ASPI

SPECIAL REPORT

Australian border security and unmanned maritime vehicles

James Mugg, Zoe Hawkins and John Coyne

July 2016

ASPI AUSTRALIAN STRATEGIC POLICY INSTITUTE

BORDER SECURITY PROGRAM

James Mugg

James is a researcher in ASPI's Defence Strategy & Capability program. His primary research interests are capability development and emergent military technologies, such as unmanned systems and advances in electronic warfare.

Zoe Hawkins

Zoe is a researcher in ASPI's International Cyber Policy Centre. She has a particular interest in drone technology and the future of warfare. Zoe is also working as a research assistant on the policy implications of quantum technology for the Centre for International Security Studies at the University of Sydney.

John Coyne

John Coyne joined ASPI as the Senior Analyst for the Border Security Program in February 2015. John came to ASPI from the Australian Federal Police, where he worked on transnational serious organised crime, national security, and counterterrorism.

About ASPI

ASPI's aim is to promote Australia's security by contributing fresh ideas to strategic decision-making, and by helping to inform public discussion of strategic and defence issues. ASPI was established, and is partially funded, by the Australian Government as an independent, non-partisan policy institute. It is incorporated as a company, and is governed by a Council with broad membership. ASPI's core values are collegiality, originality & innovation, quality & excellence and independence.

Cover image: Wave glider. Photo courtesy Liquid Robotics.

Australian border security and unmanned maritime vehicles

ASPI
AUSTRALIAN STRATEGIC POLICY INSTITUTE

BORDER SECURITY PROGRAM

James Mugg, Zoe Hawkins and John Coyne

July 2016

First published July 2016

Published in Australia by the Australian Strategic Policy Institute

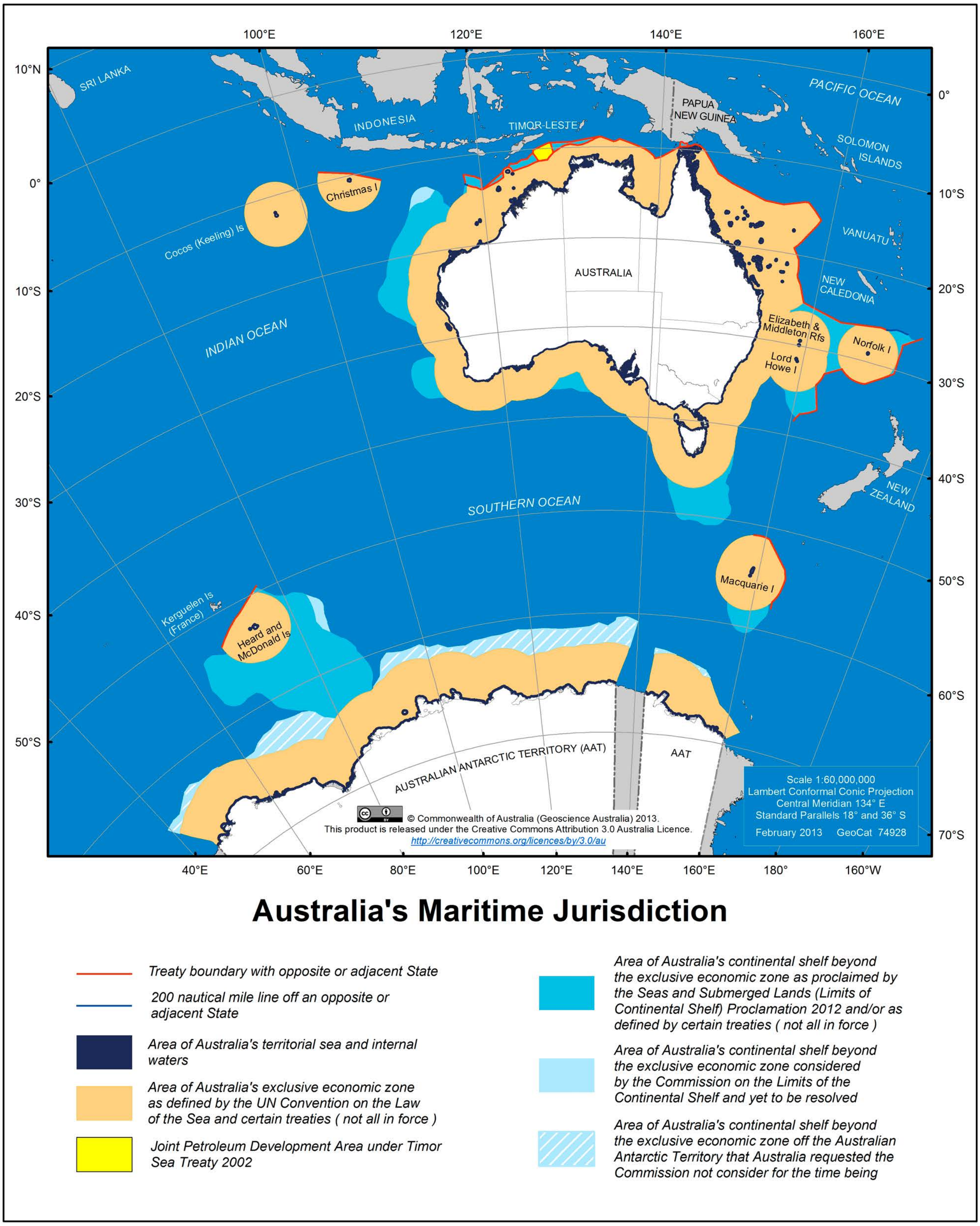
ASPI
Level 2
40 Macquarie Street
Barton ACT 2600
Australia

Tel + 61 2 6270 5100
Fax + 61 2 6273 9566
enquiries@aspi.org.au
www.aspi.org.au
www.aspistrategist.org.au

Facebook.com/ASPI.org

@ASPI_org

CONTENTS



Source: Geosciences Australia

THE BORDER SECURITY CHALLENGE

Australia's complete maritime jurisdiction covers about 14 million square kilometres, including an exclusive economic zone (EEZ) of over 10 million square kilometres. For Australia, maintaining an awareness of our maritime territory is no easy task. Protecting the sovereignty of our maritime borders has never been more difficult than it is today.

The increasing volume of maritime threats and the rise of non-traditional border security risks pose a challenge to Australia's finite traditional maritime security capabilities. Unfortunately, our wide-area surveillance capability has been developed to identify more traditional national security threats.

The Australian Defence Force (ADF) and the Australian Border Force (ABF) use a mix of air, sea and space platforms to provide broad maritime domain awareness (MDA). Those platforms exploit the electromagnetic spectrum through an array of technical surveillance and intelligence collection capabilities. The capabilities are developed and deployed with the aim of locating and classifying relatively large surface and subsurface naval vessels, as well as military aircraft. In some cases, current maritime surveillance capabilities are less effective at detecting and classifying small and irregular vessels and aircraft that are associated with today's rising non-traditional national security threats—people smuggling, transnational organised crime, marine pollution, illegal fishing and piracy—which present significant surveillance challenges.

Australia must identify strategies for pre-positioning our finite maritime response capabilities in order to be able to respond promptly, effectively and efficiently to risks across our EEZ. Put simply, neither the ABF nor the Royal Australian Navy (RAN) has enough surface vessels to guarantee the efficient interdiction of vessels in all areas of the EEZ at any time. Finding a workable national strategy to address this challenge requires strengthening Australia's MDA so that existing capabilities can be more effectively and efficiently deployed.

Unmanned maritime vehicles (UMVs) are emerging as relatively cheap and energy-efficient surveillance platforms. They don't require onboard piloting and are instead operated either remotely or semi-autonomously. They include vessels that travel across the surface of the water (unmanned surface vessels or USVs) and craft that operate underwater (unmanned underwater vehicles or UUVs), although the former currently offer more utility for border protection purposes. UMVs integrate into a broader unmanned maritime system of other UMVs, their associated networks and data management systems. Their continued development offers an opportunity for the ADF and ABF to improve surveillance efficiency in the maritime domain.

