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Girt by Sea

Understanding Australia's Maritime Domains in a Networked World

Brett Biddington AM

November 2014

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Understanding Australia's Maritime Domains in a Networked World

Brett Biddington AM

THE KOKODA FOUNDATION
www.kokodafoundation.org
RESEARCHING AUSTRALIA'S FUTURE SECURITY CHALLENGES

ABOUT THE AUTHOR

Brett Biddington AM is a Canberra-based consultant with particular interests in space and cyber-space although he looks more broadly at questions concerning intelligence, surveillance and reconnaissance and the relationship of technology to organisations. He is active in space industry development and the governance of Australian astronomy. He has completed two reports for the Kokoda Foundation on Australia's place in space.

Between 2002 and 2009 Brett was a member of the Global Space Team of Cisco Systems. This followed a 23 year career in the Royal Australian Air Force where he specialised in intelligence, security and capability development. He sponsored a wide range of command and control, intelligence, surveillance and reconnaissance projects, including the Jindalee Over the Horizon Radar Project (JORN) and classified space projects. Brett is an Adjunct Professor in the Security Research Institute at Edith Cowan University in Perth, WA. He is a Director of the Kokoda Foundation.

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The Kokoda Foundation
2/10 Kennedy Street
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T: +61 2 6295 1555
F: +61 2 6169 3019
Email: info@kokodafoundation.org
Web: www.kokodafoundation.org

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PREFACE

Work on this study began in mid-2011 with an intention to release this report late in 2011 or early in 2012. Clearly this did not happen. The initial cause for delay was personal. Later, it seemed pointless to publish before the outcome of the 2013 election was known because the longer term perspective that this paper seeks to take almost certainly would have been swept into the controversy surrounding asylum seekers.

The 2013 election is now well past and the Government has changed. The Abbott Government's asylum seeker policy, although still contentious, has seen new boat arrivals reduce to a trickle. New surveillance systems are being acquired and major changes to Australia's border protection arrangements have been announced.

This study was completed in the months following the disappearance of Malaysian Airlines flight MH370 in March 2014. For reasons unknown this routine flight from Kuala Lumpur to Beijing seems to have turned around, headed west across the Malay Peninsula then south and finally disappeared into the wastes of the Indian Ocean, probably some 1500km west of Perth. The subsequent search for any evidence of the missing aircraft was coordinated initially by the Australian Maritime Safety Authority (AMSA) and later by a Joint Coordination Centre headed by Air Chief Marshal (Retired) Angus Houston AC. The initial surface search involved satellites, aircraft and ships (both military and civil) including from Australia, New Zealand, Malaysia, China, the United Kingdom and the United States. The enormous interest generated by the disappearance of the aircraft with 239 souls on board has shone a spotlight on the importance of maritime domain awareness and of Australia's particular and unique circumstances. The search for MH370 bears eloquent testimony to the vital importance of integration and collaboration in any modern and mature maritime domain awareness system.

In May 2014, the Government announced major changes to the organisational arrangements of agencies and departments which are responsible for Australia's civil maritime domain awareness system. From 1 July 2015, the border protection responsibilities presently performed by the Department of Immigration and Border Protection (DIBP) and the Australian Customs and Border Protection Service (ACBPS) will be merged into a single Department of Immigration and Border Protection. A single frontline operational border agency, the Australian Border Force, will also be created to enforce customs and immigration laws and protect the border as part of the DIBP. This follows trends in other nations, including the United States and the United Kingdom and is enabled, in no small measure, by data integration from diverse sources that permits connections to be made between people and activities, intent and capabilities in a systematic and routine way. When linked to the broader interests of the Australian Defence Force (ADF) and the national intelligence community and civil agencies, notably the Bureau of meteorology and Geoscience Australia there now exists a platform to provide decision makers comprehensive awareness about the state of Australia's maritime domains and the activities that occur in them.

This study aims to provide policy makers, practitioners and the wider public with background, language and context that is essential for an informed understanding of the challenges and dilemmas faced by those responsible for the efficacy of Australia's maritime domain awareness system.

Brett Biddington
Canberra
November 2014

EXECUTIVE SUMMARY

Australia has vital interests in a safe and secure maritime environment. Almost all of Australia's exports (99+% by volume and more than 75% by value) that define the wealth of the Australian economy travel to their destinations by ships. Yet community understanding of the nation's dependence on the seas and oceans is limited at best. The sea does not figure prominently in the national story, except perhaps as a barrier; a means to keep unwanted people, plant and animal pests and diseases out. Cheap air travel means that Australians fly across the oceans, often to destinations in Europe, north Asia, the Americas, and Africa with no real appreciation of the diversity of the oceans below. In common parlance the oceans are to be crossed more than they are to be understood.

Some of the more important questions that arise when discussing situational awareness are:

- How much situational awareness is enough which might otherwise be expressed as how much money is Government prepared to invest in understanding Australia's maritime domains?
- What should be the balance of investment between civilian and military capabilities devoted to the Maritime Domain Awareness element of border protection?
- What is the optimal balance of investment between systems that can assist decision makers to obtain situational awareness and other systems that can respond when needed?
- Are there certain capabilities that contribute to situational awareness that must remain in sovereign control and if so, what are they?
- How is situational awareness achieved across jurisdictional, organisational and other boundaries?
- What is the impact of technological development and how do capability developers decide about the mix of platforms and sensor types in which to invest?
- What should be investment balance between platforms and sensors that collect information and the back-end systems that process, exploit and disseminate the results to decision-makers?

None of these questions is capable of being answered in isolation from any of the others.

In the 1980s, the ICT revolution began to transform all human activities, including those concerned with maritime domain awareness. No longer is it sensible or sufficient to invest in platforms, such as ships and planes and sensors such as radars and cameras. Data processing, storage, retrieval and dissemination systems need to be capable of handling the data provided by sensors in order that best use can be made of the information that has been collected. This suggests three further principles that need to be applied as the system continues to develop.

- Ensure that data, irrespective of source, is not left unprocessed and analysed for want of appropriate investment in backend systems.
- Where possible automate data flows, analysis and dissemination – save time, reduce errors and release staff for higher order tasks where judgement is essential.
- Minimise, to the extent possible, the amount of data in the system that is classified.

This relatively simple concept is extraordinarily complex to implement.

These additional considerations call for the development of a systems approach to maritime domain awareness that comprehends that each and every element of the system is, or may be, connected to every other element. The power of the system, including its resilience and redundancy is that sensors and platforms become nodes; they both contribute to and take information from the system. This relatively simple concept is extraordinarily complex to implement. Legislative restrictions, organisational impediments and a plethora of competing and conflicting technical standards combine to make cooperation and coordination very hard.

In the past decade substantial progress has been made in creating a system that provides maritime domain awareness to Australian decision makers. Perhaps the most important outstanding task is for a narrative to be developed that explains the importance of the safety and security of Australia's maritime domains to the nation's broader national security interests and economic well-being. These matters have not been well-articulated to the broader public in a comprehensive and comprehensible way. Sectional interests, for obvious reasons, discuss, for example, marine parks, commercial shipping policy, and the need for new submarines and surface ships. Needed is a story that draws the strands together to show how they are linked and to provide context for investment decisions that must be made in the coming decade, some of which will have consequences well into the second half of the 21st century.

Against a rapidly changing region dominated by the rise of China, India and, closer to home, Indonesia, Australia's approaches to understanding its maritime domains will be influenced by strategic factors and diplomatic judgements as well as operational imperatives. Australia's alliance relationship with the United States and its relationships with regional neighbours may be expected to have a profound impact on the strength of the information sharing and interoperability regimes on which so much of Australia's maritime domain awareness depends.

The purpose of this paper is twofold. First, it seeks to explain in plain English some of the principles, concepts and terms that maritime domain awareness practitioners grapple with on a daily basis. Second, it points to a series of challenges that governments face in deciding how to spend scarce tax dollars to deliver a maritime domain awareness system that is necessary and sufficient for the protection and promotion of Australia's national interests.

ACKNOWLEDGEMENT

The basic data for this study was gained in three workshops that were attended by more than 30 participants from a number of government departments, companies and industry associations in mid-2011. The time given by this people to this study is gratefully acknowledged.

VADM(RTD) David Shackleton AO, a former Chief of the Royal Australian Navy, assisted with the planning and conduct of these workshops. He also prepared a set of detailed notes that were invaluable in the preparation of this report. His contribution is also gratefully axknowledged.

The Kokoda Foundation thanks Boeing Australia, Cobham Australia and Edith Cowan University for sponsoring this study and for their commitment to fostering research and thinking about the challenges that will need to be met if Australia is to understand and properly govern its maritime domains into the future.

Disclaimer

The views expressed in this paper are the author's alone and do not reflect or represent the views of any of the sponsors or any individual employee of any of those organisations.

INTRODUCTION

"If it happened outside Sydney Heads, it didn't happen as far as Australian voters are concerned."

A cynical view of old time NSW politicians
Recounted by Alan Reid[1]

Australia has a vital interest in knowing a great deal about its maritime domains.

Knowing what is happening to the oceans themselves and to the life they sustain presents one set of challenges and opportunities. Knowing about human activities that take place on, through and over these seas and oceans presents another set. A comprehensive maritime situational awareness system seeks to synthesise knowledge of the environment with knowledge about human activity into a Common Operating Picture (COP) which is shared between multiple users who take from the COP what they need to support their decisions and activities.

This purpose of this paper is twofold. First, it seeks to explain in plain English some of the principles, concepts and terms that maritime domain awareness practitioners grapple with on a daily basis. Second, it points to a series of challenges that governments face in deciding how to spend scarce tax dollars to deliver a maritime domain awareness system that is necessary and sufficient for the protection and promotion of Australia's national interests.

There are no silver bullet solutions to these challenges. Rather there are balances to be struck between institutions, platforms, sensors, data processing and dissemination systems. Time is a further consideration. A longer view can reveal different information priorities and needs that demand different responses to those of interest from a shorter term perspective.

Setting the Scene

The Australian story, or legend, since white settlement is one of the bush and the Outback. Its heroes and heroines are those who ventured beyond the Great Dividing Range to explore and settle the vast and inhospitable interior. The epic, if ill-fated, journeys are those of Burke and Wills, John McDowall Stuart, Ludwig Leichhardt and Edward John Eyre.

In contrast, who has heard of Bass and Flinders, or John Bertrand and Ben Lexcen?[2] How many Sydneysiders know that the small ferries that bustle around the harbour bear the names of the ships of the First Fleet which brought nearly 1500 souls from Britain to Botany Bay in 1787-88? Ned Kelly was a bushranger and is a household name.

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1 Reid, A. *The Whitlam Venture*, Hill of Content Publishing, Sydney, 1976, p73.

2 George Bass discovered the strait that bears his name between mainland Australia and Tasmania and Mathew Flinders was the English navigator first to circumnavigate the Australian continent in 1801-3. John Bertrand was the Skipper of the yacht Australia II which won the America's Cup, the first non-US challenger to do so, in 1983, after 132 years of American domination. Ben Lexcen designed the 'winged keel' which provided Australia II with an important technological advantage.

Yet, Mary Bryant, her husband and seven others who stole Governor Phillip's cutter and sailed it from Sydney to Timor in 1791 – an amazing journey of 3254 miles in 69 days - barely rate a footnote in the history books.[3]

Those who created the Australian nation made much of the "Island Continent" which is "girt by sea". "One nation, one continent" was a recurrent theme of the federalists in the 19th Century. From the earliest days of European settlement, the threat of attack and even invasion has been a constant theme – French, Russians, Germans, Japanese and, more recently asylum seekers who seek to reach Australia by boat, play on a strand of vulnerability and insecurity which is deeply ingrained in the national psyche.

In something of a paradox, given the legend of the bush and our perceived vulnerabilities, the overwhelming majority of Australians (85% or more) live within 50km of the sea, most of them in a handful of capital cities. Yet the appreciation of most Australians of what lies beyond the horizon as we sit on the beach and soak up the sun, for the most part can be written on the back of postage stamp.

By virtue of geography, territorial claims and a series of legal obligations most of which have emerged since the end of World War 2, Australia has responsibilities for understanding and maintaining as generally secure 10% of the world's oceans not just in its own interests but on behalf of the international community as a whole.

The Australian economy is fundamentally dependent on the sea lines of communication remaining open and safe. 99% by volume of all goods which enter or leave Australia do so by ship. These sum to more than 80% of the total value of Australia's imports and exports.

However viewed, Australia will need to be substantially more aware of its maritime domains in the future if it is to protect and advance its national security, economic prosperity, social cohesion and regional influence in the decades to come.

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3 For a summary account see the entry under Mary Bryant in Pike, D. (ed), *Australian Dictionary of Biography, Vol 1, 1788-1850, A-H*. Melbourne University Press, Melbourne, 1966.

Organisation

The paper is organised into seven chapters.

The first discusses the concept of situational awareness with particular reference to the maritime domain and provides some definitions that are often confused or misunderstood in public discourse. The second describes the extent of Australia's maritime domains and poses some dilemmas and challenges that are presented by the boundaries as they stand and also the changes to these boundaries that may occur as we move further into the 21st Century. The third describes the threat landscape that the MDA system seeks to capture and make available to decision makers. The fourth outlines the drivers of the Australian MDA system, those factors which make it what it is. The fifth approaches MDA through a system-of-systems approach and explains how networking technologies challenge current organisational paradigms because networks change the basis for information collection and management in and about the maritime domain. The sixth reviews the sources and methods from which Australian decision makers derive their awareness of the maritime domains today and also discusses systems and technologies that may be used in the future to strengthen this situational awareness. The seventh and final chapter pulls the strands together and makes some suggestions about what Australia might do next to ensure it maintains adequate oversight and governance of its maritime domains.

A Note on Sources

This paper draws on official documents, including departmental reports ministerial statements and white papers, all of which are openly available.

The core themes and ideas, however, emerged from the closed workshops conducted in 2011 and from the comprehensive records of those events made by David Shackleton. Three years on and three governments later, the broad conclusions reached in the 2011 workshops stand.

SITUATIONAL AWARENESS IN THE MARITIME DOMAIN CONCEPTS AND DEFINITIONS

Maritime Domain Awareness, or MDA as it will be called in this paper, is a seemingly simple and straightforward concept. The term gained authority and currency in the United States in the 1990s and early 2000s and was given formal standing in a US Presidential Directive, NSPD-41/HSPD-13, entitled *Maritime Security Policy*, dated 21 December 2004.[4] The Presidential Directive defines the maritime domain as:

> "All areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances."

In summary anything and everything to do with the sea. This seems straightforward enough.

A series of subordinate documents flowed from the Presidential Directive, of which the most important is the *US National Plan to Achieve Maritime Domain Awareness*.[5] The Plan, in effect, gives meaning to the word 'awareness' and combines the breadth of the maritime domain, the 'what', with an ambitious outline of the organisations, processes, technologies and other resources that would be needed to fulfil the President's requirements. This is the 'how'.

The US definition of MDA, although meaningful to a superpower which is capable, or has the confidence to assert that it is capable, of collecting, processing, storing, analysing, disseminating and using the huge amounts of data implied by the concept, must be approached with some caution by nations with more constrained resources, such as Australia.

