the PLA conventional strike range matter?

**PLA theatre-wide C4ISR**

ASCM range is only one part of the equation: just as essential is the capability to accurately target warships at ranges in the order of several thousand kilometres and then communicate targeting data to ASCM-carrying platforms. The PLA has been actively addressing this theatre-wide challenge. It has invested heavily in land-based C4ISR capabilities. The objective of PLA C4ISR capabilities is to provide PLA combatant commanders with the necessary intelligence, information and targeting data to execute theatre-wide campaigns. PLA C4ISR is expected to be capable of operating even under heavy attack.

The PLA's ASCM capability is underpinned by highly capable C4ISR and particularly by long-range over-the-horizon sensors. For example, the PLA acknowledges that the effectiveness of its ASCMs will be largely underpinned by long-range and wide-area surveillance, as is necessary for tasking and coordinating air, surface and undersea ASCM strike platforms.

PLA C4ISR is built around a dedicated military network that includes microwave relays, high-frequency radio, satellite communications, coaxial cable and fibre-optic cable. China has already fielded quantum-encrypted land-based communications, has rollout plans to span the Chinese mainland and also aims to field a quantum-encrypted satellite communications capability by 2030.

PLA surveillance features sky-wave and surface-wave radars that provide the PLA with long-range over-the-horizon surveillance of China's air and maritime approaches. PLA sky-wave radars can detect ballistic missile launches at a range of around 2,500 kilometres, whereas PLA surface-wave radars can detect low-altitude aircraft and cruise missiles at a range in the hundreds of kilometres. The PLA also uses phased-array radar, passive radar, pulsed doppler radar and infrared sensors to further improve the tracking of air and surface targets.

Seabed sonar networks and other passive sensors provide the PLA with the capability to monitor China's undersea approaches.

The PLA's wide-area surveillance and reconnaissance capability is augmented by radar, synthetic aperture radar, infrared and electro-optical satellite constellations plus unmanned aerial vehicles.

**PLA passive defences**

The PLA has invested heavily in improving the survivability of its land-based facilities through the use of passive defence techniques, such as hardened structures and advanced camouflage techniques. Quite often, PLA passive defences incorporate multiple levels of redundancy to ensure the continuity of combat operations, even if primary assets receive battle damage. Serbian counters to NATO's bombing campaign during Operation Allied Force in 1999 not only highlighted the importance of increasing the survivability of land-based facilities from air strikes by a technologically superior adversary, but also the effectiveness of dispersion, camouflage and decoys in reducing the effectiveness of air strikes by such an adversary. There are four key passive defence elements that pertain to the PLA's ASCM capability: deception, camouflage, hardened structures and redundancy.

PLA strategic writings outline the extensive importance of deception to mislead enemy intelligence and surveillance while concealing plans and capabilities to achieve operational surprise but also contingency plans to counter unexpected surprises as unleashed by advanced adversaries. PLA techniques include carefully coordinated plans to ensure that a consistent message is portrayed across the diplomatic, political and economic levels, positioning combat assets to conform with adversary expectations, using camouflage and decoy, and exploiting operational flexibility and reserves to meet unexpected enemy challenges.

The PLA uses advanced camouflage and concealment as part of its passive defence suite. It camouflages and conceals key assets such as aircraft shelters, supply depots, aircraft parking ramps and aircraft taxiways. For example, PLAAF aircraft shelters, parking ramps and taxiways have painted-on camouflage. However, other PLAAF hardened aircraft shelters feature earthworks and floral camouflage.
The PLA has used hardened structures since the 1950s to protect critical assets and currently possesses a very sophisticated, extensive and technologically advanced network of such structures (Table 2).\(^{123}\) For example, the PLARF’s road-mobile nuclear missiles are protected by a hardened underground tunnel network, affectionately referred to as the ‘Great Underground Wall’, that’s reported to be over 5,000 kilometres long.\(^ {124}\) Hardened structures can be above ground or below ground, and vary in terms of the protection afforded.

### Table 2: Categories of hardened structures

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboveground hardened structure</td>
<td>Ground-level structures that are reinforced, are covered with earth and may</td>
</tr>
<tr>
<td></td>
<td>be shaped to withstand blast-wave effects.</td>
</tr>
<tr>
<td>Shallow underground hardened structure</td>
<td>Reinforced structures that are buried up to 20 metres below the surface.</td>
</tr>
<tr>
<td>Deep underground hardened structure</td>
<td>Reinforced structures that are buried at depths greater than 20 metres.</td>
</tr>
<tr>
<td>Strategic hard and deeply buried target (HDBT)</td>
<td>Reinforced structures that are buried at depths between 100 and 700 metres</td>
</tr>
<tr>
<td></td>
<td>below the surface. Typically, these types of structures are reserved for</td>
</tr>
<tr>
<td></td>
<td>entities at the national command level.</td>
</tr>
</tbody>
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The PLA operates a sophisticated network of hardened underground facilities that are designed to allow China’s national command authority to command PLA combat assets even while under heavy attack.\(^ {125}\) Those hardened structures are connected to the PLA’s extensive and advanced land-based C4ISR capabilities.\(^ {126}\)

[T]he PLA’s investments in underground facilities for missile, aircraft, and naval forces have made Chinese military bases and naval ports extremely difficult targets even for ‘near zero miss’ precision weapons.

—Center for Strategic and Budgetary Assessments, 2013\(^ {127}\)

The PLAAF operates aboveground hardened aircraft shelters that feature reinforced concrete 0.9–1.2 metres thick and are covered with earth.\(^ {128}\) The shelters ‘would oblige an adversary to target each aircraft shelter with multiple [precision guided munitions] to ensure that the shelter, along with any aircraft inside, was destroyed’.\(^ {129}\) The PLAAF also operates underground hardened structures to shield combat aircraft and support facilities buried at depths anywhere between 6 metres and more than 60 metres of rock.\(^ {130}\) Some PLAAF air bases have super-hardened structures that are built under mountains, with only the taxiways and runways exposed at ground level, but with hardened doors that are oriented so that nearby hills would prevent enemy guided missiles from flying through the door and detonating inside.\(^ {131}\) PLAAF air bases also feature aboveground and underground fuel storage facilities.\(^ {132}\)

The PLAN operates hardened underground submarine facilities with aboveground entrances. The PLAN’s underground submarine facilities conceal PLAN submarine preparedness and pre-deployment and other activities from foreign intelligence services, but also make PLAN submarine deployments less visible and less vulnerable to foreign overhead surveillance.\(^ {133}\) The PLAN’s Jianggezhuang Naval Base near Qingdao features an underground submarine base that has a very significant underground submarine facility and is built under a mountain.\(^ {134}\) The PLAN’s Yulin Naval Base on Hainan island features very significant underground submarine support facilities and appears to have been built under a mountain.\(^ {135}\) The Yulin submarine facility is rumoured to contain ‘several super-bunkers to protect in-port SSBNs’.\(^ {136}\) Given other PLA facilities that are hardened and built under mountains, it’s likely that PLAN underground submarine facilities are hardened and designed to withstand attacks by a wide range of ordnance.
Why does the PLA conventional strike range matter?