This special report examines the potential for UMVs to expand Australia's MDA and make the ADF's and ABF's risk management strategies more efficient. While these technologies may be in only nascent stages of development, both the ABF and private industry in Australia should investigate opportunities for greater cooperation on UMVs to support the surveillance of Australia's vast maritime territory.

MARITIME BORDER SECURITY TODAY

The scale and diversity of contemporary maritime threats to Australia make absolute maritime boundary security impossible. Instead, border security strategies are guided by efficiency and risk management.

Australia's large maritime territory and coastline make our maritime border security a mammoth task. The number of vessels operating in Australian waters is growing, and as a result border security assets are under ever-increasing strain. Each week in 2014, an average of 661 ships, 22,931 ship crew, 21,000 sea passengers, 25 recreational craft and 55,000 sea cargo consignments arrived in Australia.[1] Most of them transited through our northern approaches.

In contrast, maritime traffic in the Southern Ocean is significantly lower due to the harsh conditions in those waters. The ABFs Cape-class patrol boat, for example, can sail only as far as the 50th parallel South. To address this, the ABF has recently acquired two large-hulled vessels, the *Ocean Protector* and *Ocean Shield*, which are better able to operate in the Southern Ocean.[2]

Australia is also facing an increasingly diversified maritime threat environment. Non-military risks such as illegal fishing, marine pollution, transnational crime, people smuggling and piracy pose new challenges for our border security.

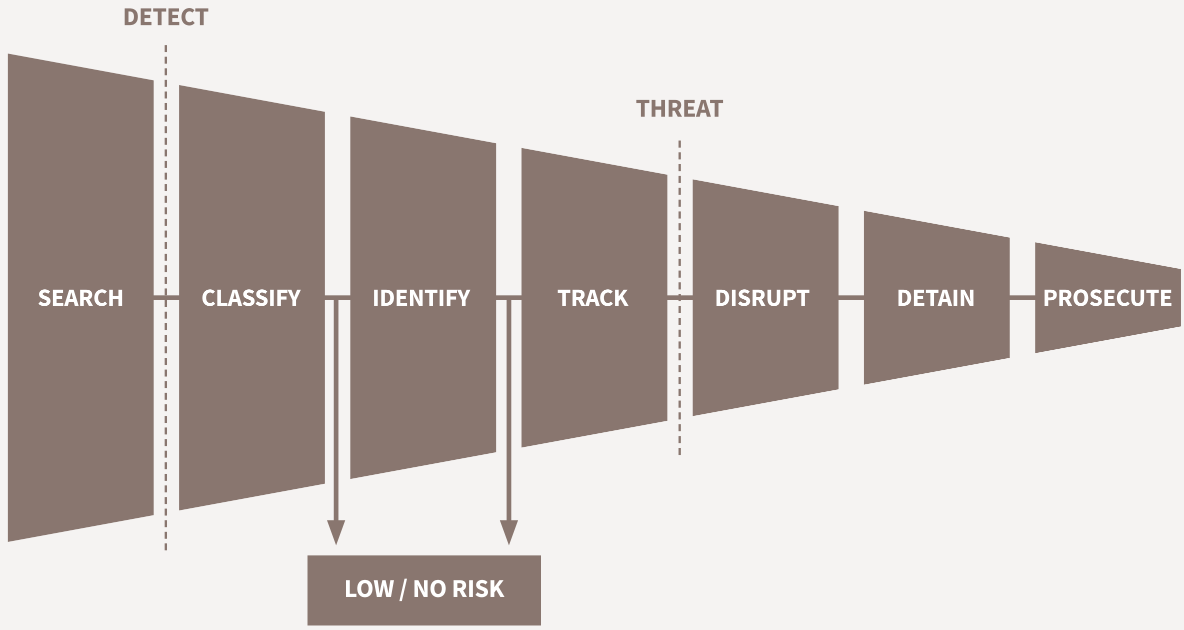
Australia employs a rigorous border security strategy to address these threats. Civil maritime security responsibilities fall on Maritime Border Command, which uses surface and air assets from the ABF and the ADF. Assets can conduct independent patrols or can be cued by intelligence reports from surveillance platforms. However, due to the expense of acquisition and the physical limitations of patrols, they are restricted in both number and range. The combination of expansive territory, growing traffic volumes, diversified threat profiles and finite capability means that border security assets will never be omnipresent. Therefore, Maritime Border Command strategically deploys its assets with a focus on risk management.

A detailed analysis of national threats must be used to inform a risk-based approach to capability deployment. Such a strategy requires an increasingly high level of MDA. Careful intelligence-led, risk-based decision-making is needed to achieve an efficient and effective maritime surveillance capability. This approach enables assets to make the most effective and efficient contribution to our border security.

A FRAMEWORK FOR MARITIME DOMAIN AWARENESS

Comprehensive maritime border security strategy depends on a multi-stage process (Figure 1). At each stage, a vessel's risk profile is assessed and a decision is made on whether to proceed to the next stage. This process starts with detecting potential threats and finishes with disruption operations, and potentially the detention of criminals.

Figure 1: Maritime domain awareness procedural chain



Searching involves surveying an area using active or passive technical or non-technical means. The aim is to identify anomalous behaviour in Australian waters. Effective searching involves the deployment of a mix of sensor types across a given search area and the integration of the different data feeds into a comprehensive situational domain awareness so that other surveillance or response assets can be cued effectively.

Detection is the moment when an object or vessel is discovered. It's achieved through one or more technical (active radar or satellite) sensors, visual detection or self-reporting. Law-abiding vessels displacing over 300 tonnes usually use an automatic identification system (AIS) to self-report their location. AISs are tracking systems used for navigation, preventing at-sea collisions and locating vessels in distress. But they are also useful in policing—vessels that don't self-report their locations may be trying to hide from authorities.

Classifying the vessel by type (fishing ship, container ship and so on) is an important step in evaluating the risk posed by the vessel. A detected vessel may be considered a higher security risk depending on its location, its type and whether it's using an AIS. For example, a large fishing vessel without an AIS signal operating in a marine reserve could be a high risk to Australia's environmental interests.

Obtaining more details about a vessel enables border protection authorities to make further judgements based on its risk profile. **Identifying** details such as country of origin and previous offences assist in determining what level of urgency the case requires.

The capability to **track** a vessel has a number of applications. Accurate tracking enables authorities to determine the vessel's direction and possible destination, which may further elucidate the threat posed. If necessary, it also informs the planning of an interception at sea or on land.

Each preceding step of the process contributes towards assessing whether a vessel needs to be **intercepted**, **disrupted**, or both by an ADF or ABF patrol boat. Disruption may involve the arrest and detention of crew members or confiscation of illicit cargo. If the vessel is involved in an illegal activity, the **interception/interdiction** itself may disrupt that activity. This process requires a manned patrol boat so that authorised personnel can board and inspect the vessel.

Where enough legally admissible evidence is available to prove that a criminal offence has occurred in an Australian jurisdiction, offenders may be prosecuted.

> Maritime domain awareness seeks to see and understand everything within Australia's maritime jurisdiction that might constitute a risk to our national security.

Ultimately, MDA seeks to increase decision-makers' understanding of maritime risks and threats by layering information and intelligence collected from space, air, surface and subsurface assets to provide a rich picture of activity at sea that can be further analysed to identify threats. In short, it seeks to see and understand everything within Australia's maritime jurisdiction that might constitute a risk to our national security.

CURRENT MARITIME BORDER CAPABILITY

Australia's Maritime Border Command uses a combination of space, air and surface assets sourced from the ADF and the ABF.

Space assets

Maritime Border Command uses commercial satellite imagery for surveillance of remote or inaccessible regions. Australia has an ongoing contract for satellite surveillance data, which since 2009–10 has been budgeted at 9.6 million square nautical miles per year.[3]

Satellites can make a cost-efficient contribution to the 'search, detect and classify' challenge. They provide greater broad-area optical and radar coverage than aircraft—even detecting vessels before they enter a country's maritime territory. Satellites can also detect and track AIS signals from cooperative vessels. However, like data from other unmanned assets, satellite data requires back-end intelligence analysis.