In fact, within the US, MDA has been applied in a somewhat more limited way than the Presidential Directive implies. Boiled down, MDA is to prevent bad people, such as terrorists, and bad things, such as drugs, from entering the United States. It also involves stopping these activities as far from the physical borders of the United States as possible.

The key tool of MDA is a Common Operating Picture (COP) which is a compilation of data drawn from many sources and fused into information repositories and information systems and networks that are accessible to multiple users. The COP is as close to real time as can be obtained and provides actionable information from classified and unclassified sources in time for officials to detect, deter and, if necessary, defeat any human activity in the maritime domain that is considered to be inimical to the interests of the United States. The COP also provide information about weather and other environmental factors.

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4 National Security Presidential Directive 41/Homeland Security Presidential Directive 13, *Maritime Security Policy*, dated 21 December 2004.

5 US *National Strategy for Maritime Security: National Plan to Achieve Maritime Domain Awareness*, Department of Homeland Security, October, 2005.

Australian Terminology

Notwithstanding the vastness of Australia's maritime domains, the phrase "maritime domain awareness" has been slow to enter the Australian lexicon. The phrase did not appear in the 2009 or 2013 Defence White Papers, the 2012 Force Posture Review or the Prime Minister's 2013 National Security statement. The phrase has been used by the Australian Customs and Border Protection Service (ACBPS). For example, in that organisation's 2010-11 Annual Plan, one objective was:

> To coordinate whole-of-government efforts in preventing, detecting and responding to potential or actual non-compliance with relevant laws in Australia's maritime domain, and to provide maritime domain awareness across government.[6]

Similar words appeared in the Annual Report of 2011-12 which were repeated verbatim in the most recent 2012-13 Annual Report.

> To coordinate whole-of-government efforts in detecting, reporting and responding to potential or actual non-compliance with relevant laws in Australia's maritime domain, and to provide maritime domain awareness. This also includes coordinating the whole-of-government effort to respond to people smuggling.[7] [8]

Although the term is used it is not defined. Maritime domain awareness of what precisely, for whom and for what purpose are questions that arise.

The RAN document, *Australian Maritime Doctrine, 2010*, provides in the glossary the definition of maritime domain awareness that is used by the US Department of Defense:

> The effective understanding of anything associated with the maritime domain that could impact the security, safety, economy or environment of a nation.[9]

The MDA concept is not as straightforward as appears at first glance.

Questions about how much or how little MDA is sufficient come down to judgements which have important ramifications for the utility of the MDA system to its users. Answers to the question, "How much is enough?" affect:

- Levels of investment in new capabilities, what those new capabilities should be and the order in which they are acquired and brought into service;
- Tasking of sensor platforms and other sources that may provide relevant data; and
- Decisions about analysis priorities.

In sum the answers determine the overall utility of the system.

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6 Australian Customs and Border Protection Service, *Annual Plan, 2010-2011*, Canberra, 2010, p19.
7 Australian Customs and Border Protection Service, *Annual Report 2011-12*, Canberra, 2012, p60.
8 Australian Customs and Border Protection Service, *Annual Report 2012-13*, Canberra, 2013, p41.
9 Royal Australian Navy, *Australian Maritime Doctrine*, Canberra, 2010, p199.

Instead of "maritime domain awareness" relevant Australian publications often use the phrase "situational awareness" or "situational awareness in the maritime domain". Irrespective of the term, Australia is seeking to substantially increase its understanding of the natural environment as well as human activities which occur above, on and under the seas which surround the continent.

Given the huge size of the maritime areas of responsibility and even larger areas of interest, Australia cannot hope to achieve the understanding to which it may aspire on its own and from its own collection and analysis resources. Help is needed from the international community for access to data from satellites, from the resources of regional nations, international organisations and from commercial entities as well. Even with such help, Australian authorities are still forced to make choices about what information to (and not to) collect, process and disseminate. Agencies also need to judge how to make most effective use of the information at their disposal in terms of responses that have immediate impacts whilst delivering longer term benefits as well.

A question to ask is whether the process of attaining MDA by any decision-maker differs in any significant way from the attainment of situational awareness by decision makers who operate in other of domains of human activity, including the land, the air, outer space and more recently, cyber space. Whilst the physical characteristics of these environments are fundamentally different, the processes by which information about these environments and human activity in and through them is gathered, analysed and used is similar. An area of growing complexity is where domain boundaries intersect and information needs to be shared between decision makers, collection agencies and response agencies across several domains. Information collected in one domain may have unrecognised relevance in another unless processes are established that encourage and permit cross-domain understanding and information sharing. Legal, cultural, operational and technical factors can all work to inhibit such flows.

A possible differentiator between the achievement of necessary and sufficient awareness in the maritime domain, in contrast to other domains, is in the complexity of the system, notably its organisational and legal complexity. A plethora of private, commercial, government and international interests intersect in the maritime domain in ways that are not emulated to the same degree in other domains. Highly complex sets of cooperative and competitive behaviours exist in the maritime domain that are codified in both the law and the lore of the sea. As the world's oceans come under increasing pressure from many forms of human activity increasingly divergent views are emerging about how to reconcile or at least mediate between short and long term interests, economic and environmental imperatives and local and international equities. Some policy makers believe that the world's oceans are a source of bounty and likely to remain so into the indefinite future. Others believe that the world's oceans and ecosystems as we know them are under profound threat from environmental change and human exploitation. These opposed positions lead to behaviours and policy responses that can be inconsistent to the point of incoherence. The starting assumptions may profoundly influence, or bias, the structure, aims and priorities of any MDA system. To the extent that the bias is explicit and understood by system users, it can be compensated for in how data in the system is valued and how decisions and responses are formed.

The following sections of this chapter outline the main terms and concepts that apply to any complex operational information gathering and decision making system. In this context MDA is a stand out example. When considered as a whole these terms and concepts indicate the complexity and the challenges that decision makers face when making operational and investment decisions that will provide adequate knowledge to decision makers to allow them to protect and advance Australia's sovereign interests and to meet Australia's international obligations in the maritime domain.

Situational Awareness

Situational awareness describes the comprehension that decision makers, at all levels, have of the environment in which they may be called on to make decisions – advance or retreat, turn right or left, hold position, allocate more resources to resolve a perceived problem, etc. Situational awareness is the sum of everything that a decision maker knows and believes when he or she makes any given decision. This does not mean that the decision maker knows all there is to be known about a particular situation. It does mean that a decision maker is prepared to make a decision on the basis of his or her understanding of that situation. The decision maker feels confident with the information at his or her disposal to decide what to do and to implement or order a course of action. Another way of thinking about this is to say that the decision maker believes he or she has sufficient information to permit the risks associated with known and even unknown information gaps to be accepted.

Situational awareness is the sum of everything that a decision maker knows and believes when he or she makes any given decision.

To the extent that there is general agreement in a decision-making team about what needs to be known before a decision can be made (the structure of the decision), and there is also general acceptance of the relevance and veracity of data that are gathered (the essence of the decision), shared situational awareness may be said to exist. An overwhelming risk with shared situational awareness is that it can lead to "group think". Alternative interpretations of the available data are not considered because they run against the grain of the prevailing orthodoxy, or alternative options or courses of action are either not considered or ruled out because they do not accord with the prevailing frame of reference of the decision-makers.

There is a common tendency to assert that better informed decisions lead, *ipso facto*, to better outcomes, than do less well-informed decisions. A common experience of those who have worked in large organisations is the boss who wants to know "all the facts" before deciding on a course of action. Apart from being a tried and true delaying tactic, this behaviour rests on the fallacy that "all of the facts" can be known. To the extent that uncertainty is removed, risk is assumed or asserted to be reduced. For many situations, this may well be the case. However, there are caveats. Many facts and the weightings given to them are context dependent. An objective lens for one person may seem biased or incomplete to another. Situational awareness implies something beyond the understanding of capabilities and dispositions; such as the locations of friendly, enemy and neutral ships in space and time and their course and speed. It implies at least some understanding, if not knowledge, of intent and suggests therefore some capacity for prediction or forecasting; of knowing with some degree of certainty what an adversary or a target of interest is likely to do, or may do, next. The facts of the situation, such as they are known, are provided by the Common Operating Picture, or COP.

Common Operating Picture (COP)

The COP is the sum of information about any given situation that is available to decision-makers. In its idealised form information from numerous sources and organisations is collected and fused into a coherent whole which is timely, accurate, and at a level of granularity relevant to any given user. The COP allows decision-makers to make decisions on the basis of shared, reliable and trustworthy information about environmental factors such as weather as well as the disposition of friendly forces or units on the one hand and competitors and adversaries on the other. The very logic of the COP can present problems to intelligence agencies that seek to protect sensitive sources and methods through formal compartmentation processes. The mantra of security before the 9/11 terrorist attacks in New York was the "need-to-know" principle. Post 9/11, a "need-to-share" principle came into vogue. The COP epitomises the "need-to-share" principle.

Sensitive operations, such as a clandestine or covert activities conducted by Special Forces or a police task force may not be accessible through the COP. In the interests of Operational Security (OPSEC) these activities may demand their own deception plans, to disguise the Indicators and Warnings (I&W) that planning and preparation for particular operations and activities can generate and that may be observed by a potential adversary.

The COP therefore, is best thought of as an approximation, or summary of activities in a designated area of operations. Routine activities are displayed and provide a basis for shared understanding which is adequate for many but not all purposes. An emerging difficulty is that sensitive operations performed on the basis of sensitive intelligence, sometimes for very specific purposes, are increasingly routine. A further complicating factor is that operational headquarters are increasingly multi-agency and multi-national in character. There is a constant tussle between the requirement to preserve secrecy in order to strengthen OPSEC, thereby protecting the identity and capacity of intelligence sources, and simultaneously the need to ensure coordination of activities between those who may be involved or who have a stake in the outcomes of particular operations.

A well-sourced and maintained COP can aid decision making especially where cross organisational coordination is needed to ensure that activities are at least de-conflicted and better still synchronised to achieve the best overall effect. The COP can also help to rule in or rule out obvious possible courses of action and provide a basis for an agreed approach, including assignment of responsibilities and resources. "Group think", as noted above, is a risk, but of a lesser order than the risk associated with agencies responding in an uncoordinated way to a given situation on the basis of less complete information that a COP can provide.

Technical Challenges for a Common Operating Picture

Numerous technical challenges confront those who would create a COP. Some of the most important are: data formats, time stamping, data storage and retention, data modification and symbology.

Data Formats

Different sensors often output data in different formats. Some formats are proprietorial whereas others are openly available. The COP processing engine must be capable of receiving and recognising data, irrespective of the format in which it is delivered, in order to add the information provided from that particular source to the overall picture.

Time

The time taken for data from different sources to be collected, transmitted and processed through the system before being available through the COP may vary. Collection systems may not always use a common time standard, such as that provided by the US Global Positioning System (GPS). More generally, the processing system must make decisions about how to describe or represent an unfolding event from information from disparate sources which may be arriving out of sequence or with different time tolerances – plus or minus milliseconds to plus or minus minutes or even hours, days or weeks in the case of intelligence from human sources. Determining which piece of information about a particular event is most accurate from a time perspective is not always a trivial matter. Data, within the COP ages, and, depending on the data source, at different rates. Some data of operational relevance is enduring, such as tide times and height predictions; some, such as a weather forecast, has currency for some hours; and other data, such as an aircraft track may be current for a few minutes or less. The COP needs to account for the data aging process to present decision-makers with the most accurate representation of the situation of interest or concern.

Determining which piece of information about a particular event is most accurate from a time perspective is not always a trivial matter.

Resolution

Different sensors view targets at different intervals and with different levels of fidelity. An example of radars that are used to detect aircraft makes the point. A high frequency sky-wave system such as Jindalee-Over-the-horizon Radar Network (JORN) might place the aircraft in a "box" in space and time that is a kilometre wide, several kilometres long and some thousands of feet deep. The presence and position of the aircraft might be checked once every 10 seconds. In contrast a microwave surveillance radar might place the same target in a box measured in metres and might update that information at intervals well less than a second. Sophisticated processing algorithms are needed to ensure that the data from these disparate systems is correlated to ensure that the tracks being developed in both systems are linked to signify that, in this example, there is only one aircraft that is being observed simultaneously by two systems and not two aircraft.

Data storage, retention and modification

Data from individual sensors is increasing substantially in volume. Communications networks, storage devices and processing systems need to be capable of handling this traffic. System owners need to make policy decisions about how much data to store, whether to store it on or off-line, and when to simply drop data because its value is considered to be limited. Each of these decisions has cost implications. They also impact on the COP and its utility for some, if not all users. An example of the issue is where tracks from separate sensors of the same object, say an aircraft, are combined into one track that is displayed on the COP. Who accepts responsibility for the track that is developed in the COP processing engine from the combination of the original data from contributing sensors? How accurate is that track and how are confidence levels assigned? What happens to the data from the original tracks? Where should that be stored for post event analysis and system performance reviews, for example? How these and numerous related questions are answered has a fundamental impact on the content and reliability of the COP and its ultimate utility as a tool for decision-makers. Such decisions also affect the design of the overall system and its establishment and running costs.

Symbology

At the end of the day, operators and decision-makers watch displays which are representations of reality drawn from data provided from numerous, disparate inputs. This is the COP. To the extent that operators believe, largely on the basis of experience, that the COP is a fair representation of reality, decisions are likely to be made on the basis of the information displayed. Over many years, conventions and standards have been developed as to how physical and human features should be represented on paper maps and charts. They are fixed and constant. Contours, roads, rivers and other features are readily understood. Digital representations provide operators some flexibility in how they choose to represent reality in ways that work best for them. Some displays allow operators to tailor colours and symbols which may assist sense-making at the individual level but which can cause confusion at the group level because the meanings and weightings that different people assign to different symbols and colours can vary markedly. As more agencies work more closely together on the basis of shared information that is represented to the broad community through a single COP, an important task will be to ensure that symbols on the display have shared meanings. There are technical, procedural and cultural dimensions to achieving such alignment.

A further risk, in this context, is the impact of cyber attack. Such an attack may do nothing more that move the symbols around on COP displays by small amounts – enough to plant doubt in the minds of operators and decision-makers. Such subtle disturbances may be more effective and difficult to overcome than an attack that shuts the system down completely. In the former case ambiguity can lead to uncertainty, indecision and delay. In the latter case, there is no question about the state of the COP and the need to gain situational awareness through alternative means immediately.

Privacy and Security Protections

Information gathered in the quest for MDA may be subject to privacy laws and security constraints. These restrictions may prevent further dissemination of data from the collection agency to other organisations, including user and analytical agencies that are responsible for maintaining the COP. Legislation and policy must be carefully coordinated and balanced to ensure that individual privacy on the one hand and sources and methods of collection on the other, are carefully protected without compromising the value and the effectiveness of the COP.