The PLA continues to maintain a robust and technologically advanced underground facility (UGF) program to protect all aspects of its military forces, including C2, logistics, missile systems, and naval forces. China has thousands of UGFs and it continues to construct more each year. The PLA utilizes these UGFs to protect valuable assets from the effects of missile strikes and to conceal military operations from adversaries.

—Office of the Secretary of Defense, 2020

The PLA also uses redundancy as part of its passive defence suite, which increases the probability of uninterrupted PLA combat operations, even if principal assets are battle damaged or destroyed. For example, PLAAF air bases often feature multiple runways and taxiways. Some bases with nearby grassy areas may be reinforced with metal mesh to serve as emergency airfields. This is pertinent because some PLAAF combat aircraft, such as the SU-27, Su-30 and J-11, are ‘rough-field’ capable. Rough-field capable means that an aircraft has features such as high-flotation tyres, reinforced landing gear, mud guards and special brakes that are designed to ‘keep foreign object debris out of the engines, which are rather tolerant already, and allow the airplane to land on a variety of surfaces—including dirt, mud, snow and ice.’

PLA active defences

The PLA also protects key facilities and infrastructure with active defence capabilities: techniques include fighter and support aircraft for combat air patrols, air and missile defence systems, electronic countermeasures and laser jamming systems.

The PLAAF operates numerous aircraft that can be used to mount serious defensive counter-air operations against enemy aircraft. It operates Russian SU-27 and SU-30 fighters, the J-11A fighter and indigenous J-10A/B/C, J-11B and J-16 fighters, plus J-20 and J-31 stealth fighters. The PLAAF also operates the KJ-500 and KJ-2000 airborne early warning aircraft, which extend the PLA’s land-based radar coverage, but also allow the PLAAF to coordinate air operations.

China's IADS [Integrated Air Defence System] also includes a C4ISR network to connect early warning platforms, SAM and AAA, and command posts in order to improve communication and response time during operations.

—Office of the Secretary of Defense, 2013

The PLA’s air and missile defence capability includes Russian S-300 and S-400 ground-based air defence systems, plus the PLA’s indigenous HQ-9 and HQ-9B air defence interceptors. Air and missile defence assets are also linked to the PLA’s extensive C4ISR network to increase the effectiveness of PLA defensive counter-air operations.

PLA doctrine also mentions the use of electronic countermeasures and jamming technologies to increase the survivability of air and naval bases against enemy air attacks, as are currently deployed by the PLAAF. PLA electronic countermeasures include infrared and electronic decoys, false target generators and angle reflectors.

Why are PLA passive and active defences significant?

The PLA's extensive passive and active defences will severely complicate Allied measures to counter the PLA ASCM threat. Ideally, Allied defensive measures would seek to degrade PLA ASCM capabilities; for example, targeting PLA ships and submarines in port, targeting PLA runways with land-attack missiles or targeting key nodes in the PLA's C4ISR infrastructure. However, PLA passive and active defences are likely to ensure the survivability of PLA ASCM launch platforms and the continuity of PLA ASCM strike operations, even while under Allied air and missile attack. Consequently, Allied forces will not only need the capability to penetrate PLA active defences and overcome PLA passive defences at distances, but will also need to target and neutralise deployed PLA ASCM launch platforms. Both those mission types will probably need to be executed at distances in the order of several thousand kilometres from friendly air or naval bases.
The PLA’s counter-intervention strategy

The PLA’s counter-intervention strategy has been a driving force behind its military modernisation and more recent expansion programs. The purpose of the strategy is to deter or deny third parties from intervening over China’s regional territorial disputes, such as preventing the US from assisting Taiwan. PLA anti-access/area-denial (A2/AD) capabilities enable and underpin the broader counter-intervention strategy. Anti-access (A2) capabilities are those that deter or deny an adversary from deploying military forces to a given operational area, whereas area-denial (AD) capabilities limit an adversary’s freedom of manoeuvre within the defined operational area.

What actually classifies as an ‘assassin’s mace’ weapon is unclear. However, the concept appears to include a range of weapon systems and technologies related to information warfare, ballistic and antiship cruise missiles, advanced fighters and submarines, counterspace systems, and air defense.

Within the PLA’s A2/AD capability are ‘assassin’s mace’ or ‘sha shou jian’ weapons that are designed to target adversary vulnerabilities by leveraging the PLA’s relative strengths. Examples of assassin’s mace weapons include ballistic missiles and cruise missiles that would inevitably be used to target adversary land-bases and naval assets at sea. PLA doctrine emphasises the heavy use of deception, surprise and assassin’s mace capabilities during the opening phases of pre-emptive military operations in a regional war. Given the PLA’s counter-intervention strategy, A2/AD capabilities and assassin’s mace weapons, the PLA would most likely use a variety of combat assets to launch ASCMs against Allied naval forces, and the intensity of attacks would be likely to increase closer to Chinese-held territory.

The PLA’s A2/AD capabilities are to date the most robust within the First Island Chain, although the PRC is beginning to field significant capabilities capable of conducting operations out to the Second Island Chain and seeks to strengthen its capabilities to reach farther into the Pacific Ocean and throughout the globe.