Unlike aircraft, satellites can't manoeuvre around cloud cover. They also have set orbital trajectories, so they can't be retargeted on demand. Most commercial surveillance satellites operate in low earth orbit, limiting their time over a particular target area. As a result, frequent surveillance coverage requires the use of multiple satellites and greater financial investment.

While satellite radar can usually penetrate cloud cover, smaller and wooden boats are more difficult to detect with radar and infrared. Optical detection is often needed to classify, identify and track them. Therefore, satellite-based surveillance offers limited effectiveness against small-craft threats faced by Australia.

JORN

The Jindalee Operational Radar Network (JORN), which is operated by the ADF, is an over-the-horizon radar network that can monitor air and sea movements across 37,000 square kilometres of Australia's waters. It provides a substantial search capability for monitoring maritime border security, but the system has some limitations:[4]

- JORN is power-intensive and is used only for short periods. Powered-down periods mean that it doesn't provide constant coverage.
- Even though JORN's footprint is large, at any given time each of the three JORN radar stations can examine only a limited area (called a 'tile'), the size of which is classified.
- JORN can detect only surface vessels displacing 300 tonnes or more (roughly the size of an Armidale-class patrol boat). This undermines its utility for detecting people-smuggling vessels, which are smaller and often have fewer metal (radar-reflective) surfaces. Consequently, its ability to detect maritime security threats is largely limited to military applications.[5]

Air assets

Huge swathes of sea territory make airborne maritime surveillance an attractive strategy for Australia (Figure 2). Aerial surveillance platforms are very effective at conducting search-and-detect operations over a broad area. Operating at high altitude increases the range of radar and visual sensors, but reduces the ability to detect low-signature targets. Like sea vessels, air platforms can be prohibitively expensive to acquire and operate, and their flight time depends on fuel capacity and available airframe hours.

Figure 2: Indicative flight path of aircraft based on range

The Royal Australian Air Force (RAAF) provides 18 AP-3C Orion turboprop aircraft as part of its border protection contribution. In addition to performing long-range maritime surveillance, the Orion is designed for use as an anti-submarine warfare, anti-surface warfare and search-and-rescue platform.

The Orions assigned to Maritime Border Command operations in 2011–12 flew 2,255 hours at a cost of $35.164 million, or around $15,593 per flight hour.[6] They will soon be replaced by a combination of P-8A Poseidon maritime patrol and response aircraft and MQ-4C Tritons under Project AIR 7000.[7]

The P-8 Poseidon jet aircraft is the US Navy's successor to the P-3 Orion. It has a range of 7,500 kilometres and an endurance of 20 hours. The Poseidon is based on the Boeing 737, which helps lower support costs. A US official was quoted in 2014 as saying the Poseidon cost only US$4,200 per hour to operate (Table 1).[8]

Table 1: Australian surveillance aircraft capabilities

	Number	Max range	Max altitude	Cruise speed	Cost per flight hour*
Dash-8	10	1,550 km	7,620m	505 km/h	$6,162
AP-3C Orion	18**	7,665 km	10,670m	650 km/h	$16,619
P-8A Poseidon	15^	8,300 km	12,500m	815 km/h	$5,456
MQ-4C Triton	7^	15,000 km	15,240m	575 km/h	$19,325

*Costs adjusted to 2015 dollars. **3 of 18 assigned to Maritime Border Command. ^ Future acquisitions

Sources: Data obtained from the RAAF, Qantas, Boeing and US Naval Air Systems Command.[9]

The RAAF's initial acquisition of eight Poseidons is expected to cost around $4 billion and be delivered between 2017 and 2020.[10] The 2016 Defence White Paper announced that an additional seven Poseidons would be acquired through the 2020s.[11]

The MQ-4C Triton unmanned aerial vehicle (UAV) is being developed from the RQ-4 Global Hawk specifically as a broad-area maritime surveillance aircraft. With an endurance of over 24 hours, the Triton can conduct radar scans over huge swathes of maritime territory. It's also capable of rapidly descending to lower altitudes for closer inspection of targets.

MQ-4C Triton. Photo courtesy Department of Defence

The Triton's likely to be a highly capable platform once its development is complete (initial operational capability is planned for 2018).[12] Seven Tritons for the RAAF, including the ground systems needed to operate them, are expected to cost around $2.5 billion.[13] The Triton's operating costs aren't yet clear, but its parent platform, the Global Hawk, cost US$14,876 per flight hour to operate in 2014, including maintenance and fuelling.[14]

The ABF outsources aerial surveillance in closer waters (Australia's 200 nautical mile EEZ) to Cobham Aviation Services as part of Project Sentinel.[15] Cobham operates 10 Dash-8 aircraft of various models with an average range of about 1,700 kilometres. A $1 billion contract signed in 2006 provides for 15,000 hours of maritime surveillance per year between 2008 and 2020 for around $5,500 per flight hour.[16] Occasionally, the Dash-8s have been supplemented with additional aircraft, such as two Reims F406s contracted for a few years until 2014–15.[17]

In the future, a cheap, medium-altitude maritime surveillance UAV might augment or replace the Dash-8 capability. Cobham has a partnership with General Atomics to support the latter's unmanned systems in the UK and potentially Australia in the future.[18]

The limited number of air assets and rotation requirements mean that there's an operational tension between broad surveillance over a large area and focused surveillance over a targeted area.

The cost of air assets limits the number of maritime surveillance aircraft that can be operated at any one time. Even a platform as sophisticated as the Triton can observe only one area at a time, like a spotlight in the dark. The Triton's capacity to fly at high altitudes gives it a large surveillance footprint. However, the limited number of air assets and rotation requirements mean that there's an operational tension between broad surveillance over a large area and focused surveillance over a targeted area. This may be ameliorated by increasing the 'revisit' rate so a given area is patrolled more frequently. However, revisiting reduces the coverage of other areas of the maritime domain.

The future of UAV use for border security is therefore promising. In addition to the high-altitude Triton UAV, a smaller fixed-wing UAV could supplement or replace the Dash-8 in patrolling Australia's EEZ. In addition, vertical take-off UAVs such as the MQ-8 Fire Scout could operate from Australia's future patrol boats, improving the boats' effective sensor range.