Ontology

The technical processes described in the previous paragraphs fit within a broader construct sometimes referred to as an "ontology". Simply put an ontology seeks to make explicit the assumptions, tacit understandings and biases made by humans that sit underneath any given model or construction of reality. An ontological approach tries to capture the essence of any given system in such a way that flaws or inadequacies might be exposed and at least taken into account if not rectified. In doing so, the prospect exists for involved agencies and individuals, to achieve common understandings about their aims, objectives and priorities as well as their tolerance for risk.

These high level understandings, if achieved, allow for a high degree of collaboration and coordination between organisations and agencies that contribute to the COP.

Related Concepts and Terms

There is a number of related terms and concepts which are important in any discussion about situational awareness. Three of the most important are Intelligence, Surveillance and Reconnaissance. These are often lumped together and given the shorthand acronym of "ISR". Each of these words points to different approaches to information gathering which traditionally have been conducted by different agencies with different cultures for quite different purposes.

There remain important policy, institutional and legal impediments that work against the achievement of optimal outcomes in terms of information sharing for common purposes.

These distinctions are blurring. Sensors and the platforms on which they are mounted are increasingly flexible and multi-modal, capable of performing, for example surveillance and reconnaissance tasks simultaneously. So called "big data" approaches to information processing increasingly permit data from many sources to be compared and for meaning to be extracted from the aggregation of tiny scraps of information that, uncorrelated, are innocuous. However, there remain important policy, institutional and legal impediments that work against the achievement of optimal outcomes in terms of information sharing for common purposes.

Intelligence fundamentally is about obtaining secret information secretly – entity A finding out something that entity B does not want entity A to know without entity B knowing for certain that entity A knows. Intelligence gathering is a deliberate process. In a perfect world intelligence agencies are provided with a range of collection requirements and a set of resources (including people, money, computers, sensors and other infrastructure) by their tasking and control authorities. The agencies match resources to tasks in an ordered fashion. Specific information about sources and methods of intelligence gathering are closely protected in an effort to allow them to remain as effective as possible for as long as possible. Once a source is compromised counter-measures can be swiftly applied and the collection agencies are faced with the task of finding other ways to regain access, if that is possible at all, to the same material in future as they has access to in the past.

Surveillance is the routine observation of activity surrounding any given observer or platform going about his/her/its normal business. The principal product of surveillance is the establishment of normalcy states and patterns against which unusual events or variations from the norm stand out. This might be an unusual weather event or biological phenomenon (eg. certain fish being caught in areas where they had not previously been seen), or an unusual exchange of people and goods at sea, or an unscheduled military exercise involving an unusual combination of ships, aircraft and other forces. Such events may lead to an immediate response or to more information being sought about the unusual event itself.

The key attribute of any surveillance system is persistence. The system must be able to observe the area of interest over a sufficient length of time to build an understanding of normal behaviour which takes account of cyclical, seasonal and other variations which occur in predictable and repeatable ways. Exceptions or variations to the norm become apparent and allow the possibility for further, more detailed, investigation, through reconnaissance and intelligence gathering.

Reconnaissance is the targeted response to an alert that has been generated within the wider information or sense-making system of an organisation. Something "doesn't look right", or seems not to be consistent with normal behaviour or is pointed to by a snippet in an intelligence report which may be inconclusive in itself but raises an alert that warrants further deliberate information gathering by some form of direct observation.

Historically, ISR activities generally and intelligence operations specifically, have been viewed as support functions to operations, be they military or law enforcement in nature. Technological change is now drawing these functions into the heart of operations, defined broadly as consciously planned and directed responses to the environment and to unfolding events. This raises further challenges especially for those agencies with strategic assessment functions which need and value time for reflection and sense-making, usually from a longer term perspective often measured in decades.

Several other concepts merit explanation. They are additional factors that tasking and response agencies need to consider when planning and conducting operations. All are relevant to capability developers and operational planners in all aspects of military, law enforcement and border protection operations.

Layered Approach is a phrase that captures the idea that there is no silver bullet in the world of ISR. Data from multiple sensors on multiple platforms, operating in different spectral bands is collected and collated. Such an approach builds resilience into the system and, perhaps more importantly, allows for much greater confidence to be assigned to the specific nature of observed events because they are seen from more than one perspective or through more than one lens. There is an important proviso, namely that the "dots are joined" or more formally, that the data is fused. When the data from space-based sensors, sensors mounted on aircraft and ship and land-based sensors are combined, in principle, ambiguity is reduced and the risk of misidentification of an object, such as a ship of a particular type, is reduced.

There is an important proviso, namely that the "dots are joined" or more formally, that the data is fused.

Indicators and Warnings (I&W) are observable and observed precursor actions or events, which are insignificant in themselves and which experience suggests, may or do precede a particular action or event of significance. Sometimes potential adversaries and competitors seek to gain tactical and even strategic advantage by disguising their intent. They may, for example, conceal these precursor activities in order to achieve surprise. This is the art of deception which may be reinforced by deliberate counter-surveillance activities. Sometimes the cessation or absence of some routine activity or event is the clue that a competitor or adversary may be about to stage a significant event aimed at delivering tactical, operational or strategic advantage.

Operational Security (OPSEC) is a term that applies to efforts made by business owners, military commanders and heads of a criminal gangs, to name three examples, to prevent a competitor or adversary from observing I&W which may point to the intent, extent and timing of a particular activity. This may be a hostile takeover bid of a rival company, a surprise attack on an enemy position or plans to import a large quantity of drugs.

Counter Intelligence is a key defensive discipline of intelligence. As the term implies, counter intelligence activities are efforts taken by entity A to detect, deter and defeat efforts by adversaries or competitors to collect intelligence about A. The Australian Security Intelligence Organisation (ASIO) has prime responsibility for counter intelligence in Australia. Most nations implement a range of security measures to deter intelligence gathering against them. Physical security measures include locks, bolts, bars, alarms and other intrusion detection devices. Personnel security measures include vetting of employees who have access to classified information. Information security measures include carefully established and documented procedures for creating, storing and transmitting classified information including hard copy and soft copy documents and records and information that might be transferred from person to person verbally. Counter intelligence officers seek to understand when the integrity of these barriers is threatened, or compromised, by whom and for what purpose.

Presence is an adjunct concept to situational awareness. Presence is the visible manifestation of ownership or stewardship. The presence of an Australian Navy ship or a Customs patrol aircraft for example, serves to remind those who see the ship or the plane that the Australian Government values its sovereign territory and adjunct seas. Presence operations can be used to reinforce to domestic audiences, as well as to others, that the integrity of Australia's sovereign territories matters and is to be respected. This leads to the related concept of deterrence.

Deterrence is about persuading an actor not do something for fear of the consequences. The actor must believe that if he or she persists with a particular course of action the party that may be harmed has the means and the will to take retaliatory action and is likely to do so. Further, such retaliatory action will inflict an unacceptable level of harm on the actor seeking to cause the harm. Presence activities, such as Australian surveillance flights near foreign fishing vessels serve to remind the masters of those vessels of their licensing, reporting and other obligations to the Australian Government if they wish to fish lawfully in Australian waters. The further message is that breaches may well be discovered and prosecuted, leading to unacceptable losses by the fishing vessel owner s and operators.

The point to take away from this section of the paper is that any system that seeks to bring information together from disparate sources to present a model of reality, a COP in short, that is trusted, valued and used by decision-makers, is inherently complex. The next section of this paper describes Australia's maritime geography and the challenges it presents to policy makers and response agencies.

AUSTRALIA'S MARITIME DOMAINS

Geography and Population

By virtue of geography, territorial claims and international legal obligations Australia has responsibilities for understanding and maintaining as generally secure roughly 10% of the Earth's seas and oceans not just in its own interests but on behalf of the international community as a whole.

Big Numbers

Australia, by land area, is the world's sixth largest country and the core maritime domain, that area for which Australia has some formal level of responsibility and accountability, is considerably larger than the continent itself. The numbers which relate to geography are large:

- The coastline of the Australian mainland is in the order of 36,000km.
- Beyond the mainland are thousands of islands, atolls and other features which generate their own coastlines which sum to almost 24,000km.
- The Exclusive Economic Zone generated by Australia and its offshore territories, including the Australian Antarctic Territory, is more than 10 million square kilometres, one of the largest in the world.
- The area for with Australia has maritime search and rescue (MARSAR), responsibilities under the Safety of Life at Sea Convention (SOLAS) is considerably larger again.

But Australia's interests do not stop at these boundaries which have been agreed by treaties and other instruments of international law. Australia's national security interests extend well beyond these limits to the western and northern extremities of the Indian Ocean, to the Persian Gulf, to the South Pacific, to the archipelago to the north and beyond to the South China Sea and into the Western Pacific as well.

99% by volume and more than 80% by value of all goods which enter or leave Australia do so by ship. The Australian economy is fundamentally dependent on the sea lines of communication remaining open and safe.

There is simply no way that Australia can or even should develop and maintain comprehensive situational awareness of all of these areas on its own account and from its own resources. Information sharing with regional neighbours and allies is an essential ingredient to Australia's approach to MDA.

The Australian economy is fundamentally dependent on the sea lines of communication remaining open and safe.

Geography also helps. Although the total areas of interest to Australia are vast, there are natural points of focus and attention. In the maritime context these are typically the straits or narrows through which ships must pass if they are to collect and deliver cargoes and move from one ocean to the next. To Australia's north the Malacca, Sunda, Lombok and Makasar Straits are vital links in the sea lines of communication that connect the nations of north Asia to the oil producing nations of the Middle East and to Australia's minerals exporting ports as well. Australia has an abiding national interest in ensuring that these straits remain open and accessible in the interests of the nation's economic and broader national security.

Small Numbers

In contrast to the large numbers that arise from Australia's geography there are also some small ones. Australia's population is 23 million (about 0.3% of the world's population). The correspondingly small tax base, and the competing demands especially from the health, education and welfare sectors, limits options and forces choices about what to monitor and measure and, when necessary, how to respond. Australia's population has doubled in the past 50 years and is expected to double again by 2050. Although Australia has the 14th largest economy in the world this represents only 2.2% of global GDP. Australia's domestic market is tiny in global terms which presents particular challenges for capital intensive manufacturing industries which must look to export markets to succeed.

The logic of markets in an increasingly globalised world also presents challenges to governments when they try to articulate what the nation needs in its intellectual and industrial base for the principle of self-reliance to have meaning. A succession of governments, through defence white papers and other reports, have struggled to define what self-reliance means and what areas of industry deserve explicit support in the direct interests of Australia's national security. Such attempts as have been made, through the stated Priority Industry Capabilities (PICs) and Strategic Industry Capabilities (SICs), in successive Defence White Papers have had only limited impact in retaining, let alone developing, skills in these defined areas – most of which have direct relevance to the understanding and protection of Australia's maritime domains.

The amount of money that Australian governments invest on all aspects of understanding, managing and securing the maritime environment is difficult to gauge but a ball park figure is in the order of $15-20 billion annually. The Royal Australian Navy (RAN) is allocated most of these funds. The RAN is presently undergoing a major re-equipment program which will see a heavier and more capable fleet in service by 2030. The Royal Australian Air Force (RAAF) conducts long range maritime patrols using AP3-C Orion aircraft and operates the Jindalee Over-the-Horizon Radar Network (JORN) which monitors Australia's northern approaches especially for movements of aircraft and ships. The RAAF is set to acquire the Boeing P-8A long range maritime patrol aircraft to replace the Orions by 2020 and also a fleet of Northrop Grumman MQ-4C Triton High Altitude Long Endurance (HALE) Unmanned Aerial Vehicles (UAV). Several other Commonwealth and State departments and agencies, some with penny-packet budgets, attempt to fulfil a daunting set of requirements. The most important of these agencies is the Australian Customs and Border Protection Service (ACPBS) which is responsible for coordinating and executing responses to non-military threats to Australia's borders. The ACBPS has a small number of dedicated patrol vessels and contracts a private company to conduct airborne patrols using a fleet of capable Dash-8 aircraft.

Information from these and other sources is collected and collated in various military and civilian command and control centres. The situational awareness derived provides the basis for tasking of ships, aircraft, radars, satellites, intelligence agencies, and liaison staff based in foreign capitals. Given the magnitude and complexity of the task, that the system works so well is something for which this nation can be proud.

Maritime Geography

The seas and oceans that surround the Australian continent as well as those that are more remote but still of vital interest are amazingly diverse. At one extreme are the small coral outcrops, tropical islands and warm and usually calm seas of the Torres Strait and Great Barrier Reef. At the other are the cold and often mountainous seas of the Southern Ocean that lie between the Australian mainland and the Australian Antarctic Territory (AAT). There are rich fishing grounds and areas where marine life is scarce. There are shallow waters on the continental shelf and through the archipelago to Australia's north and there are exceptionally deep waters beyond the continental shelf in the Pacific, Indian and Southern Oceans.

These very different environments present enormous challenges to marine architects and capability developers because of the complex cost/capability trade-offs and compromises that need to be made when decisions about new ships are being made. There is also the question of distance and endurance. The larger ships and submarines of the RAN must be capable of operating independently for extended periods, including in waters well to Australia's north. Small patrol craft, including those operated by the ACBPS, must still be capable of operating quite some distance from their home ports as has been demonstrated over the past decade in response to the challenge presented to Australian authorities by people smugglers and asylum seekers.

THREATS

The prime responsibility of the Australian Defence Force (ADF) is to counter existential threats to the nation as and when they emerge. These have been conceived in the past as direct threats by other nations, Japan in World War 2 being the most obvious and recent example. The prospect of conventional warfare, meaning the use of kinetic effects (as some say 'heat, blast and frag.') in a planned and deliberate way between nation states remains the most demanding and enduring security concern of any government and the Australian Government is no exception. This possibility drives major decisions about the force structure, disposition, readiness and sustainability of the ADF.

These very different environments present enormous challenges to marine architects and capability developers because of the complex cost/capability trade-offs and compromises that need to be made when decisions about new ships are being made.

The likelihood of a direct attack by a foreign power against Australia in the foreseeable future is remote, although several nations in north Asia do possess missiles with the range to attack targets in Australia. More likely scenarios involve the deployment of Australian forces in Coalition operations away from Australia in efforts to strengthen the overall security of a particular region or nation.

Direct threats to Australia are likely to come through a range of criminal activities some of which may be State-sanctioned, if not State sponsored. These may include attacks on information and the information infrastructure (cyber attacks) which might also damage the physical critical infrastructure (power grids, water and sewerage, transportation systems, etc). Large scale money-laundering operations can also be imagined. These could be expected to have a measurable negative effect on the domestic economy and second and third order impacts which call into question Australia's reliability as a trading partner and as a safe place in which to invest. The customary bifurcation between state and non-state actors is becoming more difficult to discern which is already presenting challenges to governments as they seek to understand whether a predominantly military or a policing response is called for in any given circumstance.

Principal responsibility for civil border protection in Australia rests with the ACBPS which has a well-established taxonomy of threats that are described by the following headings:

- Illegal exploitation of natural resources
- Illegal activities in protected areas
- Unauthorised maritime arrivals
- Prohibited imports and exports
- Piracy, robbery or violence at sea
- Maritime terrorism
- Compromise to bio-security and
- Marine pollution.