The PLA’s ASCM capability could conceivably make several contributions to China’s broader counter-intervention strategy. PLAN nuclear-powered attack submarines could be used to observe, stalk and harass Allied naval forces departing from the US western seaboard and Hawaii towards the second island chain, as well as forces moving north from Australia. PLAN aircraft carrier battle groups, surface combatants and nuclear-powered attack submarines could interdict Allied naval forces attempting to enter the second island chain: this will become increasingly viable as the PLAN battle force expands to 460 or 550 ships by 2030. Across the first and second island chains (Figure 8), PLA bombers could be used to execute saturation attacks against Allied naval forces: the PLAN H-6G bomber carries four YJ-12 ASCMs, the newer PLAN H-6J variant carries six YJ-12 ASCMs, and the JH-7 aircraft carries four YJ-83K ASCMs. The PLA’s future long-range stealth bomber is also a possible ASCM launch platform, particularly given its stealth technology, very long range and payload exceeding 10 tonnes. Allied naval forces operating in the first island chain would not only face ASCMs launched from PLA land batteries but also ASCMs launched from PLAN Houbei-class guided missile patrol boats and very heavy air attacks from PLAAF and PLAN combat aircraft. Houbei-class guided missile craft each carry up to eight YJ-83 ASCMs.
Figure 8: First island chain and second island chain

The role of ASCMs in the PLA’s counter-intervention strategy

The following is an illustration to show how the PLA’s ASCM capability fits within China’s broader counter-intervention strategy, as part of a theatre-wide PLA military campaign. A PLA military campaign across the first and second island chains in the Western Pacific would probably involve at least four main types of operations either in a carefully orchestrated sequence or concurrently: assassin’s mace operations, deep-strike operations, interdiction operations and defensive operations. Additional support for PLA military operations might be provided by other Chinese Government agencies operating under the concept of ‘non-contact warfare’, which involves the application of asymmetric and non-military methods.164

The PRC’s broad range of ASCMs and shore, ship, submarine, and airborne launch platforms as well as submarine-launched torpedoes and naval mines allow the PLAN to create an increasingly lethal, multi-axis threat against an adversary approaching PRC waters and operating areas.

—Office of the Secretary of Defense, 2021

PLA assassin’s mace operations would likely aim to neutralise ‘Allied’ military capabilities (Australian, American, Japanese, South Korean, etc.) across the first and second island chains during the opening phase of offensive PLA combat operations. While this paper focuses on ASCMs, cruise missiles are only one part of the PLA’s broader strike capability. PLA ballistic and hypersonic boost-glide missiles would target both ships at sea and land-based installations, such as those on Guam: the DF-21 ballistic missile has a range around 1,500 kilometres, the DF-26 ballistic missile has a range around 4,000 kilometres, the upcoming DF-27 ballistic missile has an estimated range of 5,000–8,000 kilometres, and the DF-17 hypersonic boost-glide missile has a range around 2,000 kilometres.166 PLA anti-satellite ordnance would target Allied satellite constellations that are used for communications, navigation and intelligence.167 PLA offensive cyber operations would aim to ‘paralyze’ Allied military capabilities in the Western Pacific theatre.168 With ASCMs, PLA JH-7 fighter-bombers would strike ships at a range of around 1,870 kilometres, while H-6J bombers would strike ships at a range of around 2,900 kilometres.169 PLA H-6 bombers would also use land-attack cruise missiles to strike land targets at a range of around 3,300 kilometres. PLA H-6 bombers would also use land-attack cruise missiles to strike land targets at a range of around 3,300 kilometres.170 The PLA’s future H-20 stealth bomber is also a potential future launcher for anti-ship and land-attack cruise missiles.171 Targets for PLA long-range bombers, such as the H-6 and H-20, might include Allied fuel and ordnance depots, missile-loading facilities and C4ISR nodes.

The addition of land-attack capabilities to the PLAN’s surface combatants and submarines would provide the PLA with flexible long-range strike options. This would allow the PRC to hold land targets at risk beyond the Indo-Pacific region.

—Office of the Secretary of Defense, 2020

PLA deep-strike operations might aim to strike at critical assets and infrastructure deep in the Allied interior and potentially well ‘beyond the Indo-Pacific region’.173 For example, PLAN nuclear-powered attack submarines armed with ASCMs and land-attack cruise missiles could hold at risk US at-sea replenishment ships, fuel and logistics hubs, and naval shipyards. They could also lace critical ports with naval mines as well as insert PLA special forces teams to sabotage key US installations.174 PLA port-mining and special forces sabotage operations would presumably focus on Allied facilities across the first and second island chains, but such operations might also be executed at other key US installations in Hawaii and San Diego. If fitted with anti-air missiles, PLAN nuclear-powered submarines could hold at risk US transport aircraft, inflight refuelling tankers and airborne early warning aircraft operating along the US western or eastern seaboards. Similar vulnerabilities presumably apply to Australia’s fuel and logistics hubs, naval shipyards, ports, infrastructure and key ADF installations.

China has gone from an obsolete mine inventory, consisting primarily of pre-WWII vintage moored contact and basic bottom influence mines, to a vast mine inventory consisting of a large variety of mine types such as moored, bottom, drifting, rocket-propelled, and intelligent mines. The mines can be laid by submarines (primarily for covert mining of enemy ports), surface ships, aircraft, and by fishing and merchant vessels.

—Office of Naval Intelligence, 2015
PLA interdiction operations might aim to intercept Allied naval forces attempting to enter or operate within the second island chain. For example, PLAN aircraft carriers, nuclear-powered attack submarines and surface combatants could be used to intercept US Navy carrier strike groups attempting to reinforce Guam. PLA H-6 and H-20 bombers could be used to execute long-range maritime strike saturation attacks against Allied naval forces.

PLA defensive operations might aim to focus on denying any surviving Allied forces the freedom of manoeuvre within the first island chain. For example, the PLAAF could maintain combat air patrols at distance from the Chinese mainland, supported by inflight refuelling tanker orbits and airborne early warning aircraft. PLAN diesel-electric submarines, surface combatants, JH-7 fighter-bombers and missile patrol boats armed with ASCMs could deliver lethal saturation attacks against Allied naval forces within the first island chain. Closer to the mainland, PLA ground-based anti-air and anti-ship missile batteries could keep Allied air and naval forces at arm’s length.

China’s current thinking on asymmetric warfare is encapsulated by a military theory termed ‘non-contact’ which seeks to attain a political goal by looking for auxiliary means beyond military boundaries or limits. Examples include: cyberwarfare against civilian and military networks—especially against communications and logistics nodes; fifth column attacks, including sabotage and subversion, attacks on financial infrastructure; and, information operation.