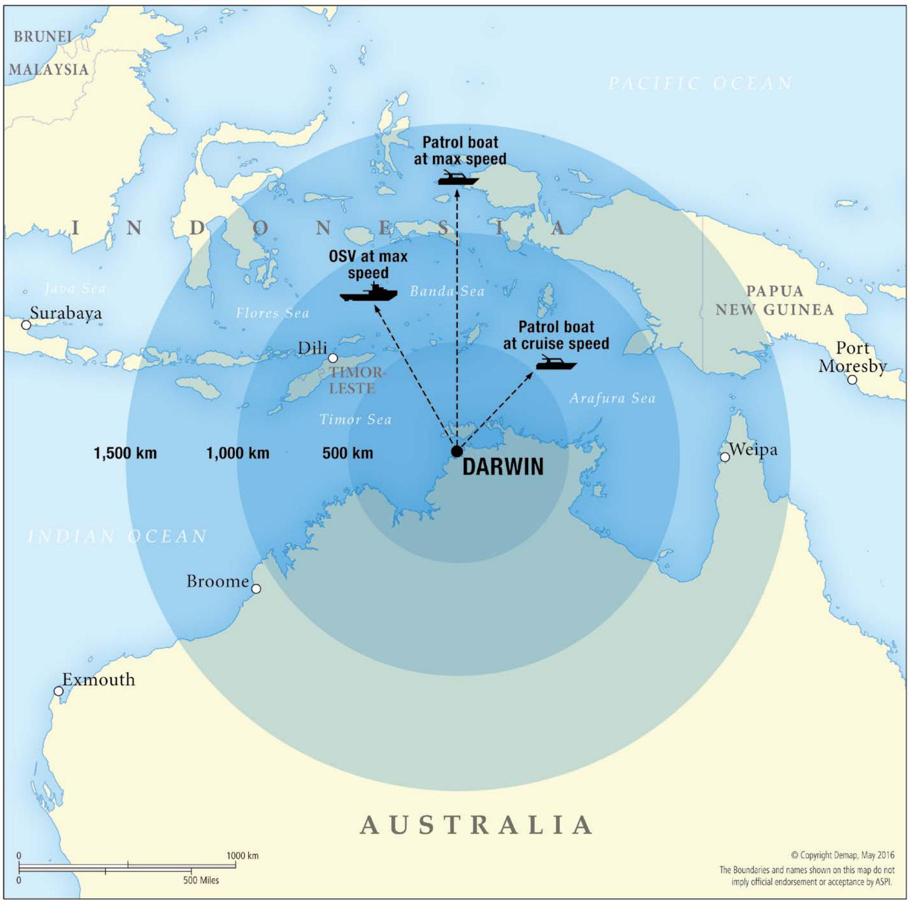
Surface assets

Patrol boats are essential to Australia's maritime border security, as at-sea interceptions and disruptions require a manned vessel. These assets are expensive to procure and to operate, so their number is limited. The finite number of vessels and their limited sensor range (Figure 3) make the fleet unsuitable for comprehensive passive search and detect functions. Instead, they are most useful when cued by a broader range of assets.

The ABF operates eight Cape-class patrol boats. The fleet is expected to achieve 2,400 sea days per year, or roughly 300 out of 365 days at sea per boat. The eight vessels cost a total of $330 million to acquire.[19] Two new Cape-class boats are being constructed for the RAN by mid-2017 at a total cost of $63 million.[20] When the contract for the Cape class was signed, it was estimated that the vessels would require $245.2 million in staffing and operating costs between 2010 and 2020.[21] Taking the delivery schedule into account, this amounts to around $18,664 per patrol day in 2010 dollars.

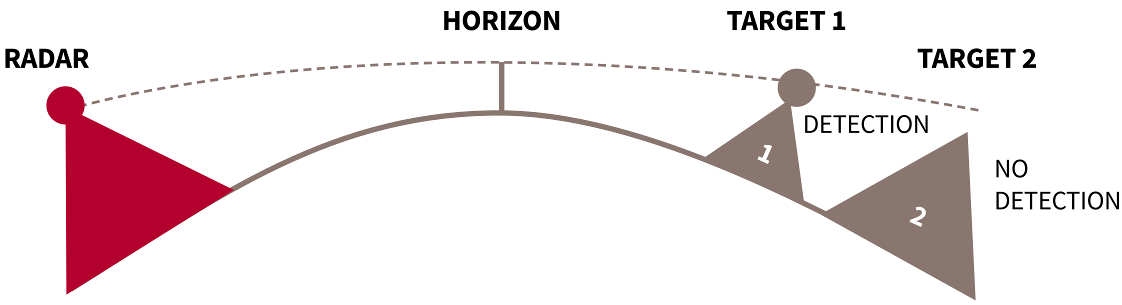
These vessels operate visual and radar sensors only, so their sensor range is limited by line of sight, depending on the size of the target vessel (Figure 4).

Figure 3: 24-hour range of border protection vessels



OSV = offshore support vessel, which includes *Ocean Shield* and *Ocean Protector*.

Figure 4: Successful and unsuccessful surface vessel detection



The ABF also operates two large-hulled long-range vessels, the *Ocean Protector* and *Ocean Shield.* The *Ocean Shield* was purchased by Defence in 2012 for $130 million as an interim sealift capability until the delivery of the Canberra-class landing helicopter dock ships.[22] It was handed over to the ABF (then the Australian Customs and Border Protection Service) in 2015. The *Ocean Protector* was formally acquired by Australia in January 2016, although it had been chartered by Customs from 2010 to 2014.[23]

These vessels are significantly larger than the patrol boats and were purpose-built for icy conditions like those in the Southern Ocean.[24] Each vessel has a large deck and can embark helicopters. The *Ocean Protector* has an impressive reach, with a maximum range exceeding 40,000 kilometres at 14 knots,[25] but its operating costs are significant: in 2013–14, a 60-day extension of its patrol cost $4 million.[26]

Table 2: Maritime patrol vessel capabilities

	Quantity	Max range	Cruising speed	Max speed	Cost per day*
Cape-class	8	7,400 km	22 km/h	46 km/h	$20,912
Armidale-class	13	5,600 km	22 km/h	46 km/h	$42,331
Ocean Protector^	1	43,000km	26 km/h	30 km/h	$66,700

*Costs adjusted to 2015 dollars. ^*Ocean Shield* operational capabilities similar to the *Ocean Protector.*

Sources: Data obtained from the RAN and ABF/ACBPS.[27]

The RAN operates 13 Armidale-class patrol boats as part of the border protection effort. This class is similar in size to the Cape class, but with a steel hull instead of the Cape's aluminium. It has a shorter range of 5,600 kilometres at 12 knots and a larger crew of 21 to 29. Fourteen boats were acquired between 2004 and 2007 at a cost of roughly $30 million apiece (one was decommissioned after a fire in 2014).[28] The average cost per day to operate an Armidale-class boat was reported in 2012 to be $39,717.[29] Maritime Border Command also has up to two major RAN fleet units available at a time (either Perry-class or Anzac-class frigates).

Most civilian vessels that transit through Australia's waters do so through the northern approaches. Maritime traffic in the Southern Ocean is significantly lower due to the harsh conditions there. The Cape-class, for example, is able to sail only as far as the 50th parallel South.[30] Patrols in the Southern Ocean are instead carried out by *Ocean Protector* and *Ocean Shield.*

Asset rotation

Due to the high cost of each vessel, Australia's patrol boat fleet numbers fewer than 25 vessels. This would correspond to about 400,000 square kilometres of EEZ per boat if they were all operating 24/7, year round. Tackling such an enormous task with limited resources requires a targeted risk-management strategy.

In practice, assets are deployed on rotation to maintain consistent surveillance capability. This allows the individual platforms to be serviced as needed to maintain operational capability. Aircraft tend to require proportionally more maintenance than surface assets, but the ratio of time available for operations versus time for maintenance can vary depending on the complexity of the platform.

The Cape-class fleet has a planned availability of 2,400 patrol days per year, which means that six or seven of the eight boats are intended to be operating at any given time.[31]

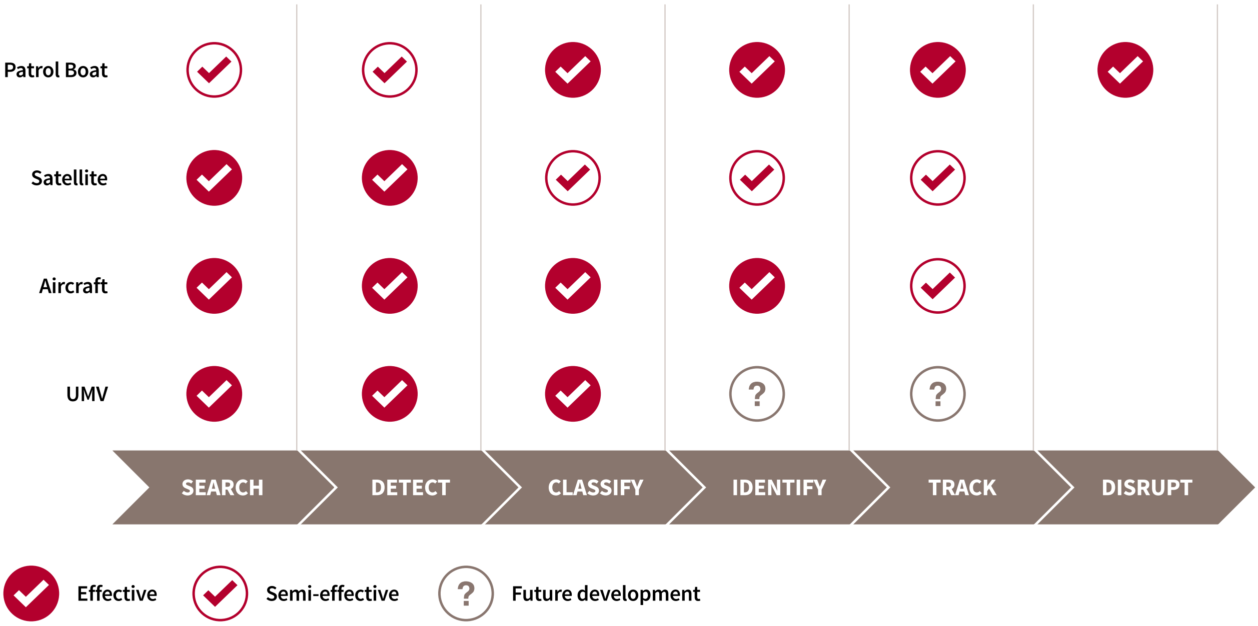
The Orion aircraft average between 7,000 and 8,000 flying hours per year, or roughly 19 to 22 hours per day.[32] This translates to about two Orion sorties per day, or one flight every nine days for each aircraft, depending on maintenance schedules.