These threats are enduring. In coming decades, however, they are likely to become increasingly connected and entwined and those with malfeasant intent are likely to exploit the dislocation and vulnerability caused by changing natural, political, economic and social environments. Nations and organisations that seek to act unlawfully enjoy a degree of flexibility and agility that is denied to governments that operate within the rules of domestic and international law. Networking technologies are as generally available to wrongdoers as they are to the law-abiding. This presents law enforcement agencies with a range of unprecedented challenges, not the least of which is how to balance the legitimate interests of the State to protect itself and its citizens with rights of individual liberty and privacy.

Some broad comments, looking to 2030, about each of the eight threat vectors listed above follow.

Compromise to Bio-Security

The most serious and enduring threat is a substantial breach of the quarantine barrier leading to a pandemic in the Australian population, which may cause many deaths and enormous social and economic dislocation. Public health officials continuously scan the progress of diseases in other countries, such as Asian bird flu. They seek to understand the pathology of the disease, how it spreads (animal to animal, animal to people, people to people) and how it may be countered (vaccine, travel restrictions, quarantine for infected people, etc).

The introduction of exotic plant or animal disease could be expected to cause a great deal of harm to affected sectors of primary industry regionally and, possibly, nationally. There would almost certainly be consequences for exports and, more broadly, across the economy.

Presently the Department of Agriculture has policy and front line responsibility to identify specific bio-security threats and to take the steps necessary to negate them. People are more likely to bring disease into Australia than are animals, so, looking ahead, this may be more a problem for border protection authorities at Australia's airports than for those protecting the maritime borders.

With respect to goods of animal and plant origin, Australian quarantine authorities are using increasingly sophisticated analytical tools to determine which ships and shipments demand close inspection. The inspection process can be slow and time-consuming especially if small objects, such as insect larvae, are being looked for.

Looking towards 2030 the likelihood of a major compromise to Australia's bio security will increase, to a point approaching certainty. This is a function of the increased numbers of people (especially), animals, plants and products (such as timber) that will cross the border.

Unauthorised Maritime Arrivals (Asylum Seekers)

For the past decade the question of Unauthorised Maritime Arrivals has been politically divisive and damaging to governments and to Australia's international reputation as well. In recent years an overwhelming proportion of the surveillance and response assets available to the ACBPS have been employed on this single border protection task in the Christmas Island to Darwin corridor, leaving many other tasks undone or underdone. The political imperative to be seen to be managing the flow of people seeking entry to Australia via small boats, has taken precedence, in terms of the allocation of scarce response assets, over the countering of other threats. This has been a question of relative priorities. Governments have accepted an additional level of risk from border security threats becoming manifest at Australia's ports and airports and around Australia's southern coastline in order to deal with the persistent flow of people who have sought to enter Australia via boats in the north-west.

Nations and organisations that seek to act unlawfully enjoy a degree of flexibility and agility that is denied to governments that operate within the rules of domestic and international law.

Most people who are in Australia illegally arrive by air as legitimate visitors and overstay their visas. They are not the focus of political controversy which is reserved for those would-be immigrants who pay criminals to bring them to Australia by boat. Typically these boats leave fishing villages in Java and often they set a direct course for Christmas Island, some 200nm to the south. The ACBPS sometimes, but not always, receives advance notice that a boat is on its way. The *modus operandi* of many boats is to reach Australian territorial waters at Christmas Island and then to announce their presence and seek assistance.

Today there are 30-40 million people in the world who have been displaced by war, famine, and racial and religious persecution; they are all searching for a safe and secure home. Looking towards 2030 Australia is likely to remain a destination for more, possibly many more, asylum seekers than is the case today. The 'push' factors, some of which are listed below, are not going to go away any time soon. Indeed they are likely to amplify.

- continued overall growth in global population – from seven billion today to more than 10 billion by the turn of this century;
- continued growth of cities;
- chronic unemployment and under employment, especially of young men, in the Middle East, Africa, Latin America and parts of Asia;
- increased pressure on food and water supplies, especially in the poor neighbourhoods of cities and drought prone areas;
- the impacts of global warming (however caused) – sea level rise, more frequent and extreme weather events;
- increased pressure on energy supplies, notably oil and gas, until substitute fuels are found; and
- continued persecution of religious and ethnic minorities.

Aid programs that attack the root causes of these fundamental challenges faced by humanity may help, but Australia's contributions, by definition, will be small and of marginal influence. Concerted action by many nations working closely together will be needed if the numbers of displaced people are to be brought within manageable bounds.

Meanwhile, the Australian MDA system must be capable of anticipating peaks and troughs in asylum seeker flows in order to manage limited response capabilities as effectively as possible.

Almost certainly not all who seek asylum in Australia have genuine or sustainable claims. There is also a clear risk that some purported asylum seekers have links to terrorist organisations and criminal syndicates. They are not people this country would seek to welcome as new citizens. A rigorous clearance and vetting regime, therefore, makes sense. These processes can be time-consuming and costly and delay can lead to medical and psychological problems for some asylum seekers whilst their cases are being investigated.

Prohibited Imports and Exports

The importation and export of prohibited goods is probably the threat to Australia's border that most frequently occurs. Criminal activity, from very well-funded and planned activities to those that are opportunistic and 'one-off', provides a threat vector which is persistent, diverse and increasingly difficult to counter. Narcotics and precursor chemicals for drug manufacture are of obvious concern. So too are weapons, endangered and exotic animal and plant species, pornography and other materials subject to censorship laws. Intelligence and effective liaison with counterpart agencies well ahead and behind the border is essential to counter these threats.

Looking towards 2030 the incidence of the import and export of prohibited goods is certain to rise as a function of: the anticipated increase in the numbers of people entering and leaving Australia and the range and volume of goods being exported and imported in an increasingly global market with global supply chains.

Organised crime syndicates are expected to be deeply involved in these activities. The ACBPS understands this only too well and also understands the enormous advantage gained by any syndicate that can call on the help of trusted 'insiders'. To this end, the ACBPS has initiated a major internal reform program that aims to weed out corrupt officers and to instil a culture, backed by review and investigation processes, which places exceptionally high value on individual and corporate integrity. This shift in emphasis and culture is consistent with the ACBPS moving from a passive compliance checking to an active policing mindset.

So-called "big data" analytics may well provide pointers to malfeasant behaviour that presently goes undetected. Increasingly sensitive and reliable surveillance and electronic inspection technologies at points of entry and departure will be further elements in a layered system that is increasingly integrated and hard to beat. The point of this system will be twofold; to detect and prosecute illicit importation and export activities and to force those with malfeasant intent to turn their attention from Australia to 'softer' markets elsewhere.

Illegal Exploitation of Natural Resources

Illegal fishing is the most important threat within this broader category. In recent years, there has been a noticeable decline in the detection and apprehension of foreign fishing vessels (FFV) fishing illegally in Australian waters. A combination of factors would seem to be at work; better navigation systems which allow FFV to not stray unintentionally into Australian waters, better air and sea surveillance and, in some places, less fish. Organisations involved in illegal fishing may also have very good intelligence about Australian fisheries enforcement activities, allowing incursions to be carefully timed to avoid being caught. Fisheries authorities are concerned that as fish stocks dwindle in less well-managed fisheries FFV may be tempted to make systematic incursions into Australian fisheries, which are among the best managed in the world.

Looking towards 2030 the nexus between organised criminal activities, fishing, legal and illegal, and the smuggling of goods is almost certain to strengthen. There is already evidence of such activities including licensed boats that under-report their catches and transfer the surplus to waiting support vessels. Other licensed boats have been known to dock at Australian ports to replenish fuel and supplies and have tried to use these activities as cover for smuggling operations. Others have rendezvoused at sea with vessels that are used to transfer contraband across the customs barrier.

Future similar operations will be well-planned, well-resourced and well-executed. Multi-source intelligence, careful analysis of financial transactions, and close inter-agency cooperation will be essential if these types of activities are to be thwarted.

Illegal Activities in Protected Places and Marine Pollution

These threats have the potential to harm the marine environment, notably those areas which have been designated as marine parks and which are deemed to have conservation or other values that merit special protection. The Great Barrier Reef is one obvious area, of world heritage value, where conscious efforts are made to minimise damage to the ecosystem caused by human activity.

Looking towards 2030 pressure will build on all of Australia's marine reserves from commercial and leisure activities as well as from broader environmental changes. Emerging surveillance technologies that use inexpensive networked sensors should assist regulatory authorities to gain a more comprehensive and timely understanding of the state of the marine reserves as well as human activity that occurs in them.

The importation and export of prohibited goods is probably the threat to Australia's border that most frequently occurs.

In the next two decades, shipping will be progressively more closely monitored. Technologies such as the Automatic Identification System (AIS) will record and track the movements of ships globally, and anomalies in course and speed will be readily detected and capable of further investigation. Ships that seek to avoid or confuse AIS systems by not disclosing their presence will stand out as non-cooperative targets and immediately arouse suspicion. Such systems will need to be tightly integrated into the information systems already in use by the ACBPS to reach their full potential.

Piracy, Robbery or Violence at Sea

These threats have not yet manifested themselves in, or close to, Australian waters. However, piracy globally is increasing and has the potential to disrupt imports to, and exports from, Australia. RAN ships have been involved in anti-piracy operations off the Horn of Africa and in the Gulf of Aden. Australia is cooperating with regional nations to ensure that piracy and associated threats are kept as far from Australian waters as possible and that these activities are not allowed to disrupt sea commerce through the critical straits to Australia's north.

Looking towards 2030 piracy is likely to remain an active threat, especially in the western Indian Ocean. Some ships that sail to and from Australia could be at risk of being overtaken by pirates. There is every possibility that pirates will become better organised and resourced possibly through links with organised crime syndicates.

Maritime Terrorism

Since 9/11 Australia has devoted considerable attention to understanding the terrorist threat to Australia and to developing robust counter-terrorism plans, capabilities and coordination arrangements between agencies and jurisdictions. Several plots by Australian citizens and residents have been foiled and the would-be terrorists brought to trial. There is no evidence on the public record of terrorists planning to commit acts of maritime terrorism against Australian ships, foreign ships serving Australian ports, the ports themselves or their approaches. A particular and growing concern is the vulnerability to terrorist attack of the gas platforms off north-western Australia. These structures are large, difficult to reach and more resilient that might seem to be the case at a cursory glance. Although the planning of such attacks might proceed in secret, almost certainly there would be indicators and warnings of the proposed attacks, especially if carried out by an organised group. Well-integrated counter intelligence, security intelligence and law enforcement organisations, providing they have the systems and legal authority to 'join the dots' and share what they know, would permit counter actions to be planned and taken.

Of possibly greater concern, certainly from a public perception and confidence perspective, is the prospect of a successful attack on a cruise ship in an Australian port or with embarked Australian passengers. Relevant authorities are alert to this possibility and invest effort to ensure that such an event does not occur.

The ACBPS is aware of the magnitude of that task that the threat vectors above present. Its approach is summed up by the phrase "intelligence led and risk based" If there is one common thread, it is money. At some point, money, to be of long term use, must enter the legitimate finance system and here, with increasingly sophisticated data analytics, is where it can be identified and tracked.

Of possibly greater concern, certainly from a public perception and confidence perspective, is the prospect of a successful attack on a cruise ship in an Australian port or with embarked Australian passengers.

In May 2014, the Commonwealth announced the formation of a single frontline operational border protection agency from 1 July 2015. The new agency, to be known as the Australian Border Force (ABF) will be established within a single Department of Immigration and Border Protection that combines the functions currently performed by the Department that already has that name with the ACBPS. The Australian Border Force will draw together the operational border, investigations, compliance, detention and enforcement functions of the two existing agencies. Whether Department of Agriculture officials who are responsible for quarantine matters will be rolled into the ABF is yet to be determined.

The COP must account for all of these threats. The information to hand is used to determine levels and locations of response activities by the civil and defence capabilities that Australia commits to border protection and to maritime security more generally. Where connections can be made between threats such as the identification of an organisation that is financing people and drug smuggling activities and possibly illegal fishing as well, the possibility exists to negate or remove such nodes. The help of other governments is often needed for these sorts of activities to be carried out.

DRIVERS OF THE AUSTRALIAN MDA SYSTEM

A number of drivers or vectors have been identified that have major impact on the structure and size of Australia's maritime domain awareness system. These are not altogether mutually compatible or consistent and judgement is needed to reconcile conflicting interests and values sufficiently to allow for wise decisions to be made about current operational priorities and future capability investments. The drivers identified by this study, in no priority or other particular order are:

- *Climate change* - the impacts of climate change and increasing understanding of the rate at which climate is changing and the impact of those changes on oceans, coasts, including cities, and marine life;
- *The US Alliance* – how the alliance might alter in form and substance in the next 20 – 30 years to reflect the rise of China and India on the one hand and the need for fiscal restraint on the other;
- *Fiscal realities* - the desire of Government to reduce costs across the board, including those associated with the governance of Australia's maritime domains and its broader maritime interests;
- *Organisational imperatives* - for institutions, including the single Services acting in their own interests, the ADF acting as a whole, Commonwealth departments and agencies and the intelligence community to remain relevant and adequately-resourced;
- *The States and Territories* - their rights, responsibilities and interests, especially those of Queensland (coal exports, the Great Barrier Reef and the proximity of New Guinea) and Western Australia (energy and mineral exports);

- *The "global commons"* - and Australia's obligations and responsibilities as a good international citizen;
- *Cross border flows* - the economic, political, social and bio-security impacts of predicted increases in all cross border flows - including people, animals, plants, money, goods and information in a globalised and networked world;
- *Non-State and transnational actors* – the influence and impact of organised criminal groups, terrorist and other extremist organisations; and
- *Technological Change* – as complex networked systems, including complex networked threats, that are software-defined and data driven, become the defining context for human cognition and action instead of the platform-based systems of the past.

To the extent that these drivers can be prioritised, reconciled and arbitrated, the prospect exists for a national maritime domain awareness strategy and associated narrative to emerge that is compelling, sustainable and defensible. It must embrace more than military interests and capabilities. It must pull together all of the strengths of the Australian nation as they apply to its maritime domains and interests and encapsulate what Australia seeks to do and be known for doing with regard to the governance of those domains.

A clear consensus of the panels which informed this Kokoda paper was that incremental investments and adjustments are unlikely to meet the information requirements of decision makers in the future. Demands of timeliness and fidelity (accuracy and level of detail) will be in tension with inevitable and growing cost constraints. Adoption of new technologies may mitigate but not entirely resolve this tension. A 'more of the same' approach will not deliver the situational awareness that Ministers, senior officials and frontline staff will consider necessary and sufficient for Australia to govern its maritime domains as an essential element of national strategy.

When presented with this dilemma authors of papers such as this are often tempted to call for an organisational, whole-of government response, usually led by the Prime Minister and his department. Such calls have behind them an assumption that the constitutional, legislative and institutional arrangements which define political and bureaucratic power in Australia are quite flexible and that they can accommodate such an approach. Ministers, however, worry about whole-government approaches because they present the possibility of loss of power and influence by particular portfolios and, worse, they can lead to money being diverted from the departmental appropriation to the whole of government scheme over which Ministers and their departments have reduced influence. From an outsider's perspective what may seem a rational and cost-effective way of making the best of new technologies can be seen as a threat from the Ministerial and portfolio perspective.