—Office of the Secretary of Defense, 2008

Non-contact warfare support for PLA military operations might be provided through a range of internationally focused clandestine activities, as run by Chinese Government agencies. In Chinese asymmetric warfare theory, ‘non-contact warfare’ refers to asymmetric and non-military means to help achieve the broader political objectives, such as subversion, sabotage and attacks on infrastructure. In wartime, China’s international activities might involve propaganda to shape global public opinion, diplomacy to slow the formation of allied coalitions, and sabotage to infrastructure owned by Chinese state-owned enterprises, such as the Port of Darwin. It’s also possible that, in the hours, days or weeks preceding a PLA military campaign, Chinese intelligence services might clandestinely orchestrate a range of ‘accidents’ or ‘mishaps’ to generate fear or social unrest across key democracies; for example, the activation of Chinese intelligence service sleepers to disrupt sewage plants, power plants or supermarket logistics hubs. Chinese-flagged oil tankers might conveniently suffer ‘tragic’ and ‘accidental’ oil spills in critical ports just hours before the commencement of PLA offensive military operations.
So why should Australia and its allies be concerned?

Four key reasons mean that the PLA’s extensive ASCM capability is of great concern to Allied naval forces: ASCMs are difficult to detect and difficult to counter, but also trigger depth-of-fire and proliferation issues.

PLA ASCMs will be difficult to detect partially due to their sea-skimming terminal phases of flight and partially due to their low signatures. For example, the PLA’s YJ-18 is a supersonic, sea-skimming ASCM that has a range of around 537 kilometres. First, naval surface ships fitted with S-band and X-band radars can detect hostile sea-skimming ASCMs only at a range of around 18.5 kilometres. This is because of the curvature of the Earth’s surface and because phased-array radars (for example, the RAN’s Hobart-class AN/SPY-1D(V) and Anzac-class CEAFAR phased-array radars) detect hostile targets on a line-of-sight basis. Second, PLA ASCMs are likely to feature reduced signatures, such as a reduced infrared or radar cross-section signature. One factor is the PLA’s increased understanding of stealth technology, given its own domestic stealth aircraft programs such as the J-20, J-31 and upcoming H-20 stealth bomber. Another factor is China’s state-sponsored espionage that has directly targeted US stealth technology. In 2010, Noshir Gowadia, a naturalised US national, was convicted of illegally furnishing the Chinese Government with classified information pertaining to the US Air Force’s B-2 stealth bomber, in addition to assisting the PLA to develop a stealthy cruise missile with a low infrared signature. Gowadia exploited his classified knowledge of the B-2 stealth bomber from his time working as a security-cleared engineer with Northrop Grumman between 1968 and 1986.

PLA ASCMs will be difficult to counter without incurring damage to the defending surface ship due to several factors. First, PLA ASCMs will continue to evolve in terms of speed and high-G evasive manoeuvres in the terminal phase of flight, but also in terms of seeker technology that will increasingly be able to distinguish between defensive countermeasures and the defending surface ship. Second, the PLA has well-developed penetration aid technologies that could be miniaturised and used aboard future ASCMs to improve survivability against surface ship anti-air defences: it’s also possible that the classified features of current PLA ASCMs already include such penetration aids. For example, PLARF nuclear-tipped ballistic missiles feature jamming, chaff and decoy technologies. Third, PLA advances in artificial intelligence increase the probability that the classified features of current or future PLA ASCMs will enable the autonomous swarming of surface ships in a coordinated, multi-vector strike. Fourth, as the speed of PLA ASCMs increases, so too will the probability of secondary damage to the defending surface ship, even if anti-air defences successfully intercept the inbound ASCM. This is because, as PLA ASCMs become capable of hypersonic or very high supersonic terminal approaches, even a successful intercept by shipboard anti-air defences risks hypersonic or very high supersonic debris inflicting serious damage to the defending surface ship.

The sheer number of PLA ASCMs and launchers triggers depth-of-fire issues for Allied navies. This is because the PLA can execute ‘saturation attacks’ against Allied surface ships with dozens or hundreds of ASCMs. PLA saturation attacks would either overwhelm the defending ships’ anti-air capabilities or severely deplete shipboard VLS missile magazines. Assuming that any Allied surface ships survived unscathed, shipboard VLS magazines would be severely depleted or exhausted. At that point, the defending ships might only have point-defence systems, such as the Mk-
So why should Australia and its allies be concerned? 15 Phalanx or Mk-15 SeaRAM, to defend against further air attacks. Phalanx and SeaRAM would be unlikely to defend surface ships for very long: the Phalanx’s 1,500-round magazine would be depleted after 20 seconds of firing, whereas SeaRAM carries only an 11-round magazine.

The depth-of-fire problem faced by Allied navies is made considerably worse by the scarcity of Mk-41 VLS cells aboard naval ships. For example, the RAN’s Hobart-class guided missile destroyers each carry a 48-cell Mk-41 VLS missile battery. Each cell can accommodate only one long-range weapon, such as the Standard Missile 6 (SM-6), or four medium-range air defence interceptors, such as the Evolved Sea Sparrow Missile (ESSM).

The depth-of-fire problem is magnified by the fact that shipboard Mk-41 VLS magazines, as used by RAN and US Navy surface combatants, can’t be reloaded at sea, unless already scarce VLS cells were to be sacrificed for a shipboard strike-down crane. Even if at-sea reloading were an option, it might take 1–2 full days to complete, during which time the ship would be unavailable for fleet combat operations. Currently, RAN ships would need to return to HMAS Stirling near Perth or the Port of Eden on the southern NSW coast to reload: the total turnaround time for ships operating in the first island chain could be weeks. Alternatively, RAN ships could reload at ports in South Korea, Japan or Guam; however, such ports would most likely be severely damaged from heavy PLA air and missile attacks.

Table 3: Mk-41 vertical launching system (VLS) load-out options

<table>
<thead>
<tr>
<th>Designation</th>
<th>Name</th>
<th>Role</th>
<th># per Mk-41 VLS cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGM-109E</td>
<td>Tomahawk</td>
<td>Land-strike</td>
<td>1</td>
</tr>
<tr>
<td>RGM-158C</td>
<td>LRASM</td>
<td>Anti-ship</td>
<td>1 (future integration option)</td>
</tr>
<tr>
<td>RUM-139</td>
<td>ASROC</td>
<td>Anti-submarine</td>
<td>1</td>
</tr>
<tr>
<td>RIM-161</td>
<td>SM-3</td>
<td>Ballistic missile defence</td>
<td>1</td>
</tr>
<tr>
<td>RIM-174</td>
<td>SM-6</td>
<td>Very long-range air defence</td>
<td>1</td>
</tr>
<tr>
<td>RIM-66</td>
<td>SM-2</td>
<td>Long-range air defence</td>
<td>1</td>
</tr>
<tr>
<td>RIM-162</td>
<td>ESSM</td>
<td>Medium-range air defence</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: Lockheed Martin Corporation, Mk-41 Vertical Launching System, 2019, online.