Maintenance rotation means that the total number of assets isn't representative of the force that's available to operate at any one time. This must be taken into account when considering the effectiveness of current capabilities, and must also inform the strategic deployment of resources.

Assessment

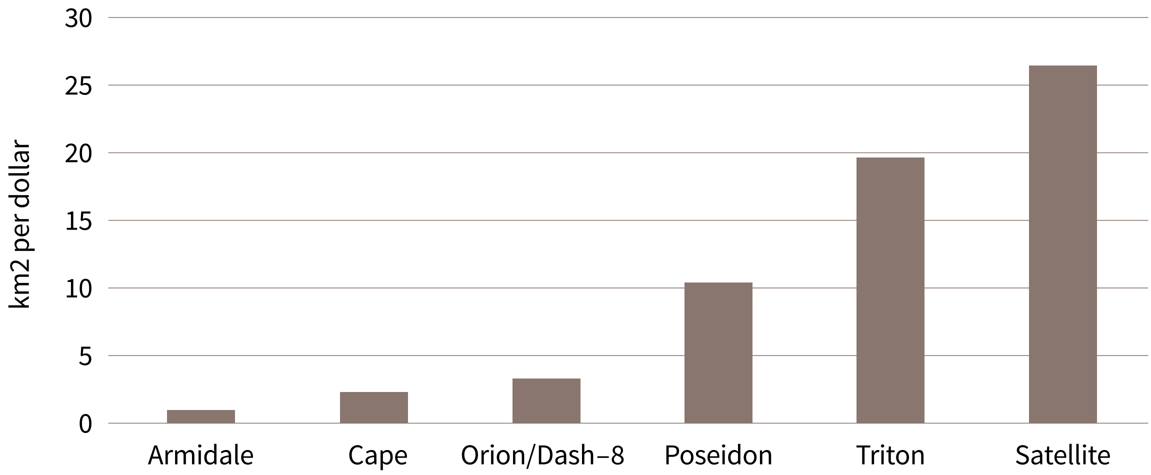
Comprehensive MDA is supported by a diverse range of assets. All offer particular benefits and specialisations, but each has limitations, so each platform is likely to perform optimally in some stages of the process and less effectively in others (Figure 5).

Figure 5: Maritime surveillance capabilities



Australia's MDA capability is increasing in robustness and efficiency (Figure 6). The purchase of new airborne assets, in particular, will improve the cost-effectiveness of Maritime Border Command operations to detect potential threats. However, this will require significant capital investment in the relevant platforms.

Figure 6: Cost-effectiveness of MDA assets



Sources: Data obtained from the US Department of Defense,[33] ANAO and Parliament of Australia.[34]

Such costs may be justifiable, given the monetary and security value of safeguarding our maritime territory against threats, but also highlight opportunities for innovation.

There's also room for new strategies to improve the efficiency and effectiveness of Australia's maritime border protection efforts. The most sensible place to begin this innovation is with maritime border surveillance capabilities.

THE POTENTIAL OF UMVS

UMVs are emerging as relatively cheap and energy-efficient platforms with applications in multiple sectors, including defence, law enforcement and oceanography. The international UMV industry is growing rapidly: some 30,000 unmanned watercraft are expected to be built over the next decade at a cost of over US$15 billion.[35] There are multiple operational unmanned systems in surface (USV) and underwater (UUV) domains that use a variety of conventional and renewable energy sources.

UMVs have the potential to innovate border security surveillance as a new strategic capability.

UMV capabilities

UMVs cover a spectrum between energy-intensive / low-endurance platforms and low-energy / high-endurance platforms. Each platform's mobility, endurance and sensor capability are contingent on the energy it uses. Depending on how they are optimised, different UMV platforms can offer a variety of advantages over manned alternatives.

Energy efficiency

Energy-hungry features, such as high-speed propulsion or energy-intensive sensors such as active sonar, are restricted to relatively low-endurance platforms. These energy-intensive platforms tend to use high-density liquid fuel. The US Navy's Fleet-class Common USV (CUSV) has a displacement of 7.7 tonnes and endurance of about 48 hours;[36] the Republic of Singapore Navy's Venus 16 displaces 26 tonnes and has an endurance of 36 hours.[37] The larger fuel-powered UMVs are restricted in endurance only by fuel capacity and the need for maintenance; for example, the US Navy's experimental Sea Hunter antisubmarine warfare continuous trail unmanned vessel displaces some 140 tonnes and has a planned endurance of 60–90 days.[38] Large UMVs still have an energy advantage over manned platforms, since the absence of a crew removes the need for food, other supplies, living quarters and amenities, thus reducing space and power requirements.

Lower energy platforms, such as the Liquid Robotics Wave Glider and Ocius Bluebottle, can rely on wind, solar and wave energy.[39] The principal restrictions on renewable energy sources are the efficiency of the collection medium (such as solar panels) and the energy density of battery technology. A more energy-dense battery would allow a UMV to operate for a longer time before needing to recharge.

A low-energy platform is most likely to operate only passive sonar and visual sensors, although short bursts of relatively power-intensive sensors may become increasingly possible.

Fleet-class Common USV (CUSV): energy-intensive / low endurance

A common unmanned surface vehicle. Photo courtesy US Navy.

Textron Systems' CUSV is a conventional fuel-powered USV with a maximum range of about 2,200 kilometres and an endurance of around 24 hours. It's 12 metres long, displaces 7.7 tonnes and has a top speed of around 28 knots. The boat is designed to be deployable from the US Navy's Freedom-class and Independence-class littoral combat ships, and is remotely operated.

The Fleet class has a modular payload bay, which can be optimised for anti-surface warfare, antisubmarine warfare, mine countermeasures, reconnaissance or communications relay. It also has a towing capacity of around 2,250 kilograms at 10 knots, and is equipped with an optical camera and radar mast.

The CUSV is currently planned for use by the US Navy's littoral combat ships as a deployable mine countermeasures platform.[40]

Operational efficiency

UMVs have a major advantage over UAVs in that they can be kept forward-deployed and activated remotely only when needed. This reduces the pressure on energy-intensive platforms, limits travel requirements and increases the appeal of hybrid energy platforms such as the ASV C-Enduro.[41]

Whereas many UAVs still require a remote pilot most of the time, UMVs can be highly autonomous. A UMV that's programmed to loiter in a specific location can use GPS to orient itself and remain permanently on station. Human control is necessary only when there are changes to its operational parameters.

Note that the absence of crew doesn't imply a complete lack of associated personnel. Like all platforms, the most highly autonomous UMV requires staff for data management. Whether the data comes from a manned or unmanned platform, it still needs to be interpreted by an analyst. In fact, a proliferation of forward-deployed sensors on UMVs could significantly increase back-end data management requirements. There's a substantial intelligence component involved in interpreting radar and sonar data, and it's unlikely that software or artificial intelligence will eliminate the need for experienced human analysts in the near term.