Australia, like every other nation on Earth, is struggling to come to terms with the implications of the internet and its associated technologies. These uncertainties and risks, however, seem not to have affected it ready and wide embrace. The internet provides means for routine and profound cooperation and collaboration across organisational, jurisdictional and sovereign boundaries. How this can be achieved within the fixed framework of a federal system and departments of state that are strongly entrenched and enmeshed in the public policy framework is less obvious.

Perhaps a longer term approach will be necessary which places higher value on Ministers and public officials possessing and being rewarded for the way in which they apply such skills as team building, team work and collaboration than has been so in the past. How well Ministers and officials work across rather than within organisational and other boundaries may become a differentiator for promotion, for example. Such attitudinal and behavioural shifts are hard to effect, take time and, although possibly driven centrally, can be implemented within organisations that already exist.

A maritime domain awareness system, as described in the following chapter, is only possible because of the internet and related technologies that allow for data from many sources to be brought to bear on any given situation. The strength of the MDA system is directly proportional to the extent to which boundaries that were set and might have made sense in the 19th and 20th centuries can be negotiated to allow best advantage to be taken of information that is shared, valued and used in ways not possible in the past.

In the maritime domain, as in all complex areas of public policy, there are no simple answers and there is no clean sheet of paper start. There are strong vested institutional, legal, economic, commercial and other interests that have a clear view of what they do, for whom, at what price and with whom they will and will not, may and may not cooperate. The concept of maritime domain awareness challenges the hierarchical information flows of these arrangements and encourages the development of mechanisms and behaviours which reward data sharing and the integration of information from disparate sources into common operating pictures and reference frameworks. For some organisations and the individuals in them, this behaviour is counter-intuitive and change has been resisted and has been slow.

Supercomputers are allowing humans to understand and visualise the Earth's seas and oceans as a complex system of systems in which subtle links and influences, not previously amenable to observation, can now be analysed and interpreted. This applies to physical structures such as the seabed, to ocean chemistry and interactions with the atmosphere, to the biology of plants and animals that live in the seas and to human activities as well. All actors with oversight or regulatory responsibility in the maritime domain must look beyond their immediate concerns and responsibilities if they are to really appreciate the point and impact of the work they do on the broader system.

Australia has basically looked to our major alliance partner to bear the strategic weight of the relationship which, in the case of the United States, is the implied nuclear guarantee.

Distance, isolation and alliance relationships with the dominant naval power of the time (Britain from the arrival of the First Fleet in 1788 to World War 2, and the United States since then) have led a succession of Australian governments to adopt a reactive and, until quite recently, poorly coordinated approach to sustained investments in the nation's ability to understand, protect and promote its vital maritime interests. Australia has basically looked to our major alliance partner to bear the strategic weight of the relationship which, in the case of the United States, is the implied nuclear guarantee. Australia's contribution has been the provision of real estate (hosting of joint facilities such as the intelligence facility at Pine Gap near Alice Springs, Marines in Darwin for training purposes and soon, space surveillance systems at North West Cape) and the commitment of forces to conflict zones, such as Iraq and Afghanistan. These forces have tactical value and, possibly more importantly, are tangible expressions of commitment to the Alliance. They add legitimacy to American actions on the one hand and warfighting capacity (even if limited) on the other. A corollary is that Australia's options to exert influence in its own right through diplomacy, and force if needed, are correspondingly constrained.

Australian strategic and defence policy has long emphasised the importance of self-reliance which has implied a certain capacity for action independent of our major alliance partner. Whatever that term might have meant in the past, it seems either less relevant or in need of fundamental re-definition in an increasingly globalised and interdependent world. The 2015 Defence White paper presently being developed presents an opportunity for this aspect of policy to be re-visited and re-interpreted. To do so would be to make an important contribution to strategic debate and to Australia's perceptions of itself today and into the future. In the present context it should also provide insight into investments that Australia anticipates needing to make in MDA to meet future challenges in the maritime domain decisively.

Australia's interests, in the next 20-30 years, and especially in the so-called 'global commons', of which the oceans are but one example, may not intersect as neatly or as fully as they have with those of the United States since World War 2. This is not to say that the alliance relationship will not remain at the foundation of Australian strategic policy. It will. It is to say that the nature of this relationship, may need to be adjusted to mutual benefit. Events in the Crimea and continuing conflict in the Middle East may distract the US from committing the weight of effort to Asia that the re-balance promised. The US may well look to Australia to do more heavy-lifting than has been the case in the past and most of this is likely to be in the maritime domain.

Both Australia and the US may need to think again about the shape and extent of their relationship to take better account of their straightened financial circumstances in a region that is growing rapidly in economic terms and in which nations are becoming more wealthy, confident and assertive. Choices exist and how they are exercised may be expected to have profound impact on Australia's place in the region and the world for the next 30-50 years.

The world is moving beyond a decade in which national security affairs have been dominated by responses to terrorism in the aftermath of the 9/11 attacks on the World Trade Centre in New York. Osama Bin Laden is dead and the bulk of western forces, including Australians have withdrawn from Afghanistan. The world is slowly recovering from the 2008-09 Global Financial Crisis and the planet shows increasing signs of stress from global warming. These massive forces for change present an opportunity, indeed a responsibility, for Australia to develop a much deeper understanding of its place in the world as a sovereign nation and to contextualise its interests, especially in the maritime domains for which is has sovereign, legal and moral obligations. Capacity for decisive independent action in protection and advancement of Australia's maritime interests is a costly enterprise. New investments should only proceed on the basis of the clearest possible understanding of Australia's maritime domains and their effect on the security and well-being of the Australian nation.

A SYSTEM-OF SYSTEMS APPROACH TO SITUATIONAL AWARENESS

The purpose of any situational awareness system is to aid decision making. If the system is working properly decisions should be better informed and synchronised between agencies and organisations with shared, complementary or overlapping responsibilities. Decisions must also be timely.

Situational awareness systems are comprised of several elements

- A requirements setting system which, in an ideal model, is based on a clear understanding of what decision makers want to know;
- A tasking system which translates requirements into the tasking of collection assets;
- A collection system which gathers the data that has been sought and passes the data to a processing system;
- A data processing, analysis and evaluation system which seeks to provide answers to the requirements that led to the tasking in the first place;
- An information dissemination system which passes processed information to users or which allows users to interrogate data bases themselves to search for answers or amplifications to questions of particular importance;.
- A record keeping and storage system and
- A security system that serves as a system boundary.

Figure 1. Elements of a Situational Awareness System

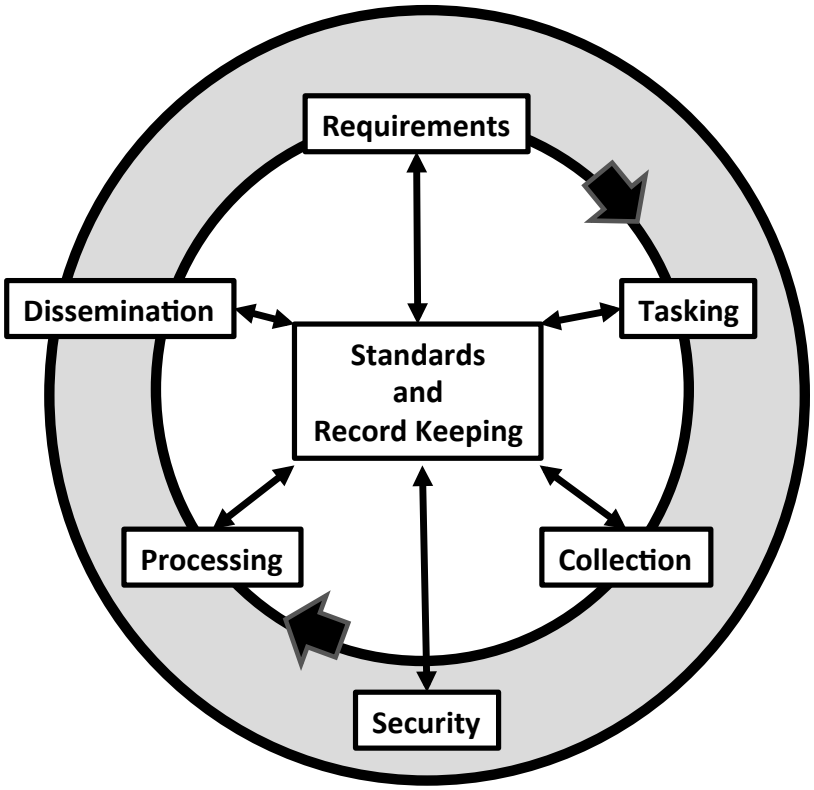

Figure 1 captures the essence of the system. Like all models, it is a simplification of the real world. Although the cycle would, in a perfect world, start with the requirements setting and tasking authority, it can begin at any point. Also the arrows suggest a continuous, sequential process. This is not always how things actually work. For example, the collection system may bring to light information about unexpected activities that had not been predicted or sought by the tasking authority. Or an analyst, trawling through records, may discover a pattern that leads to a new interpretation about a series of events that warrants further examination of both old records and through new collection. More formally, there are feedback loops between each element of the system that can short circuit the ideal flow implied by the model.

A further point is that many situational awareness systems are 'virtual' in the sense that no single agency or authority owns or is responsible for all elements of the system. This is certainly the case with the Australian MDA system. The Australian Government has overarching responsibility but particular functions and capabilities are spread amongst various departments and agencies, each with their own charters, imperatives, aspirations and limitations. They are at once competitors and collaborators. They compete for political influence and funds, in an increasingly contested funding environment. They collaborate to the extent necessary to gain benefit from the system, as a whole, and to demonstrate the value of the contribution they make to the overall system. Some operate under strict legal and other restrictions, including for example privacy laws and security agreements with third parties, which sometimes limit the amount and type of data they may share with others. Beyond the Commonwealth the States and Territories both contribute to and take from the system as do companies with interests in the maritime domain.

The model, as represented by the diagram, does not fully account for the dynamic nature of activities undertaken. Three dimensions beyond the diagram which need further explanation are (1) time (leads and lags in the system), (2) the organisational and personal biases inherent in the system and (3) response activities that are initiated as a result of information provided by the system to relevant authorities.

Time: Leads and Lags

Time is needed to acquire new capabilities in response to new information requirements or simply to replace existing collection capabilities that come to the end of their operational lives. Some capabilities in the system take much longer to acquire than others. This is not just a question of technology platforms, sensors, supercomputers and communications networks although the acquisition lead-time for some of these capabilities can be a decade or more. People with language skills and deep understanding of relevant cultures, also take years to educate and train and their skills are fungible meaning that continuous investment is needed to maintain their currency. Long lead times are generally acceptable in replacement or upgrade programs because the date by which time the new capability is needed can usually be anticipated and planned for. An important proviso is that replacement and upgrade projects are not delayed for budgetary or other reasons to such an extent that future capability and operational effectiveness is compromised.

Furthermore investments need to be balanced across the system in order that bottlenecks are avoided. There is little point for example, in having access to satellite data if the ground reception station has not been built, or the data storage and processing system has not been upgraded to meet new demands or the analysts have not been recruited and trained to make best use of the data source now at their disposal. Such disconnects happen all too frequently meaning that optimal system performance is at best delayed and sometimes only achieved at additional cost.

Organisational and Personal Interests and Biases

Analyses of capabilities and processes such as those discussed in this paper often proceed on the basis that nations act in their rational self-interest following a process that involves the systematic collection of evidence and its dispassionate analysis in which costs and risks are carefully weighed. In his classic account of the Cuba Missile Crisis, *Essence of Decision*, Graham Allison called this the "rational actor" model. It remains the common denominator for much discourse in international relations.[10] A hallmark of the "rational actor" model is that nation states tend to be personified in the literature: "China did this, and Malaysia did that", as if these two nations were people. Such simplification is a useful shorthand providing its limitations are acknowledged and understood.

Allison postulated two further models to explain the behaviour of both the United States and the Union of Soviet Socialist Republics (USSR) during the crisis. He called these the "organisational process" model and the "governmental process" model. For simplicity he numbered the models "I", "II", and "III".

Such disconnects happen all too frequently meaning that optimal system performance is at best delayed and sometimes only achieved at additional cost.

In the world that Alison wrote about information flowed through the formal and informal centres of power and authority in organisations in a more or less linear and predictable fashion. Information was a scarce commodity and there was a nexus between information and power. One of Alison's key points was that key American actors in the crisis had disparate goals and measures of success that could not be accommodated in any analysis of the crisis that referred to the rational actor model alone.

This comment applies equally to Australia's approach to situational awareness in its maritime domains which is also not capable of being explained by reference only to behaviour that Alison's rational actor model might describe and predict. There are important organisational and political influences (Alison's Models II and III) to be taken into account as well.

Another way of illustrating the relationships between elements of a situational awareness system is to emphasise sequence and flow. Figure 2, uses the Australian MDA system as an example, to illustrate these relationships. As with the model outlined in Figure 1, there is implicit order and logic. However general system attributes or functions have been replaced by concrete words to describe how MDA is achieved and by whom.