PLA ASCMs also trigger proliferation issues for Allied navies, for two reasons. First, the Chinese Government sells its precision strike weapons widely, including ballistic missiles and ASCMs; for example, Pakistan has previously acquired Chinese ASCMs. China has also sold arms to Iran, and in some cases those weapons were on-sold to terrorist organisations. Second, terrorist groups have already obtained Chinese ASCMs via middle-parties such as Iran. For example, on 14 July 2006, the terrorist group Hezbollah attacked the INS Hanit, an Israeli Navy warship, with two Chinese-designed C-802 ASCMs. The C-802 ASCMs were initially sold to Iran, which on-sold them to Hezbollah. This instance demonstrates that Allied navies also face an ASCM threat from sub-state terrorist groups. It’s also worth noting that Chinese arms sales are often successful because Chinese arms are often cheaper than competing products, ‘generally come with fewer end-use restrictions’, and other countries that produce technologically advanced arms are restricted by multilateral arms export regulations such as the Missile Technology Control Regime.
A single Hobart-class guided missile destroyer carries 48 strike-length Mk-41 VLS cells. With a load-out of 48 SM-6 air defence interceptors, a PLAN strike package of just eight H-6J bombers (each carrying six YJ-12 ASCMs) would deplete a Hobart destroyer’s entire Mk-41 VLS magazine: this assumes an optimistic 100% SM-6 intercept success rate.

However, Hobart destroyers will more likely employ a layered defence with a load-out of 32 SM-2/SM-6s and 64 ESSMs. This loadout would allow every PLA ASCM to be countered with one shot of SM-2/SM-6 and two shots of ESSM as a backstop. In theory, this would only allow a single Hobart destroyer to defend against 32 PLA ASCMs: just six PLA H-6J bombers would be needed to deliver 36 YJ-12 ASCMs.

The RAN’s problem is made even worse by a shortage of capable air-defence surface combatants. The current RAN surface combatant fleet contains only three Hobart-class destroyers and eight Anzac-class frigates. The Anzac frigates feature only an 8-cell Mk-41 VLS, which can carry only 32 ESSMs, but also use a combat system that can’t support the more capable SM-2 and SM-6. The core problem is that the Anzac-class frigates will remain in service until around 2044. This is partly due to the first replacement Hunter-class frigate being projected to arrive around 2033, but also because subsequent deliveries will occur at two-year intervals. Even when the Hunter-class frigates do arrive, each ship will carry only 32 Mk-41 VLS cells. This means that the RAN surface combatant fleet won’t be able to deploy significant numbers of long-range anti-air, anti-submarine, anti-ship and land-attack ordnance. Long-range weapons will be needed to counter and degrade the PLA’s ASCM capability by holding at risk PLA launch platforms such as aircraft, surface ships, submarines and land batteries.
Between 14 and 18 February 2022, a PLAN Type-052D Luyang III-class guided missile destroyer and a PLAN Type-071 Yuzhao-class amphibious transport ship transited through the Timor and Arafura seas, penetrating Australia’s EEZ. On 17 February, one of the PLAN vessels illuminated a Royal Australian Air Force P-8A Poseidon maritime patrol aircraft with a military-grade laser.

The incident as a whole raises several issues and questions. First, both PLAN ships aren’t antiquated platforms but rather first-rate ships with advanced capabilities.

Second, the PLAN is rapidly building ships of this calibre by the dozen and plans to expand its battle force to 460 or 550 ships by 2030.

Third, the PLAN is introducing several types of long-range surface combatants that are ideal for carrying large payloads of cruise missiles. The PLAN’s Type-052D Luyang III guided missile destroyer carries a 64-cell vertical launch missile battery that can carry a mix of anti-air missiles, anti-submarine rockets and cruise missiles, including the YJ-18A ASCM—by late 2020, the PLAN had launched 25 Luyang III destroyers. The PLAN’s Type-055 Renhai-class guided missile cruiser is fitted with a 112-cell vertical launch missile battery that can carry a mixed payload of anti-air missiles, anti-submarine rockets and ASCMs, plus likely future payloads of land-attack cruise missiles and anti-ship ballistic missiles when they become available; by 2020, eight Renhai-class cruisers had been launched.

Fourth, the PLAN’s recent deployment underscores the Chinese Government’s increased confidence in the proficiency of its armed forces, but also its willingness to deploy first-rate military platforms right onto Australia’s doorstep.

The PLA is already a major military power in the Indo-Pacific region and it will only get stronger in the years to come – more advanced technology, more combat assets and better trained personnel. How the Chinese Government will use its rapidly evolving military power, both now and in future decades, is anything but certain. The recent lasing incident raises disturbing questions about future plans that the Chinese Government might have for the Indo-Pacific region.
A road map for countering PLA ASCMs

Approaches for countering PLA ASCMs

Countering PLA ASCMs and defending RAN surface ships might involve one or more of the following approaches: deepening fleet magazines; disaggregation and distribution; breaking the ‘kill chain’; and offensive air and missile defence.

Deepening fleet magazines might involve putting more Mk-41 VLS cells to sea or using deep-magazine technologies. Examples of deep-magazine technologies include rail guns, lasers, high-power radio frequency weapons and DARPA’s Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES).212

Disaggregation would involve decomposing the multiple functions of expensive crewed surface combatants into a large volume of relatively cheap, specialised platforms that could then be distributed in order to complicate adversary ASCM strikes and increase the effectiveness of RAN surface fleet operations.213 Large numbers of disaggregated naval platforms could complicate enemy efforts to identify critical vulnerabilities or high-value assets.214 Similarly, large numbers of distributed naval platforms could force an adversary to verify the value of each potential target with electro-optical and infrared satellites, which is time consuming, or alternatively target every naval platform, which would consume large numbers of ASCMs.215

Breaking the ‘kill chain’ would involve disrupting, degrading or neutralising key enemy capabilities that underpin the PLA’s effective application of ASCMs. The ‘kill chain’ refers to all systems and assets that are required to ‘find, fix, track, target, engage, assess’ enemy targets.216 Finding involves detecting enemy targets; fixing involves positively identifying targets and precise locations; tracking involves monitoring target movements; targeting involves selecting the appropriate capability and obtaining command approval; engaging involves the dispatch of combat assets; assessing involves determining whether further attacks are required.217 The PLA ASCM kill chain will involve finding, fixing and tracking Allied surface ships using over-the-horizon skywave radars and wide-area surveillance satellites, targeting Allied ships using land-based and satellite encrypted communications networks, engaging Allied ships with dispatched combat assets, and assessing the effectiveness of maritime strikes using surveillance satellites. Breaking the PLA’s ASCM kill chain might involve using long-range bombers to target PLA C4ISR nodes, key facilities or surface ships. It might also involve blinding, jamming and neutralising PLA satellite constellations, or alternatively using offensive cyberattacks to degrade PLA land-based communications networks.