Cost-efficiency

At present, UMVs allow for an increase in the volume of maritime surveillance data at relatively low expense compared to aerial or manned assets. For example, if a single MQ-4C Triton costs US$120 million,[42] the same amount could purchase roughly 400 Wave Gliders with towed-array passive sonar.[43]

Additional technical intelligence collection always comes at a cost. For an intelligence collection platform to be cost-effective, the value of the data to border security efforts has to exceed the expense of managing the data. Therefore, it's the ratio of platform cost to intelligence utility that determines the value of a strategy. The Triton may in fact produce more useful data per dollar than 400 Wave Gliders, but one Triton and 400 Wave Gliders could be more effective and more efficient than two Tritons (Figure 7). For example, UMVs could facilitate more targeted cuing of Tritons or other expensive assets, and thus increase operational efficiency.

Wave Glider: low-energy / high endurance

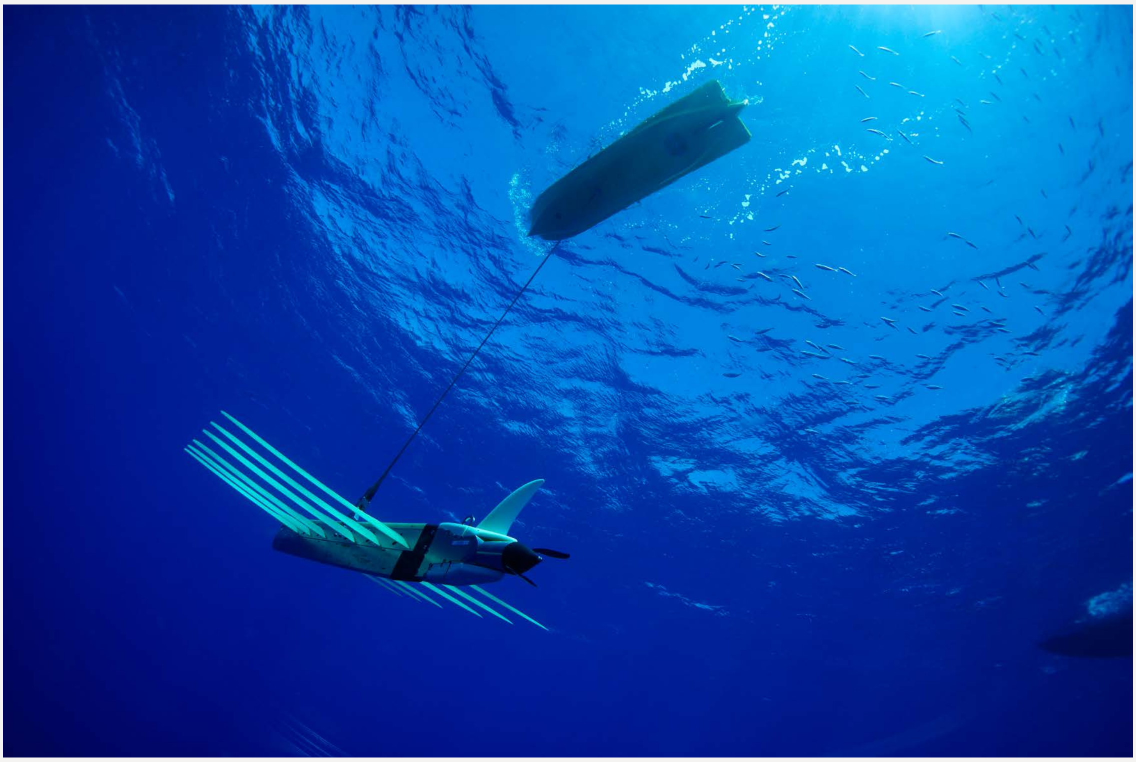
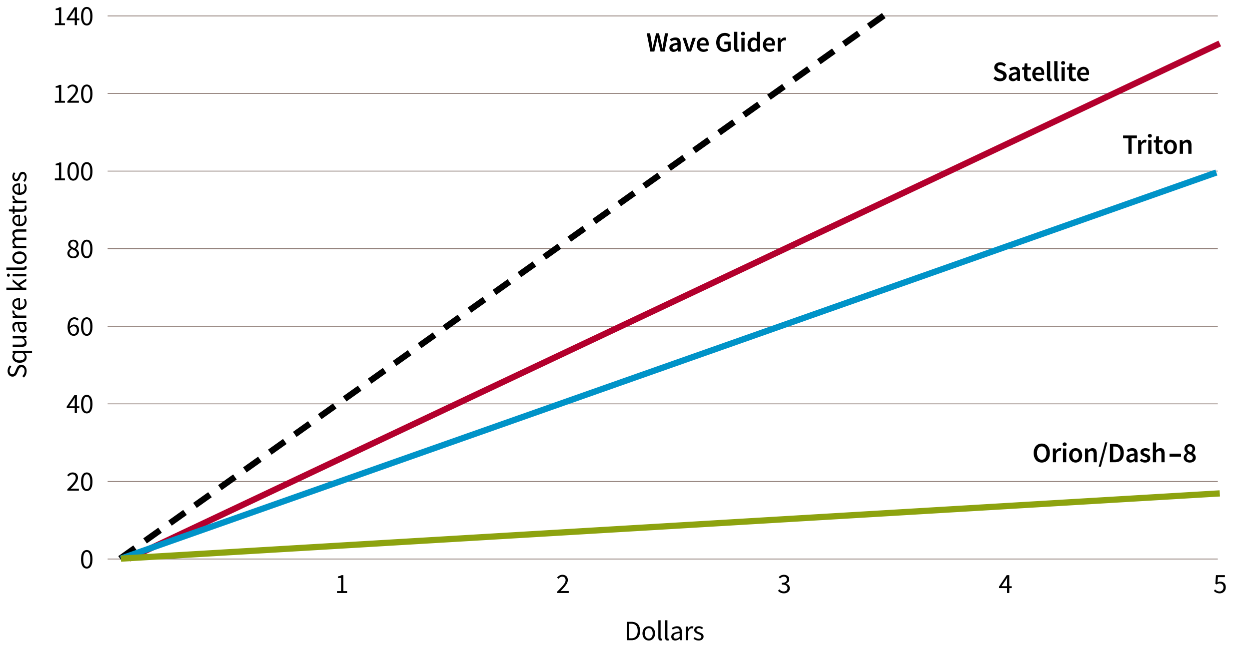


Photo courtesy Liquid Robotics.

Liquid Robotics' Wave Glider is designed to be energy self-sufficient in order to stay operational for up to a year at a time. One part of the system floats on the surface and the other part glides beneath the surface, so it can harvest both solar and wave energy. The two sections are connected via a 7-metre tether and act as one system. The platform is roughly 2 metres long, weighs 150 kilograms and has a variable speed that depends on ocean currents.

The Wave Glider has GPS-enabled autonomous navigation capabilities and includes an optical camera, an AIS receiver, meteorological sensors and acoustic sensors. It can be equipped with more sophisticated towed-array passive sonar to aid in detecting surface and underwater vessels, which makes it more useful for antisubmarine warfare and MDA. The Wave Glider's meteorological sensors also allow it to perform as a mobile, ocean-based weather station or oceanographic station.[44]

Figure 7: Cost ratios of MDA platforms



Ideally, these developments can be achieved while keeping operating costs down in order to remain competitive with other maritime surveillance platforms, such as the Triton or commercial satellites. There's a great deal of market potential for cost-effective solutions in the MDA industry. For example, a small UMV with a 25-kilometre sensor radius could be cost-competitive with a Triton if it costs $100 or less per hour to operate. A Wave Glider or similar UMV should be able to operate for less than $50 an hour, which is conservatively indicated in Figure 7. Actual costs will depend on payloads, at-sea launch requirements and the frequency of remote piloting.