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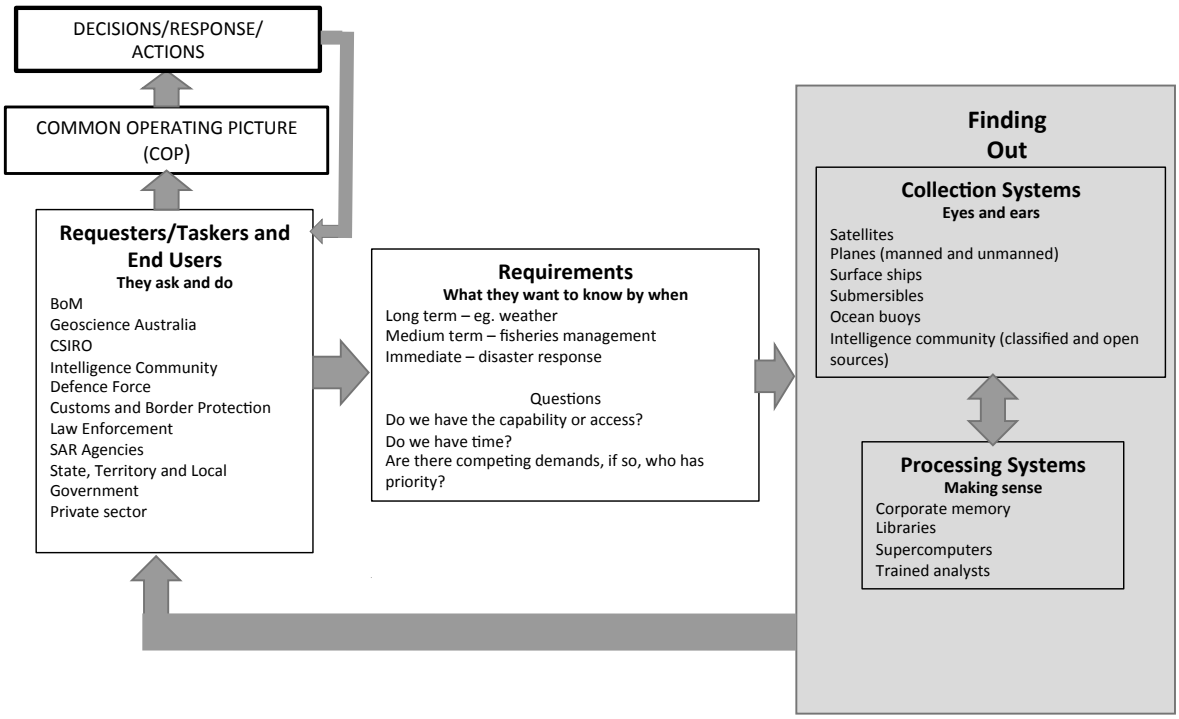
10 Allison G T, *Essence of Decision: Explaining the Cuban Missile Crisis*, Little Brown, Boston, 1971

Figure 2. One representation of the Australian MDA System

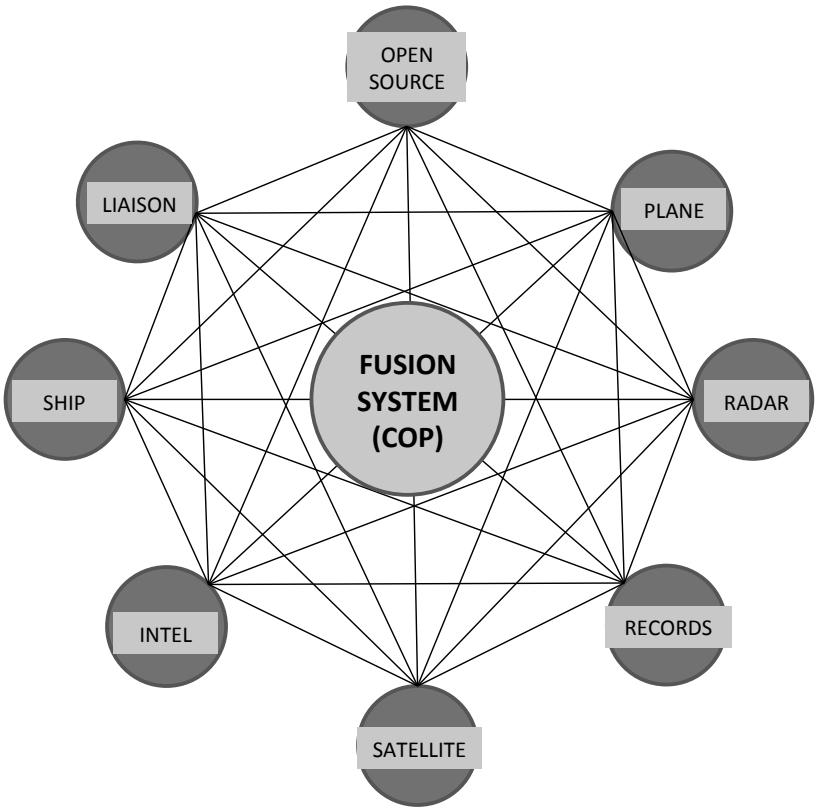


This seemingly well-ordered world has been fundamentally changed by the invention, rapid and ubiquitous adoption of the internet and associated technologies. When Allison wrote *Essence of Decision*, the internet did not exist. Since the 1980s internetworking technologies have transformed the way in which information is collected, processed, exploited, disseminated and stored. Networking technologies enable information to flow more or less simultaneously up down and across organisations making checks and balances that applied in the past far more difficult to apply. More profoundly, the world moved, in general terms, from one of information scarcity to one of information glut. There are certainly times when, with respect to a specific situation or circumstance, decision makers are frustrated by insufficient information. However, current fusion systems assume that data from numerous sources is plentiful and needs to be winnowed to be of use to decision makers.

All organisations, large and small, for profit and not-for-profit and public institutions, including government departments and agencies, are struggling to harness the potential of the internet whilst also maintaining some measure of control of the information that enters and leaves these organisations. The transformation in the way information flows today is illustrated below. Everything can be, and often is, connected to everything else. But the real complexity arises from the fact that these connections are dynamic; they are no longer static. They come and go in myriad combinations and permutations to satisfy requirements which also rise and fall in the attention they demand and the priority they are given.

Figure three is a schematic that seeks to demonstrate visually the complexity of just the "collection" node of Figure 1 or the "finding out" element of Figure 2. The COP is the technological response to reduce to complexity of the data generated in the networked system to a point that humans may have some hope of comprehending what the data is telling them in order that reasoned responses may be taken.

Figure 3. An MDA Collection Network



Collection is one of the steps in the MDA process. Eight generic information sources in the example above, give rise to the possibility of 28 two-way connections any combination and permutation of which may be active at any given time. The Common Operating Picture (COP), is the principal means by which decision-makers attempt to stay on top of the flood of data that is now available. It helps them make sense of the information at their disposal and to contextualise it for their own purposes.

Policies, practices and cultures are fundamentally challenged by the transformational nature of the internet. The 'need to know' principle is being displaced by a 'need-to-share' principle of which the COP is an important reflection. This fundamental shift is not without risk, especially from disaffected 'insiders', such as Edward Snowden. His release into the public domain of documents that he stole from the National Security Agency (NSA) have caused significant harm to the United States and its allies at the strategic, operational and tactical levels of diplomacy and military operations. His revelations have sparked an important debate about the privacy protections to be afforded citizens in a networked world in which any information passed over the internet, in technical terms at least, is accessible to any determined observer.

Data fed into a COP is similarly vulnerable and new balances between operational necessity and security and the 'need to know' and the 'need to share', are evolving at all levels of activity. This is discussed below in the section that addresses tasking and requirements setting.

In the 1980s, the ICT revolution began to transform all human activities, including those concerned with maritime domain awareness. No longer is it sensible or sufficient to invest in platforms and sensors alone. Data processing, storage, retrieval and dissemination systems need to be capable of handling the data provided by sensors in order that best use can be made of the information that has been collected. There are at least three corollaries.

- Ensure that data, irrespective of source, is not left unprocessed and analysed for want of appropriate investment in backend systems.
- Where possible automate data flows, analysis and dissemination – save time, reduce errors and release staff for higher order tasks where judgement is essential.
- Minimise, to the extent possible, the amount of data in the system that is classified.

These considerations drive a systems approach to maritime domain awareness which accounts for every element of the system being connected to every other element. The power of the system, including its resilience and redundancy is in the network.

Response Activities

A constant challenge for capability developers and systems designers is to achieve an optimum balance between those elements of the system that are devoted exclusively or substantially to observation, analysis and prediction and to those elements that can respond to a developing situation. For many years the Commonwealth has invested in ships and aircraft that can perform both functions and has avoided investing in sovereign capabilities that can observe but not respond. Earth observation satellites are an obvious example of capabilities that can only observe. Australia owns and operates none of these systems, preferring instead to gain access to data from foreign-owned and operated satellites through a variety of government to government and standard commercial arrangements.

As noted already the Government has announced its intention to purchase a number (possibly seven or eight) MQ-4C Triton High Altitude Long Endurance (HALE) UAVs later in the decade. These aircraft, to be operated by the RAAF are surveillance and relay communications platforms with no capacity to directly respond to any event in Australia's maritime domains that warrants physical presence. This is the first time that Australia has invested in dedicated platforms, optimised for maritime ISR, that have no inherent response capability at all.

Manned aircraft, operating at lower altitudes than typically will the Triton, can provide a deterrent effect simply by being seen. They can also drop life-rafts and other aids and, in extreme circumstances, launch weapons. Ships and patrol vessels have boarding parties that may help to thwart people-smuggling operations or to regulate the activities of Foreign Fishing Vessels (FFV) in Australia's Exclusive Economic Zone (EEZ). They can and do assist in recovery operations associated with natural disasters and, in extremis, they can launch weapons.

Acquisition of the Tritons will provide decision-makers with the capability for persistent ISR in maritime and littoral areas of particular interest. They will have application and relevance at all levels of activity – the tactical, operational and strategic – in the governance of Australia's maritime domains. They also offer an opportunity to Australian tasking authorities to acquire the experience and confidence needed to task Earth observation satellites that, at some point in the future, may be acquired and operated by Australia in order to meet specific national requirements that the foreign-owners and operators of satellites on which Australia is completely dependent today cannot or will choose to not meet. Unlike the Tritons, which are confined to operating in national or international airspace unless granted specific permission to enter the sovereign airspace of other nations, satellites have no such restrictions. The laws of physics and orbital mechanics mean that they overfly otherwise denied areas with impunity.

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Tasking and Requirements Setting: Strategic, Operational and Tactical Perspectives

This section of the paper provides examples that are intended to highlight some of the dilemmas and challenges inherent in creating and maintaining a maritime COP. The MDA system must serve multiple users simultaneously. They have different priorities and time imperatives and they seek information at different levels of detail or granularity. Some information requirements can be satisfied from local sources whilst others require inputs, via the COP, from external providers. Invariably, there are more requirements than there are capabilities to meet them all so negotiation skills becomes vitally important if decision makers at all levels are to have their most important priorities met.

The conventional military distinctions between the tactical, operational and strategic levels of activity is used to demonstrate how complex requirements can become and how information from all levels is needed and can be used by others. The tactical/operational/strategic schema applies equally well to civilian MDA activities as it does to military activities.

Tactical Level

A ship's captain is vitally interested in the environment in the immediate vicinity of his or her ship. On board sensors include radars, sonars (active and passive), electronic monitoring equipment (basically radio receivers), and the eyes of the crew who routinely scan the horizon through binoculars. Information from these sensors feeds into a plot that might include the position, course and speed of other vessels that are nearby but out of visual range because they are obscured by weather or are below the horizon.

Some ships have helicopters which, when airborne, can extend the observation range of the ship from a few tens of kilometres to potentially hundreds of kilometres.

Information from on board, or organic sensors, has two advantages over information from other sources. It is immediate and its veracity can be readily tested. The decision maker, typically the ship's captain, when faced with information that is ambiguous or unclear, can immediately check the sensor and question the sensor operator. If doubt persists, the captain can factor this doubt into his or her decision as a calculated risk. He or she may decide to accept the risk and continue as planned or, as a precautionary measure, may take some other action such as altering the course and speed of the ship. A key point is that the information available to the captain, even if incomplete or ambiguous is trusted because its provenance is known.

In a networked world, some of the information gained by the organic sensors of the ship almost certainly will be transmitted to and shared with others. This information may add to the fidelity and comprehensiveness of the COP. However, care needs to be taken to ensure that the information provided is evaluated and correlated to overcome possible problems of duplication and timeliness.

Teasing this point out, there are times when ships (and aircraft too) seek to gain tactical advantage by not disclosing their presence. In such circumstances they may turn off their radars and radio transmitters so as not to emit signals that may be intercepted by an adversary or a third party. In such circumstances, when they do begin to transmit again, some information that they pass may have been overtaken by more recent information, from a different source or sources, about the same event. The main issues from the point of view of a COP are data latency and data matching, making sure that old news is not, in effect, re-circulated.

Tactical level decision-makers sometimes have extremely detailed information needs that can only be provided from external sources. For example, a RAN Patrol Boat may intercept a foreign fishing vessel (FFV) that is fishing without authorisation in Australian territorial waters. The FFV may be a new type, not seen before. The Patrol Boat captain might seek detailed plans of the FFV to maximise the situational awareness of the boarding party before the boarding takes place in an effort to minimise risks associated with this inherently hazardous activity. This might extend to knowing, in advance, in which direction particular bulkhead doors swing. If these drawings or plans are not held in a central repository such as an intelligence agency, the time taken to obtain them through industry contacts or foreign liaison channels may give the captain no choice but to proceed and accept risk he or she would prefer to have avoided.

Beyond having and valuing immediate situational awareness, the ship's captain is also looking to the near future to understand the environment, in its broadest sense, into which his or her ship is sailing in the next few hours and days. The captain wants accurate weather forecasts from data derived by weather satellites and forwarded to the ship by shore-based radio or communications satellites. This translates to wind, cloud (fog) and sea state. The captain understands, incidentally, that the weather reports broadcast from his or her ship is fed into the predictive models that are also served by the satellites. The ship's data provides 'ground truth' which enables the models and therefore the forecasts, to be refined. This information allows, for example, for routine maintenance to be planned and on-deck and below deck activities to be optimised from perspectives of safety and efficiency.

Operational Level

Decision makers at the operational level are typically responsible for the conduct of a broad set of functions within a usually quite large but still defined physical area. They have assigned resources, including people, and, in the case of the maritime domain, ships and aircraft that can perform ISR and response functions. Decision makers can direct these assets and conduct activities within their assigned area of responsibility in pursuit of the objectives set by higher levels of authority. In addition to these capabilities that they can task directly, they may also request access to additional capabilities, for specified purposes, from a higher level of organisational authority. Operational level decision-makers, for example with civil maritime border protection responsibilities, have access to relevant intelligence from national agencies and often have responsibilities for coordinating activities between numerous departments and agencies in Australia including defence, law enforcement, immigration, quarantine authorities and relevant State, Territory and local governments.

Operational level decision makers may also have limited international liaison responsibilities on matters of direct concern to their assigned tasks.

Australia is one of a handful of middle powers with capacity and experience in planning and conducting civil and military operations at the operational level.

Australia is one of a handful of middle powers with capacity and experience in planning and conducting civil and military operations at the operational level. At the heart of these activities is a command support system that gives decision makers the confidence and skill to plan and direct the activities of people and platforms from various organisations, sometimes from several nations. Military parlance for these activities is joint and combined operations. However, in the MDA context, there are important civil and commercial contributors to be taken into account as well. This capability was clearly evident in Australia's leadership of the operation to locate the final resting place of the missing Malaysian airliner, flight MH370. The early weeks of the search, which focussed on detecting debris from the aircraft that may have been still floating on the ocean surface presented special challenges because operational, safety, and public information considerations needed to be carefully managed to not exacerbate the stress on affected families, the emotionally charged media coverage and the evident strains, especially in China's bilateral relationship with Malaysia.

Australia set out to acquire the skills needed to conduct activities at the operational level in the 1980s, initially through re-structuring the command and control arrangements of the Australian Defence Force (ADF) and later through the creation of Border Protection Command, now the Australian Customs and Border Protection Service (ACBPS). This has been a thirty year journey. Some important milestones and initiatives include:

- The establishment of the Australian Defence Force Academy in 1986 to build a sense of common purpose and deep friendships and trust between officers of the three Services as their careers progressed from their days as cadets.
- A series of Defence ICT projects designed to create a joint command support environment and a joint intelligence support environment that started in the 1990s and continue to this day.
- The establishment of Headquarters Northern Command (HQNORCOM) in 1988
- The establishment of Headquarters Australian Theatre (HQAST) in 1996 which morphed into Headquarters Joint Operations Command in 2004 and which is now located in purpose built facilities near Bungendore NSW.