Offensive air and missile defence would involve using expensive long-range ordnance to kill enemy ASCM launch platforms while defending ships from air and missile attack with a variety of medium-range systems. Long-range ordnance carriage would be underpinned by large numbers of strike-length Mk-41 VLS cells aboard RAN ships: SM-6s for engaging enemy aircraft, LRASMs for engaging enemy surface ships and ASROCs for engaging enemy submarines. Such long-range weapons are expensive but are cheaper than the enemy aircraft, ship or submarine that they destroy.218 Medium-range defence systems are cheaper and can be carried in larger numbers; for example, ESSM Block II, RIM-116 Rolling Airframe Missile (RAM) Block II and other deep-magazine technologies.
Short-term options

The RAN could immediately begin upgrading the defensive capability of its surface ships as a stopgap, until more permanent solutions can be brought into service. The short-term upgrades would primarily rely on proven military-off-the-shelf technology that’s already fielded, in order to minimise delays and risk.

RAN surface combatants, such as the Hobart-class destroyers and Anzac-class guided missile frigates, could be armed with larger volumes of medium-range anti-air capabilities.

One advantage is that each Mk-41 VLS cell carries four ESSMs versus one SM-2 or one SM-6. For example, a Hobart-class guided missile destroyer can carry 32 SM-2/SM-6 interceptors plus 64 ESSMs; alternatively, it could carry 192 shots of ESSM. Anzac-class frigates carry only ESSMs. The ESSM has a speed exceeding Mach 4 and a range exceeding 50 kilometres. The ESSM’s range is sufficient for an RAN surface combatant to defend itself and ships under escort. The ESSM Block II incorporates a new X-band sensor with semi-active and active functions that will allow the Block II to defeat future threats, including small-signature targets fitted with decoys and countermeasures, as well as anti-ship ballistic missiles and future breeds of ASCMs.

Figure 9: Hobart-class Mk-41 vertical launching system

Source: Department of Defence, online.

RAN surface combatants could be upgraded with improved defence against ASCM threats that emerge between a ship and the horizon—a distance of around 18.5 kilometres.

Currently, Hobart-class destroyers carry one Mk-15 Phalanx close-in-weapons system, and Anzac-class frigates carry none. The Phalanx is designed to provide surface ships with a last-ditch defence against hostile air and surface threats, when all other defences have failed. Phalanx uses a 20-millimetre gatling gun with an effective
engagement range of around 1.6 kilometres. This is a problem because even a successful intercept by Phalanx risks hypersonic or very high supersonic missile debris inflicting secondary damage to the defending RAN ship.

One solution is to retrofit RAN surface combatants with the Mk-49 guided missile launching system. Each Mk-49 launcher contains 21 RAMs and has a total above- and below-deck weight of 6,366 kilograms when loaded with RAM Block II interceptors. For comparison, the Mk-15 Phalanx Block 1B weighs 6,120 kilograms.

The RAM Block II is an infrared-guided interceptor that defends against aircraft and surface craft, as well as both current and emerging ASCMs. Once launched, the RAM Block II doesn't require target illumination by the defending surface ship. The RAM Block II has a range of around 13.9 kilometres and a speed of Mach 2+. If RAN surface combatants were fitted with four Mk-49 launchers, each ship would have 84 shots of RAM Block II, resulting in a serious self-defence capability that can be reloaded at sea.

Another solution would be to fire hypervelocity projectile (HVP) rounds from existing Mk-45 five-inch naval guns, as are already installed aboard Hobart-class destroyers and Anzac-class frigates. HVP rounds have a speed of around Mach 3, have an effective range of 18.5 kilometres against hostile ASCMs and can be fired at a rate of 6–20 rounds per minute.

Figure 10: Mk-49 missile launcher for the Rolling Airframe Missile

A road map for countering PLA ASCMs

The RAN’s Canberra-class landing helicopter docks (LHDs) could also be upgraded with a CEAFAR phased-array radar, a Mk-41 VLS missile battery and several Mk-49 launchers. The RAN’s Anzac-class frigates already use the CEAFAR phased-array radar, SAAB 9LV combat system and Mk-41 VLS. This package could be installed aboard the RAN’s LHDs along with several Mk-49 launchers. The combination of ESSM Block II and RAM Block II interceptors would provide a quantum leap over the LHDs’ non-existent ability to defend against ASCMs.

The RAN’s LHDs could use embarked rotary-wing aviation assets to provide a deployed task group with organic early warning of inbound air and missile threats, but only if the helicopters were fitted with an appropriate air search radar. Due to the curvature of the Earth’s surface, phased-array radar surface combatants can detect sea-skimming air and missile threats only at a range of around 18.5 kilometres. However, an embarked helicopter operating at 800 feet would increase the parent ship’s detection of hostile aircraft and ASCMs to 55 kilometres, but only if fitted with an appropriate air search radar.

**Medium-term options**

In the medium term, the RAN could consider an alternative force structure with a mix of crewed surface combatants and disaggregated uncrewed assets in order to deepen fleet magazines as well as to underpin offensive air and missile defence operations.

The RAN could look at acquiring more capable guided missile destroyers of a mature design. For example, the Japanese Maritime Self-Defence Force has the Maya-class guided missile destroyer or the US Navy’s Arleigh Burke-class destroyer Flight III. Both ship designs carry a 96-cell Mk-41 VLS, which is double the firepower of the Hobart class. But American and Japanese destroyers also enjoy other advantages, such as the AN/SPY-6 radar aboard Flight III Arleigh Burkes or growth margins for high-energy weapons aboard the Maya class.
The RAN could also explore a new class of disaggregated large unmanned surface vehicles (LUSVs) to carry additional large numbers of strike-length Mk-41 VLS cells. For example, the Center for Strategic and Budgetary Assessments (a leading American think tank) has proposed converting a 2,000-ton offshore patrol vessel into an offboard magazine ship for crewed surface combatants, with the ability to carry VLS missile tubes. In this concept, crewed surface combatants would act as the ‘flagship’ of a combined crewed and uncrewed surface action group. The addition of radars and sonars would improve the sensor coverage of such a crewed and uncrewed surface action group, but would also allow the crewed surface combatant to go to EMCON (or emissions control) and thereby be less detectable by enemy sensors and ASCMs. LUSVs would effectively become force multipliers by providing deeper VLS missile magazines but in a disaggregated package with baked-in margins for LUSV losses or battle damage to the weapons and sensors of the crewed surface combatant.