Multi-tasking

Depending on the sensor packages that a given UMV operates, it could also perform tasks for other agencies, such as hydrographic surveys and marine life observation. This might help reduce costs further by using the UMVs to produce data products for other public or private sector clients. A private contractor providing UMV-based surveillance data may be the optimal arrangement.

UMV strategies

Expanding the role of unmanned systems in MDA will improve the ability of Maritime Border Command to perceive and address a greater volume of potential security threats in Australian waters. UMVs' unique characteristics make them a valuable force multiplier for existing assets. They could be used in concert with manned surface assets and air assets to maximise the effectiveness of the whole surveillance ecosystem.

If a UMV detects a nearby target of interest, an aircraft or patrol boat could then be deployed to investigate. If a vessel can't be identified using the UMV's sensors, an airborne asset such as a Poseidon or Triton may be better able to assess the threat. The UMV could be cued by satellite imagery to position itself in advance of incoming targets. If interdiction is required, a patrol boat is still the only asset capable of completing that task, but improvements in maritime intelligence and surveillance capability should ensure that patrol boats are only used when and where they're needed.

Surveillance of Australia’s northern maritime approaches

The low cost of small UMVs could allow for a wide net of passive surveillance across large areas of Australia’s ocean territory. Most potential maritime threats to Australia emanate from our northern waters, so an array of persistent, roughly equidistant UMVs along our northern approaches could act as a line of first detection against incursions.

The range of sensors depends on a number of variables; for example, the range of passive sonar depends on how much noise the target vessel makes, as well as the sea conditions. The affordability of UMVs means that the number of assets deployed can be high and be adjusted over time to improve scope.

C-Enduro: a hybrid

Photo courtesy ASV.

ASV’s C-Enduro combines a diesel fuel generator, a wind turbine and a solar panel system into a medium-endurance system with greater sensor capability than completely renewable-powered systems. The platform is 4.2 metres long, weighs in at 350 kilograms, and has an endurance of up to 3 months. It can travel at 4 knots for up to 6,500 kilometres and has a top speed of 7 knots. It can operate remotely, autonomously or semi-autonomously.

The C-Enduro has several payload options, including towed-array passive sonar, active dipping sonar, meteorological sensors, oceanographic sensors, or an electronic warfare capability. The power requirements for more energy-intensive sensors can erode the practical endurance of the platform, as they may rely on the limited diesel capacity. However, this would probably mean that the platform is better able to detect submarines and surface vessels than lower-energy platforms.[45]

Targeted guarding of high-value maritime zones

Another use for low-energy UMVs such as the Wave Glider or Bluebottle would be to loiter in targeted areas of marine territory based on their value. For example, such an area might be at high risk from illegal, unreported and unregulated fishing, or a common smuggling route.

An underwater asset such as the Kongsberg Seaglider could play a similar or complementary role, and have the benefit of operating at deeper and variable depths (making it useful for sonar applications).[46] Like the Wave Glider and Bluebottle, Seagliders don't emit active sonar waves, so they can be safely deployed in marine reserves and marine mammal habitats.

> Exactly where UMVs are deployed would depend on Maritime Border Command assessments of high-risk or high-traffic areas.

Exactly where UMVs are deployed would depend on Maritime Border Command assessments of high-risk or high-traffic areas. The locations could vary with the season or offer a tactical flexibility in response to changes in malicious tactics.

A consideration when using UMVs, especially those that are deployed for extended periods in remote areas, is that they may be vulnerable to theft, sabotage or destruction. This exposure places some security limitations on the types of sensors deployed on them.

THE FUTURE

Emerging UMV capabilities

Today's in-service passive surveillance UMVs offer clear capability benefits for Australia's border security. It's likely that emerging and future conventional and hybrid UMV platforms will offer exponentially better capabilities for border protection, servicing more of the border protection task.

At present, UMV platforms can assist in the search, detection and identification components of the MDA process for extended periods. There's now enormous potential for technological innovation to increase the operational utility of future UMVs so that they can support the classification, identification and tracking of vessels in Australian waters.

Improving energy efficiency will increase the sensor capabilities and mobility of low-energy UMVs. This will expand their utility into the classification and identification processes. Battery technology will allow UMVs to use power-intensive sensors such as active sonar or radar more often, thereby improving their surveillance capabilities.

Likewise, improving the efficiency of energy-intensive platforms will enhance their endurance and range, increasing the potential for UMVs to be used in tracking missions. Current conventionally fuelled UMVs such as the CUSV and Venus 16 tend to be shorter range boats designed for minehunting and reconnaissance missions.

For example, the Sea Hunter continuous trail unmanned vessel is designed to track submarines and, at the stage of sea trials, it already demonstrates the potential of USVs for long-range tracking. It's only slightly smaller than a patrol boat and relies on conventional fuel, which gives it significant endurance. A future USV could conceivably be used to track a surface vessel for a long period until disruption by a manned asset can take place. This will have the additional benefit of making these platforms usable in the broader search and detection functions. Further developments could allow conventional UMVs to be forward-deployed to better enable tracking operations in targeted areas.

Developing methods for the effective forward-deployment of power-intensive UMV platforms will produce gains in the identification and tracking of target vessels. This will help mitigate the limitations imposed by energy storage capacity.

Integrating UMVs into Maritime Border Command

There are prospects for UMVs to improve the capabilities of Australia's ABF and ADF patrol boats, or to be used for oceanographic purposes.

However, this special report concentrates on the use of UMVs as a new strategic capability for wide-area surveillance that is both cost-effective and operationally viable.

The attributes of UMVs mean that both the ABF and the ADF would benefit from developing and operating a UMV fleet. The operationalisation of UMV technology is still in a nascent stage and will require continued investment, research and innovation for the platform to reach its potential utility. In this context, civil maritime security is the responsibility of Maritime Border Command, so there's an argument that any capability development activity in this area should be under its auspices.

> Maritime Border Command should consider an entrepreneurial public–private sector collaboration model.

To reduce the organisational risk associated with being an early adopter of UMV technology, Maritime Border Command should consider an entrepreneurial public–private sector collaboration model. Such a framework could involve offsetting the operational costs and risks of a UMV capability by outsourcing UMV operation and maritime data collection to private enterprises.

A private sector entity could develop and deploy capabilities on an ongoing contractual basis. Data management and the analysis requirement for UMV capabilities could be included in an outsourcing agreement or handled by Maritime Border Command. Such an approach would leverage the private sector's ability to acquire, deliver and operate new technologies more quickly than the public sector. However, this approach would afford the ABF and ADF fewer opportunities to control capability or operational specifications.

The current approach of commercialised satellite data collection provides an informative example of the value of outsourcing maritime surveillance.

Adopting a partnership approach for enhanced maritime surveillance would have benefits for the security and flexibility of the border security strategy. There are security challenges associated with leaving confidential military-grade technology exposed and unmanned in the open ocean. Using commercial-off-the-shelf technology would lower the intellectual property risks. It would also avoid the rigid and long-term acquisition cycles typical of military technological investment. Employing UMVs as a commercial service would provide agility and allow for ongoing adjustments to the scope and scale of the private sector contract in response to threat developments in the maritime domain.

A partnered or outsourced approach could also have substantial economic benefits for Australian industries. From the manufacture of components to the construction and whole-of-life support of Maritime Border Command UMVs, there would be many opportunities for industry growth. There are innovation opportunities in platform development, energy-efficiency technology, sensor technology and data management. These private sector developments could translate into export sales, especially if a private maritime surveillance enterprise is successful in Australia.

RECOMMENDATIONS

In the interests of improving the efficiency of Australia's maritime border security efforts, this report recommends that:

- both the public and the private sector continue to invest in the research and development of UMV technologies as a cost-effective enhancement of existing surveillance capabilities
- future capability development decisions for Maritime Border Command:
  - take into account the utility of a network of UMVs capable of carrying a variety of sensor arrays to enable the cost-effective cuing of existing expensive border security assets
  - compare and contrast the capabilities and efficiency of UMV and UAV systems as well as manned systems
- Maritime Border Command consider whether it can offset the operating costs of a UMV capability by offering maritime data collection contracts to the private and not-for-profit sectors
- Maritime Border Command consider whether a UMV network could be a value-add to its data and maritime intelligence collection services for other government agencies and departments.