- The withdrawal of Indonesian forces from Timor Leste and their replacement by an Australian led multinational force in 2006 which paved the way for elections and Timor's transition to independence.
- The experience gained by commanders, units and crews in a decade of war and war-like operations in the Middle East (Iraq and Afghanistan, the Arabian Sea and the Indian Ocean littoral.
- The establishment of Border Protection Command in 2005 which morphed into the Australian Customs and Border Protection Service in 2009.
- Operation Ache Assist, the civil and humanitarian relief operation that followed the Boxing Day Tsunami of 2004.
- Operation Sovereign Borders and its predecessors which were designed to counter people smuggling operations usually from Indonesia. Although politically contentious, at the operational level, close civil/military cooperation became the norm.
- Most recently, the multi-national search operation to find the missing Malaysian airliner, flight MH370. The flight was bound from Kuala Lumpur to Beijing on 8 March 2014 but, in circumstances that remain a mystery, the plane set an entirely different course and seems to have crashed into the Indian Ocean 1,500km west of Perth, WA killing all 239 people on board. The search effort was initially coordinated by the Australian Maritime Safety Authority. However, its increasing complexity in operational, diplomatic and political terms, saw overall responsibility being vested in Air Chief Marshal (retired) Angus Houston AC. His knowledge of the operational environment, his extensive command experience, his understanding of the domestic political environment and his friendships throughout the region are a text book case of MDA at its most sophisticated and best.

Strategic Level

In 2007, Rod Lyon from the Australian Security Policy Institute (ASPI) produced a paper called *Australia's Strategic Fundamentals* in which he identified three schools of strategic thought which have been prevalent in Australian strategic thinking since the 19th Century.[11] Lyon named the three schools as 'Globalists', 'Regionalists' and 'Continentalists'.

> 'Globalists' have argued that Australian security is essentially determined by the global order, that the global order is critically determined by events distant from Australia, and that our strategic policy therefore should be an extroverted one. 'Regionalists' have argued that Australia needs to come to terms with its Asia–Pacific strategic environment, that Britain's 'far east' was always our 'near north', and that Australia should build security with Asia rather than from it. 'Continentalists' have argued that the defence of Australia must be the primary focus of the ADF, that Australia's defence problems are unique, and that we should build a defence force which maximises our ability to protect the continent by exploiting the sea-air gap to our immediate north.

11 Lyon, R., *Australia's Strategic Fundamentals*, Special Report, No 6, Australian Strategic Policy Institute, June 2007.

Sam Bateman and Anthony Bergin in another ASPI paper asked whether Australia and Australians regard the oceans as a moat that keeps others out or as bridge that permits relationships to be built and friendships to flourish.

How governments, and the nation as a whole, balance globalist, regionalist and continentalist perspectives and resolve the question of moat or bridge has profound implications for economic development, military force posture and force structure and priorities for Australia's foreign relations and diplomacy. Understanding the maritime domains is integral to their governance. Activities as diverse as environmental management and sea control can only proceed on a basis of deep knowledge and understanding, which permits operational and new capability priorities to be established and realised.

As noted earlier, Australia's national security posture is built on the bed rock of the US alliance. This situation is not likely to change any time soon. Both sides of politics in Australia embrace the alliance and there is strong support for the alliance from the wider electorate. Some commentators have started to argue that Australia needs to develop an international and regional persona that is somewhat more independent and less evidently tied to the US than is the case today. These views are driven by the rise of China and a perception in some quarters, the rhetoric of the "re-balance" notwithstanding, that US power in the Asia Pacific is waning in relative and absolute terms.

Australia's national security posture is built on the bed rock of the US alliance.

The future level of US commitment to the Asia Pacific region has fundamental implications for the Australian MDA system. If more information from US sources is shared with Australia, there is potentially less that Australia has to collect for itself. Alternatively, and taking a more sophisticated view, Australian collection systems will be freed for tasks that otherwise might not have been possible to perform. This provides, in principle, for a richer MDA system for Australia and also provides Australian officials with information that is unique and that can be shared or traded with others to mutual benefit.

Regardless of whether particular governments are 'Globalist', 'Regionalist' or 'Continentalist', there would seem to be an array of data relevant to Australia's maritime domains which would provide baseline information to inform policies and response options at the strategic level.

There is other data that is strategy dependent. For example, if Australia is at all serious about conducting routine submarine operations in the South China Sea and the Western Pacific deep understanding of these ocean environments, from a physical perspective and in terms of human activities, will be an essential element of overall capability. If, however, Australian strategy were to focus primarily on the defence of the Sea-Air gap to the immediate north and northwest of the continent, different requirements and ways of meeting those requirements can be contemplated.

The strategic level of activity involves questions of national priorities and resource allocation. The Commonwealth does not invest in MDA per se. Rather MDA is achieved through investments in the armed forces, intelligence, border protection, law enforcement, diplomacy and scientific research. The sum of the information that comes from these sources, when aggregated, compared, fused, and disseminated provides the COP from which policy makers and response agencies can derive MDA.

The next section of this paper discusses the principal sensor systems and other data collection methods that are used by Australia to develop the COP.

COLLECTION SYSTEMS USED BY AUSTRALIA

The Australian Government gathers data from numerous sources to develop its maritime COP. Some decisions about next generation sensor systems to provide situational awareness in Australia's maritime domains have been made in the past year and the Defence White Paper of 2015 may point the way to further new investments as well.

This is no simple task and investment balances will need to be struck between:

- Sensor Types and the platforms on which they are mounted;
- The Front and Back end of sensor systems;
- Sensor Systems, Weapons Systems and Hybrids;
- Intelligence and Statecraft (diplomacy and human contact) and Surveillance Technologies (remote sensing of all types);
- 'Big Data' Analytics and Remote Sensing Systems;
- Self-protection systems and area sensors; and
- Single use (usually military) and 'dual use' systems where the one system is tasked by and provides data to both national security and civil users.

There are also questions of how to ensure that legacy systems are integrated with new capabilities as they come on line.

Sensors that can provide data relevant to situational awareness in the maritime domain may be located in space, on aircraft (manned and unmanned), on land, such as the Jindalee Over-The-Horizon Radar Network (JORN), on ships and other surface craft, on submarines and other submersibles. Sensors may be active, such as radars and active sonars; these systems send out a signal and listen for the return pulse. Or, they may be passive; such as visual light and infra-red sensors and signals intelligence (SIGINT) systems that can intercept radio and radar emissions and extract useful information from them.

Each of these systems has advantages and disadvantages. Radar systems on satellites or aircraft can 'see' through cloud and can detect objects such as ships in tropical areas where there is often cloud cover. However, radar emissions can be detected which discloses the presence and possibly the location of their source to an adversary, thereby allowing him to mount an attack or to avoid being attacked.

Sensors and other sources are layered and controlled by various agencies. Table 1 is an inventory of collection systems that provide inputs to Australia's maritime situational awareness system. The table does not set out to be definitive. Its purpose is to demonstrate the complexity of the system and by inference to indicate the enormous challenges to be overcome if optimal capability balances are to be achieved across the system.

Table 1. Collection systems used to gain situational awareness in the maritime domain.

Source	Ownership/Control	Main first line users
Earth observation satellites		
Two broad types: **passive** working in the electro-optic, infra-red and various radio emission bands and **active** radar satellites which transmit pulses to Earth the reflected energy of which is used to gain information	All foreign owned	Bureau of Meteorology Geoscience Australia (GA)
	Mainly civil agencies such as NASA, NOAA, ESA and JAXA which provide free-to-ground data under a range of international and bilateral agreements	State and territory land and property management agencies Research agencies, notably CSIRO, and universities
	Various US national security agencies for data provided for surveillance and intelligence gathering purposes	Australian Geospatial Intelligence Organisation (AGO) and other components of the Australian Intelligence Community
	Commercially owned and operated	Government purchases increasingly channelled through a panel, hosted by GA
Aircraft		
Long haul Routine Passenger Transport (RPT)	Foreign and Australian carriers, reporting data relevant to weather reporting and prediction	BoM - routine reporting – data points to improve the fidelity of predictive models
Government owned and leased aircraft	RAAF, ACBPS, AMSA and other agencies, surveillance and reconnaissance of human activities using radars, ELINT and line of sight visual and IR sensors Helicopters for SAR	Government control and tasking authorities to understand normalcy states and to detect and respond especially to non-cooperative targets or to targets displaying unusual or uncharacteristic behaviour
Research organisations	Oceanography Hydrography Research organisation owned or commercial leases to support particular research projects	eg. Laser Airborne Depth Sounding (LADS) Nominated Principal Investigators
Surface Ships		
Government ships	RAN, ACBPS, State and Territory police and other agencies for in-shore work	Government control and tasking authorities for sea control, exercises and border protection duties – often engaged in incident response and rescue
	RAN hydrography	Marine charting
Two ocean-going ships (one ice capable) and smaller, inshore, vessels	CSIRO and Antarctic Division	Nominated Principal Investigators for research
Smaller, inshore, vessels	Other Commonwealth departments and agencies, State and Territory governments – eg. port authorities and police	
Commercial ships	Commercially owned and operated	Position and related reporting IAW maritime regulations to port, safety and other Government agencies

Source	Ownership/Control	Main first line users
Submersibles		
Submarines	RAN	Government control and tasking
Ship towed arrays	RAN mainly for tactical ASW purposes ie. submarine detection (data may feed to higher agencies)	Ships commanders Principal researcher
Fixed arrays	Allied navies (for submarine and ship detection)	Intelligence and tasking authorities
Robots	Various research organisations	Nominated Principal Investigators for research
Intelligence		
	Government agencies	Intelligence agencies, then passed to operational users almost exclusively at Commonwealth Government level
Radar		
Surveillance, weather	RAAF, Jindalee Over-the-horizon Radar Network (JORN)	Government control and tasking
	Ships radars for local situational awareness (may be networked for over-the-horizon situational awareness and data may feed to higher agencies)	Ship commanders
Other Sensors		
Ocean Buoys	CSIRO ocean conditions below and at the surface, currents, weather	Nominated Principal Investigators for research
Hand held imagery and visual observation	Port authorities, ACBPS, law enforcement agencies	Security officials, criminal investigators

The table illustrate the variety of sensor/platform combinations that collect data for many government and other purposes. There are both overlaps and gaps. Coverage for many purposes and applications does not need to be continuous. For others tasks, continuity and persistence is imperative.

Some quantitative factors that must be considered include the following.

- **Time**: Most sensors are not available continuously to cover any given area. This is not necessarily a problem but tasking authorities, having determined their information requirements, need to think carefully about the frequency of coverage necessary to understand and, if necessary regulate, a particular area or activity. This directly impacts the tasking of platforms of all types on which the sensors are fitted and also has an important capability impact in terms of the numbers of platforms of various types that are needed to perform various missions.

- **Resolution**: For some purposes, knowledge of the mere presence (or absence) of some particular activity is sufficient for operational authorities. At other times, high resolution imagery is needed, together with a competent operator, to establish a chain of evidence for later presentation in court. There are also many 'in-between' cases where some information, regardless of the sensor, used is better than none.

  Three terms relevant to surveillance systems that look for human objects such as ships and aircraft and that are fundamentally dependent on resolution are "detection", "classification" and "identification". Detection simply denotes the presence of an object in space and time. Classification, refers to the type of object that has been detected (eg. an oil tanker or a war ship). Identification implies that the system has been able to put a name to the object detected (HMAS Sirius or the bulk coal ship Brilliant Century).

- **Spectral Response**: Sensors that operate in different frequency bands reveal different information or work better at some times than at other times. Infra-red sensors detect heat and heat signatures that can assist in the identification of ships, by type, class and sometimes even by name or pennant number. Many visual light sensors can only operate in daylight hours unless artificial illumination (eg flares) is provided. Low light sensors are used at night but typically have a limited field of view. Infra-red sensors can operate in darkness and most radars operate as well at night as they do in the day. An important limitation of the JORN system is the so-called dawn and dusk 'terminator'. JORN depends on the presence of a stable ionosphere. However at dawn and dusk the ionosphere changes its structure and can even disappear. A corollary is that the JORN system has a sophisticated ionospheric sensing and modelling system build into the operating system of the radar to assist operators to use the radar as effectively and efficiently as possible over the course of the day.

- **Ground Truth** A great deal of data about Australia's maritime domains come from satellites. The value of this information is considerably enhanced when the results of observations made from space can be calibrated with measurements made in situ, including from known locations at known times on the surface and under the sea. Ground truth in the present context is provided typically by ocean buoys and measurements taken by ships and aircraft.

- **Calibration and Validation (CALVAL)** A corollary of Ground Truth is CALVAL. Sensors on satellites cannot be regularly maintained and calibrated by technicians on the ground. Instead their sensitivity, which changes over time (they tend to become less sensitive), needs to be regularly measured in order that the data being relayed to Earth can be adjusted to account for the sensitivity of the sensor at the time that an image was made. CALVAL is the process by which targets with precisely known absorption and reflectance characteristics are regularly imaged and the results that are provided can be checked against the theoretical norm. Any variance can then be applied to other observations by the same sensor leading to more accurate results overall. Australia hosts a number of CALVAL sites that are used by other nations to support their Earth observation satellite programs.

Tasking authorities need to understand in great detail the operational strengths and limitations of the platforms on which sensors are mounted as well as understanding the characteristics of the sensors themselves. More than this, they need to understand the broader system impacts of tasking one platform/sensor combination over another, assuming that choice exists.

The following sections discuss in more detail some of the strengths and limitations of different sensor systems with specific reference to the Australian situation.

Aerial Systems: Manned and Unmanned Aircraft

Several Australian Government departments and agencies use manned aircraft in support of their maritime patrol and response missions. The RAAF has a fleet of 19 aging AP-3C aircraft. The ACBPS uses commercial contractors to provide civil maritime patrol operations using Dash-8 aircraft and helicopters (the latter mainly in the Torres Strait) and the Australian Maritime Safety Authority (AMSA) operates a fleet of five Dornier aircraft positioned at each of the four corners of the continent that are capable of performing Search and Rescue operations close to the coast.

The Dash-8s shoulder the lions' share of the task, in the order of 90%, in terms of flying hours and area covered. In recent years they have focussed their efforts on the Christmas Island to Darwin corridor to detect and assist in the apprehension of boats carrying asylum seekers.

As well as their commitments in the Middle East, including missions over the Arabian Gulf, anti-piracy operations in the Gulf of Aden, and support to land operation in Iraq and Afghanistan, RAAF AP-3C aircraft have made a substantial contribution to border protection operations. These activities have come at a cost. The RAAF has lost skills in maritime strike and anti-submarine warfare (ASW). The latter is of particular concern as Australia moves to acquire a fleet of new submarines. Airborne ASW is an essential element of undersea warfare and this capability will need to be re-built in coming years.

The AP3-C fleet is due to be replaced in the next five years under Defence project AIR 7000. The plan is to acquire a mix of eight manned and up to seven unmanned platforms. The manned aircraft will be the Boeing P-8A Poseidon aircraft which is based on the Boeing 737 commercial airliner. The Australian Government has already announced that it will purchase eight of these aircraft and has an option to purchase at least four more. The P-8A, "promises higher cruise speeds, higher maximum altitudes, significantly longer range, and a longer time on station compared to the P-3".[12] It will also be capable of carrying and delivering weapons and have an air-to-air refuelling capability.