Other packages for disaggregated LUSVs might include DARPA’s Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES), high-power radio frequency (HPRF) weapons, jammers, and dazzling lasers. The MAD-FIRES round is fired from the BAE Systems 57-mm naval gun at 80 rounds per minute and defends against air threats, such as ASCMs and unmanned aerial vehicles (UAVs), out to a range of around 18.5 kilometres at an approximate cost of US$25,000 per round. HPRF weapons use radio frequency pulses to destroy or damage the electronic systems of a hostile missile, but can’t engage threats beyond line-of-sight and aren’t always effective due to atmospheric effects. Jammers could counter radar satellites, whereas shipboard lasers could blind or damage electro-optical and infrared satellites.

The RAN could further improve the long-range detection and tracking of hostile ASCMs by fielding a family of uncrewed assets to expand the multi-domain sensor coverage of RAN surface ships. For example, the SM-6 interceptor is capable of engaging aircraft, land-attack cruise missiles, ASCMs and ballistic missiles in the terminal phase of flight at a range exceeding 370 kilometres. However, surface-ship-launched SM-6s can’t engage sea-skimming ASCMs at ranges beyond 18.5 kilometres unless aided by a radar 185 kilometres in front of the surface combatant or at an altitude exceeding 10,000 feet. This suggests that the RAN should consider investing in assets such as UAVs, unmanned surface vehicles (USVs), unmanned underwater vehicles (UUVs) and high-altitude airships.

Rotary-wing or fixed-wing UAVs with miniaturised sensors and datalinks could provide deployed RAN forces with over-the-horizon detection of air and missile threats as well as cueing for ordnance to neutralise enemy ASCMs and launch platforms. Small-displacement USVs could be fitted with scalable radars, variable depth sonars and datalinks to provide deployed RAN forces with over-the-horizon detection of air and missile threats, plus terminal cueing for ordnance to neutralise enemy ASCMs and launch platforms. Oceangoing UUVs could provide deployed RAN forces with superior underwater situational awareness through the deployment of towed, passive and active sonar to detect enemy submarines armed with ASCMs at significant distance from deployed RAN forces. Alternatively, semi-submerged UUVs might carry vertically launched, short-range anti-air missiles and passive radar to attrite enemy ASCM raids at over-the-horizon distances.

High-altitude airships could be fitted with miniaturised sensors, such as active and passive phased-array radars and optical and infrared sensors, to provide deployed RAN forces with tactical early warning of inbound ASCMs, approaching enemy ASCM launch platforms, or both. For example, the US Navy’s E-2C Hawkeye is fitted with the AN/APS-145 radar and operating at an altitude of 25,000 feet can detect air threats at ranges of around 482 kilometres. This idea has currency, given that a 2019 Center for Strategic and Budgetary Assessments report identified ‘stratospheric balloons’ as platforms for electro-optical, infrared and radar sensors. The ‘Firefly’ project is an Australian collaborative research venture that aims to develop high-altitude balloon technology that can be fitted with surveillance or communications packages.

The RAN could also consider introducing a very large unmanned combat aerial vehicle (UCAV) to exclusively provide deployed RAN task groups with a loitering long-range air cover capability. Such UCAVs could carry large payloads of anti-air, anti-ship and anti-submarine ordnance and sonobuoys to hunt enemy ASCM launch platforms, plus air-to-air ordnance to attrite enemy ASCM raids. For example, Boeing’s Loyal Wingman is a UAV that has a range greater than 3,700 kilometres. With appropriate modifications, such as larger fuel tanks and a large internal
A road map for countering PLA ASCMs

weapons bay, Loyal Wingman could become a very long-ranged loitering UCAV. A UCAV with this type of capability could expend all ordnance and then return to Australia to rearm and repeat the process, thereby effectively providing deployed RAN task groups with a replenishable magazine. Another possible UCAV application might be to act as an uncrewed airborne early warning platform or over-the-horizon communications relay for deployed RAN fleet units.

Figure 12: Boeing’s Loyal Wingman UAV

Source: Department of Defence, online.

Longer term options

In the longer term, the RAN could consider adding long-range platforms and systems to help break an adversary’s ‘kill chain’. Options might include large-displacement magazine ships, long-range bombers, cyberattack capabilities and anti-satellite capabilities.

The RAN could acquire new ‘magazine ships’ with very deep and flexible magazines to carry very long-range strike ordnance to hold at risk elements of the PLA’s ASCM ‘kill chain’. The MITRE Corporation conceived a ‘magazine ship’ based on the US Navy’s T-AO-205 John Lewis-class fleet oiler because the hull is relatively cheap at around US$500 million and would have the speed to keep up with existing Aegis surface combatants. MITRE’s magazine ship would incorporate four weapons sections, each capable of accommodating one high-energy weapon, such as a rail gun with a 1,000-round magazine, or 256 Mk-41 VLS cells or 24 vertical launchers to support long-range maritime ballistic missiles, such as a new version of the US Army’s former Pershing II. Rail guns fire 6–10 projectiles per minute using electromagnetic energy at speeds around Mach 5 and at ranges around 129 kilometres, but with an effective range against sea-skimming ASCMs and ballistic missiles more likely to be around 55 kilometres. Lasers are another type of high-energy weapon; for example, a 500-kilowatt laser could be used to defeat ASCMs at a range of around 18.5 kilometres, or a 5-megawatt laser could be used to defeat ballistic missiles in the terminal phase of flight at a range of 5 kilometres. However, lasers can engage threats only within line-of-sight and can be disrupted due to atmospheric effects such as water vapour in the air.
Breaking the PLA’s ASCM kill chain could also be achieved through the acquisition of a B-21 Raider long-range stealth bomber capability. B-21 Raiders could be used to penetrate heavily defended Chinese airspace to strike at critical elements of the PLA’s ASCM kill chain.256 Targets might include PLA air and naval bases, C4ISR nodes, land-based over-the-horizon sensors and satellite ground control stations. Furthermore, with the integration of relevant ordnance plus an air and maritime search radar, the B-21 could execute long-range ASCM strikes against enemy warships as well as provide long-range air cover to deployed RAN task groups with air-to-air missiles.257 Such air-to-air missiles might also be capable of attriting enemy ASCM raids. The B-21 Raider is being developed under a publicly acknowledged US Air Force ‘Special Access Program’, so range and payload estimates aren’t yet publicly available. However, the publicly available specifications of the legacy B-2 Spirit stealth bomber (Table 4) provide some insight into the type of range and payload that the B-21 might feature, such as standoff-range cruise missiles like the JASSM-ER for attacking land targets at a range of around 1,000 kilometres and the LRASM for maritime targets at a range of around 926 kilometres.258 The GBU-57 massive ordnance penetrator is significant because it can neutralise hardened targets buried under 60 metres of 5,000-psi reinforced concrete.259 An Australian fleet of approximately 30 B-21 Raiders would provide a ‘combat coded’ force of 16 bombers for combat operations—25% of the overall fleet would be needed for training plus a further 20% as a reserve for combat attrition, with the remaining 55% combat coded.260