NOTES

1 Australian Customs and Border Protection Service, *Annual report 2013–14*, online.

2 Department of Immigration and Border Protection, 'Ocean Protector boosts Australia's border protection', media release, 1 March 2016, online.

3 The area surveilled has varied from year to year, as detailed in Australian Customs and Border Protection Service, *Annual report 2010–11*, online.

4 B Hoffman, 'Was billion-dollar radar turned off?', *Sunshine Coast Daily*, 27 September 2014, online.

5 RAAF, *Fact sheet: Jindalee Operational Radar Network*, online.

6 Senate Standing Committee on Legal and Constitutional Affairs, *Australian Customs and Border Protection Service*, Question no. 105, 24 May 2012, online.

7 Department of Defence, *Maritime patrol aircraft replacement*, online.

8 Claudette Roulo, *DoD maintains support to find missing Malaysia Airlines Flight 370*, US Department of Defense, 24 April 2014, online.

9 RAAF, AP-3C Orion, online. RAAF, P-8A Poseidon, online. RAAF, MQ-4C Triton unmanned aircraft system, online. RAAF Museum, A9 Lockheed P-3 Orion, online. Boeing ,P-8A Poseidon, online. Naval Air Systems Command, MQ-4C Triton, online. Qantas, Dash 8, online.

10 RAAF, P-8A Poseidon, online.

11 Department of Defence, *2016 Defence White Paper*, online.

12 MQ-4C Triton, Naval Air Systems Command, online.

13 Cameron Stewart, 'No land role for $2.5bn Triton maritime drones', *The Australian*, 12 June 2015, online.

14 Aaron Mehta, 'USAF looks to Global Hawk upgrades', *DefenseNews*, 7 March 2015, online.

15 'Project Sentinel', *South Australia the Defence State*, no date, online.

16 2010 dollars; 'Surveillance Australia wins Coastwatch prize', *ADM: Australian Defence Magazine*, 10 January 2008, online.

17 Immigration and Border Protection Portfolio, *Portfolio Budget Statements 2015–16*, Related paper no. 11, online.

18 'Cobham and GA-ASI extend partnership to provide UAV whole life support in the UK and Australia', General Atomics and affiliated companies, no date, online.

19 Sara Everingham, 'Customs Cape class patrol boats used for border security struggling to find permanent berth, *ABC News*, 8 June 2015, online.

20 'Expansion of Cape class program', *Austal: ships, systems, support*, 13 December 2015, online.

21 Australian National Audit Office (ANAO), *Management of the Cape Class Patrol Boat Program*, Report 13 of 2014–15, 16 December 2014, online.

22 David Ellery, 'Defence buys boat bound for Customs', *Sydney Morning Herald*, 20 March 2012, online.

23 Department of Immigration and Border Protection, ‘Ocean Protector boosts Australia’s border protection’, media release, 1 March 2016, online.

24 ‘Australia defence ship Ocean Shield docks in Hobart raising hopes illegal fishing boat patrols will start’, *ABC News*, 25 February 2015, online.

25 Australian Customs and Border Protection Service, *Southern Ocean patrol vessel—ACV Ocean Protector*, September 2010, online.

26 Attorney-General’s Department, *Portfolio Budget Statements 2013–14: Attorney-General’s Portfolio*, online.

27 Australian Customs and Border Protection Service, ‘Southern Ocean Patrol Vessel – ACV Ocean Protector’ (archived pdf), online.

28 Ian McPhedran, ‘The navy’s patrol boat fleet is over worked and under maintained according to new report’, *news.com.au*, 4 January 2014, online.

29 Parliament of Australia, Questions in writing, Royal Australian Navy, 10 October 2012, online.

30 Austal, ‘Austal Patrol 58—Cape class patrol boat’, *Austal Ships Systems Support*, no date, online.

31 ANAO, *Management of the Cape Class Patrol Boat Program.*

32 Actual flying hours listed in annual *Defence Portfolio Budget Statements 2014–15*, online.

33 Poseidon data assumes that the US$4,200 per hour operating cost quoted by US official is accurate, and that the area surveilled per hour is roughly equal to the Dash-8/Orion. In practice, the Poseidon is likely to be more effective than the Orion.

34 ANAO, Management of the Cape Class Patrol Boat Program, online; Parliament of Australia, Senate Estimates 2012-13 Attorney-General’s Portfolio, Questions on Notice No. 105, online; Parliament of Australia, Hansard, Royal Australian Navy, (Question No. 1216), October 10, 2012, online.

35 John Keller, ‘Unmanned marine vehicle companies to build 29,550 systems worth $15.4 billion in next decade, *Military & Aerospace Electronics*, 27 May 2015, online. Approximately half of this is going to be in the torpedo market.

36 ‘Fleet-class Common Unmanned Surface Vessel (CUSV), United States of America’, *naval-technology.com*, no date, online.

37 ‘Singapore unveils Venus 16 unmanned surface vehicle’, *Defence Blog*, 3 November 2015, online.

38 David Szondy, ‘DARPA readies unmanned ACTUV sub hunter for sea trials’, *gizmag*, 15 February 2016, online.

39 ‘Energy harvesting ocean robot’, *Liquid Robotics*, 2016, online.

40 ASV Unmanned Marine Systems, *Product information: C-Enduro*, 2016, online.

41 ‘Fleet-class Common Unmanned Surface Vessel (CUSV), United States of America’, naval-technology.com; Sam LaGrone, ‘Textron division wins $34 million contract for LCS unmanned minesweeper’, *USNI News*, 6 October 2014, online.

42 US Government Accountability Office, ‘MQ-4C Triton unmanned aircraft system (MQ-4C Triton)’, *Defense acquisitions: Assessments of selected weapon programs*, March 2015, online.

43 Daniel Terdiman, ‘Hundreds of floating robots could soon surveil the oceans’, *CNet*, 23 September 2014, online.

44 ‘Energy harvesting ocean robot’, *Liquid Robotics*.

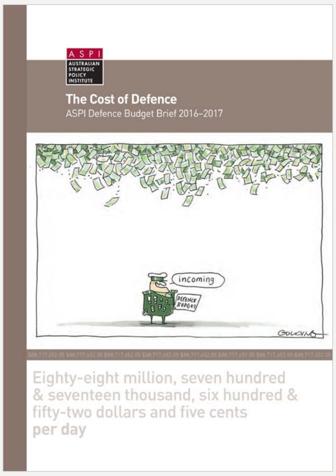
45 ASV, *C-Enduro: long endurance ASV*, no date, online.

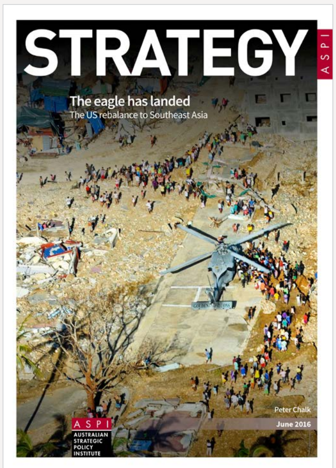
46 Kongsberg, *Autonomous underwater vehicle—Seaglider*, no date, online.

ACRONYMS AND ABBREVIATIONS

ABF	Australian Border Force
ADF	Australian Defence Force
AIS	automatic identification system
EEZ	exclusive economic zone
JORN	Jindalee Operational Radar Network
MDA	maritime domain awareness
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
UAV	unmanned aerial vehicle
UMV	unmanned maritime vehicle
USV	unmanned surface vessel
UUV	unmanned underwater vehicle

Some previous ASPI publications





Australian border security and unmanned maritime vehicles

ISSN 2200-6648