Table 4: Specifications of the B-2 Spirit stealth bomber

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<tr>
<td>Range</td>
<td>11,112 kilometres</td>
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<tr>
<td>Payload</td>
<td></td>
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<tr>
<td></td>
<td>16 AGM-158 JASSM-ER cruise missiles or 16 AGM-158C LRASM cruise missiles or 2 GBU-57 massive ordnance penetrators or 192 GBU-39 small diameter bombs or 80 Mk-62 naval mines</td>
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Other capabilities to break the PLA’s ASCM kill chain might include offensive cyberattack capabilities and anti-satellite weapons. Although offensive cyberattacks could theoretically break the PLA’s ASCM kill chain by attacking the PLA’s C4ISR networks, the reality is that cyberattacks might not work at all. This is because the PLA has built its land-based C4ISR network around a dedicated military network with high-grade encryption. Furthermore, any such networks are likely to be heavily protected with numerous multilayered hardware and software protections.

Another way to break the PLA’s ASCM kill chain might be to introduce surface-ship-launched anti-satellite weapons aboard the ‘magazine ships’ mentioned above, which would provide the RAN with a hard-kill solution against prying PLA surveillance satellites.
The PLA has been actively modernising for the better part of 25 years and in recent years has rapidly expanded, with the objective of being able to fight and win wars against technologically advanced opponents. Examples of PLA advances include the current Type-055 Renhai-class guided missile cruisers and Type 052D Luyang III guided missile destroyers, but also the forthcoming H-20 long-range stealth bomber. By 2030, it’s estimated that the PLAN will have between 460 and 550 battle force ships.\textsuperscript{261}

The PLA has developed a technologically advanced and sophisticated inventory of missiles, including ASCMs, and many PLA missiles either match or exceed anything in the inventory of Australian and US forces.

The PLA’s strike capability is likely to be very resilient, with numerous layers of baked-in redundancy, that would make it extraordinarily difficult for Allied strikes to cripple the PLA’s strike capability. For example, the PLA has extensive theatre-wide C4ISR and passive and active defences, but is also likely to have very deep ordnance stockpiles—those factors are likely to ensure the continuity of PLA strike operations, even while under heavy attack.

The PLAN’s recent forward deployment of advanced naval surface ships to penetrate Australia’s EEZ raises the disturbing prospect of intense future PLA belligerence, particularly given the projected future size of the PLAN battle force.

It’s worth noting that a retired senior US naval intelligence officer has previously assessed that there’s the very real risk of regional war with China in the ‘decade of concern’ between 2020 and 2030.\textsuperscript{262}

For Australia, the problem is that the current RAN battle force isn’t appropriately equipped to meet the PLAN’s threat of today; nor does the future RAN battle force appear to be appropriate to meet a projected threat environment in which the PLAN will be the largest navy in the Pacific theatre. For example, the RAN’s Anzac-class frigates will remain in service until around 2044 but lack a sufficiently deep anti-air missile magazine to stay in the fight for very long, carry Harpoon ASCMs that appear to be outranged by PLA ASCMs, and can’t support longer range anti-air or strike missiles.\textsuperscript{263}

More concerning is that the current and planned ADF force structure appears to be missing critical capabilities that would probably be needed in any regional conflict. For example, the ADF doesn’t possess a very long-range strike capability that would be able to penetrate heavily defended enemy airspace and hold at risk enemy land, sea or air targets at intermediate ranges.

Arguably, Australia’s defence planning has largely escaped the consequences of complacency, underinvestment and a lack of innovative solutions due to successive decades of unchallenged US strategic primacy in the Indo-Pacific region. Today, US strategic primacy is being actively contested, if not visibly eroded. It’s therefore hard not to conclude that Australia has been caught napping at the wheel, but also that Australia’s national defence planning can’t continue to meander at a peacetime pace—it would appear that wholesale changes are warranted.

There might be many ways to go about change across the whole Australian Defence organisation, but Australia is rapidly running out of time. A good and expeditious starting-point might be a bipartisan parliamentary inquiry with the aim of educating the general public on what a regional war against a nuclear-armed major-power adversary would look like and what would be needed to defend the Australian way of life from such a threat. In parallel, the government should commission a bipartisan and independent review of Australia’s defence capabilities, to be headed by an experienced, security-cleared and eminent Australian—a ‘Dibb Review 2.0’.
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<table>
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<td>A2/AD</td>
<td>anti-access/area-denial</td>
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<td>ADF</td>
<td>Australian Defence Force</td>
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<tr>
<td>ASCM</td>
<td>anti-ship cruise missile</td>
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<tr>
<td>ASROC</td>
<td>anti-submarine rocket</td>
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<tr>
<td>C4ISR</td>
<td>command, control, communications, computing, intelligence, surveillance and reconnaissance</td>
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<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency (US)</td>
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<td>EEZ</td>
<td>exclusive economic zone</td>
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<td>ESSM</td>
<td>Evolved Sea Sparrow Missile</td>
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<td>Global Positioning System</td>
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<td>HPRF</td>
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<td>HVP</td>
<td>hypervelocity projectile</td>
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<td>large unmanned surface vehicle</td>
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<td>landing helicopter dock</td>
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<td>Long Range Anti-Ship Missile</td>
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<td>Multi-Azimuth Defense Fast Intercept Round Engagement System</td>
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<tr>
<td>VLS</td>
<td>vertical launching system</td>
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