As noted earlier the Northrop Grumman MQ-4C Triton has been named by the government as its preferred HALE UAS. The Triton is a version of the Global Hawk aircraft that has been modified specifically for long endurance operations over water. Both the P-8A and the MQ-4C aircraft will have the ability to collect massive volumes of data which, even with automated processing, will present challenges to information systems and to human analysts. Both platforms will be reliant on access to communications satellites as the prime means by which data will be transferred to other units and to processing centres on land. A safe and secure space environment and assured access to communications satellites are essential enabling capabilities for both aircraft.

12 Hollins, K. *Blue water birds: Transitioning from the AP-3C to the P-8 and a UAS*, in Australian Defence Business Review, March 2013, Canberra, p14.

If fiscal constraints slow the introduction into service of both the P-8A and the Triton especially, the RAAF could be faced with the problem of having to maintain three aircraft types (AP3-C, P-8A and Triton) for a period. This will add strains to the workforce and slow the acquisition of knowledge and experience that will be critically important if the best is to be obtained from the new systems not only as they relate to each other but as they dovetail with other new capabilities including the F-18 Growler, the F-35 Lightning and the range extension potentials offered by air-to-air refuelling.

The RAAF has gained experience in operating UAVs in Afghanistan and has paid considerable attention to the practicalities of operating a mixed fleet of manned and unmanned platforms in future to achieve optimal outcomes.

Successive Governments have favoured fixed wing aircraft as the preferred primary platforms for maritime surveillance.

The ACBPS presently depends on a fleet of Dash-8 aircraft, to meet most of its civil maritime surveillance requirements. The Dash-8s and crews are provided by an Adelaide-based company, Cobham Australia. The Dash-8s are a capable aircraft with a sophisticated suite of visual, thermal and electronic sensors. They may be expected to complement the P-8A and the MQ-4C. In particular the Dash-8s, once released of some of their longer range duties, should be able to increase the density of patrol activities in areas of particular interest and in doing so to increase levels of presence and deterrence.

Successive Governments have favoured fixed wing aircraft as the preferred primary platforms for maritime surveillance. Tasking authorities and operators are comfortable with these systems; they know their strengths and limitations. Aircraft have been seen to represent lower risks than some postulated alternatives, including balloon-based and space-based systems. Aircraft have the additional advantage of being unambiguously under sovereign control and, critically, they are seen as being extremely responsive and flexible. The likelihood that manned aircraft will be displaced as the workhorses that provide situational awareness in the Australian maritime domain, even in constrained fiscal times, is considered to be remote.

Space

Although Australia does not own or operate any Earth observation satellites of its own it is a sophisticated user of satellite systems for communications, Earth observation and position, timing and navigation. These uses and the associated dependencies have not been as well-recognised in the past by policy makers and the broader public alike. There is evidence, however that this situation is changing. Space attracts increasing attention in Defence White Papers and associated documents and in April 2013 Australia released its first national space policy (called formally a *National Space Utilisation Policy* to dampen any expectation that Australia is about to invest in human space flight or space exploration missions).

Satellites monitor the environment in broad terms, including phenomena such as sea surface temperature, ocean colour, cloud formations and soil moisture to enhance weather prediction and to improve climate modelling and agricultural practices. They provide synoptic cover of major natural events such as floods, fires and the impact of tsunamis. They search for the signs of ballistic missile launches to provide early warning. They listen for radio and radar emissions which can disclose the presence, location and identity of ships and aircraft. They make increasingly fine grain images such as those which may accessed through applications such as Google Earth.

A distinct advantage of satellites is that they operate without the need for permission above the territory of any sovereign nation. This is a function of the laws of physics as they apply to objects that orbit Earth. American satellites can look into the backyards of China and Russia just as the satellites of these two nations can and do observe activities in the United States

Except for satellites in GEO, which can provide persistent coverage of a large area of Earth, the rest come and go, relative to an observer on Earth, at regular and predictable intervals which may be days or even weeks apart. The implications from the operational perspective of a surveillance system are three fold:

- An informed entity which seeks to conceal activity from being observed by any given satellite knows when to cease activity at a given site to give an impression that activity is not taking place;
- The same observer may incorporate the predictability of satellite passes in deception operations that seek to influence the behaviour of a competitor or adversary more broadly than simply concealing immediate activities; and
- Earth observation satellites in LEO especially, which includes all high resolution imaging satellites, are not persistent and their effectiveness may be further reduced by cloud cover and other phenomena which prevent targets of interest being seen and imaged from space.

Australia's Use of Satellites for Situational Awareness in the Maritime Domain

Australia makes considerable use of satellite data to understand its maritime domains. Use of communications satellites, including commercial leases, and use of the US funded and maintained Global Positioning System (GPS) is basically taken for granted. The departments and agencies that make most use of data from remote sensing satellites are discussed below together with some current concerns and plans for remediation.

Bureau of Meteorology (BoM) depends heavily on data from a number of weather satellites that provide data "free to ground" under international agreements to the BoM. The Bureau maintains a series of satellite ground stations which receive the data from the satellites and pass it into the ground processing system, notably a very large supercomputer in Canberra. The data is fed into various models which allows predictions to be made with increasing levels of accuracy and confidence. In recent years the BoM has been able to extend the early warning period of heat waves and other extreme weather from hours to days, in no small measure because of its ability to integrate satellite data with other observations more precisely and more quickly. These advanced warnings are also issued with unprecedented confidence due to the fidelity of the data and the increasing sophistication and reliability of the models.

A substantial element of Australia's aid program is allocated to the provision of weather services and climate information to regional neighbours.

Ground truth and complementary data is provided by the observations of ships and aircraft, automatic weather stations on isolated reefs and coasts, and tethered and floating buoys such as those in the CSIRO-led Argo program. Data from these remote sensors is passed, often by communications satellites, back to the BoM to further enrich the models and refine the predictions.

Geoscience Australia (GA) GA's formal contribution to Australia's understanding of its maritime domains extends to the coastal margins of the Australian mainland as well as the island territories. In 2011, GA published a report *Continuity of Earth Observation Data for Australia: Operational Requirements to 2015 for Lands, Coasts and Oceans*[13]. The report painted described the extent of Australia's dependence on data provided by Earth observation satellites and pointed also to fragilities in the current arrangements. Quite a few satellites on which Australia depends are due to end their operational lives in the next few years and not all are being replaced leaving potentially large gaps in data that Australia has come to rely upon over many years.

A companion to the Geoscience Australia report was released by CSIRO in January 2012. The report called *Continuity of Earth Observation Data for Australia: Research and Development dependencies to 2020*, outlined the diverse uses to which Earth observation data from space is put by Australian researchers.[14] It noted the growing opportunities that exist for international research cooperation and it reinforced the seventh finding in the GA report that emerging gaps of greatest concern are medium resolution electro-optical and Synthetic Aperture Radar (SAR) data.

The next generation of Earth observation satellites will generate substantially more data than those currently in operation.

The next generation of Earth observation satellites will generate substantially more data than those currently in operation. Earth stations will need to be upgraded from narrowband to broadband receiver, processing and storage systems. The Commonwealth has plans to upgrade existing ground infrastructure to cope with the additional data from next generation Earth observation and GNSS systems focussing on civil applications.

In summary, relevant Australian Government departments and agencies, in concert, are taking small but practical steps to ensure continuity of Earth observation data from space for a range of environmental monitoring tasks for both operational and research purposes. These investments will allow data to be gathered about Australia's coastal areas and surrounding oceans and may be expected to inform future policy decisions, and the operations of protection and response agencies.

Some observers are critical of Australia for not having its own remote sensing satellites. They argue that because the nation lacks the ability to obtain images without reference to others it is exposed to an unacceptable level of sovereign risk. A more compelling and sophisticated argument is that without data sources of its own, Australia lacks the ability to trade Earth observation data with others. In the past Australia, in effect, has traded real estate (hosting of ground stations) for access to data. The model has served Australia well in the past but its future utility is less certain. As more nations operate their own satellites they seek to share data on a *quid pro quo* basis. Presently, Australia has nothing to trade. It is not hard to imagine that this may have been a problem in the context of the early days of the search for MH-370 in the Indian Ocean.

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13 Geoscience Australia, *Continuity of Earth Observation Data for Australia: Operational Requirements to 2015 for Lands, Coasts and Oceans*, Canberra, 2011.

14 CSIRO, *Continuity of Earth Observation Data for Australia: Research and Development dependencies to 2020*, Canberra, 2012.

Satellite Remote Sensing in Support of ACBPS Operations

The ACBPS makes use of satellites to monitor shipping movements in two basic ways. Increasing use is being made of the Automated Identification System (AIS) for cooperative targets. In addition, radar satellites are used to monitor activity in the fishing grounds around Heard Island and McDonald Island in the southern Indian Ocean in an effort to deter and prevent illegal fishing in the Exclusive Economic Zone around these two Australian island territories. If illegal activity is detected the challenge remains to determine how to respond. The distances involved allow a poacher plenty of time to leave the area before an Australian Government ship can arrive.

Satellite Remote Sensing in Support of Defence and National Security

The use of space-based sensors by Defence and the wider national security community is difficult to discuss for the simple reason that there is little information on the public record from which to draw. The national security community does have privileged access to data from US intelligence-gathering satellites, however, quite severe constraints govern the release and use of this data beyond the intelligence community and a relatively small group of officials. These constraints can limit the usefulness of information gained from these sources.

The 2009 Defence White Paper contained a paragraph, 9.80, which foreshadowed that Australia would acquire a SAR satellite at some point in the coming decade.

As a significant new measure, the Government places a high priority on assured access to high-quality space-based imagery to meet Defence's needs for mapping, charting, navigation and targeting data. It has decided to improve Australia's intelligence collection capabilities by acquiring a satellite with a remote sensing capability, most likely to be based on a high-resolution, cloud-penetrating, synthetic aperture radar. This important capability will add to Australia's standing as a contributing partner within our alliance framework with the United States, which will be given access to the imagery collected by this system.[15]

The importance of this paragraph should not be understated. It signalled that Australia was looking to strengthen its commitment to space-based remote sensing by doing more than processing data provided by others. Mention of a SAR sensor can be taken to imply that the Commonwealth was seeking to strengthen its understanding of the tropical regions to Australia's north which are often covered by cloud. The projected satellite, especially if launched into an orbit around the Equator, would transit Australia's northern approaches every 90-100 minutes or so and provide both cueing information and collateral to JORN and to Australian ships and aircraft operating in those areas.

Whether the 2015 Defence White Paper will pick up where the 2009 White Paper left off with regard to a sovereign Earth observation system from space remains to be seen. However, space from a security and operational perspective is emerging as an area likely to demand greater operational attention in the future; something more than a strategic element in Australia's alliance relationship with the US as is the case today. There are clear implications for Australia's understanding of its maritime domains of responsibility and interest.

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Ships and other Surface Craft

Ships carry an array of sensors which are optimised for mission success. In the case of navy ships, success may be defined as self-protection and targeting. Commercial craft use different measures of success such as collision avoidance for a cargo ship and location of shoals of fish for a trawler. Most of these sensors are limited in range (basically to the horizon) although ship-borne aircraft and helicopters, manned and unmanned, have the capacity to extend that horizon. Data from individual ships can be fed into systems that permit cooperative targeting (eg. Ship A can fire a weapon at a target for which a firing solution has been provided by Ship B). This same data can be provided to the COP as either new information or confirmatory of information already in the system.

Ships also provide important ground truth for atmospheric and ocean environment measurements (temperature, air pressure, wind, current, salinity, etc.). These data are routinely fed into models and assist the BoM, for example, to produce more accurate weather predictions further into the future.

Submarines and Submersibles

Submarines carry an array of sensors which are optimised for mission success, defined broadly as self-protection and targeting. The range of organic submarine sensors, acoustic sensors in particular, is typically limited by water conditions (salinity, turbulence, ducting, temperature, ambient noise, etc.). Depending on the prevailing tactical situation a submarine that detects a target may not want to provide that information immediately to the COP for fear that transmission of the data may disclose its own presence to the target.

In the next 20 years robotic submersibles are likely to come into their own. Just what their impact will be on undersea operations of all types, including warfare, remains to be seen.

In the next 20 years robotic submersibles are likely to come into their own. Just what their impact will be on undersea operations of all types, including warfare, remains to be seen. Noting Australia's commitment to acquiring a new fleet of capable conventionally powered submarines, a corollary should be the acquisition of knowledge about robotic submersibles – their signatures and capabilities – in order to inform the COP as it develops.

Technical Databases and Signature Measurement and Management

A critical and sometimes overlooked or under-appreciated aspect of situational awareness in the tactical domain is the vital importance of technical databases. Radars for example may be readily identified as being of a particular type which can quickly be matched to a platform that typically carries that particular radar as standard fit. Most radars, however, have individual quirks which can permit that particular radar to be correlated with a particular ship. In a tactical situation the capacity to achieve hull-to-emitter correlation can provide information of great value. For example, in a conflict a submarine captain may be aware that two enemy ships of the same class and with the same type of radar are in her vicinity. She may also know that one of those ships has expended all of its torpedoes and has not re-provisioned whereas the other has not. If she can link the particular radar to one or other of the ships she gains an immediate advantage.

Although the fine details of signatures of particular ships and aircraft may not be immediately available through the COP, they do need to be gathered, evaluated, stored and disseminated to relevant users. In the case of acoustic signatures, ships' pumps are of particular interest because they emit distinctive signatures. The acoustic signatures of any given collection of pumps can allow not just a class of ship but the exact ship (by name or pennant number) to be identified.

The ADF has specialist units devoted to the collection, analysis, storage and dissemination, as needed, of this sort of information. Accurate and relevant signatures databases can be thought of as the crown jewels of situational awareness in the maritime domain because of the enormous tactical advantages they can confer.

"Big" Data

In the past decade computer software has been invented which allows vast quantities of structured and unstructured data to be trawled for pieces of information that are innocuous if disconnected but can provide actionable intelligence if linked. For example, way bills, airline passenger manifests, movement of funds in and out of bank accounts, which in isolation are meaningless, together can point to, for example, preparations for an importation of drugs or other contraband. The important point from the perspective of situational awareness in the maritime domain is that more thorough exploitation of data already in the hands of authorities can lead to understanding without the need to task dedicated collection assets.

An implication for capability developers and project officers is to ensure that a balance of investment is achieved across all facets of any ISR project. Sensors and the platform matter but so too do the supporting processing exploitation and dissemination systems. If these are not in place there is little point collecting information in the first place.

Dual Use Technology

The core technologies on which many of the systems described above depend are increasingly 'dual use' in nature. This means that they are not the exclusive preserve of the military or the broader national security community. The piece that becomes sensitive is not the 'what' of the system but rather the 'how', its use and application. The gap between systems designed for military use and their civilian and commercial equivalents is closing rapidly which means that the technological edge of the 1950s and 60s which gave western forces an edge over potential adversaries is eroding – quite quickly.

Dual use technologies in Australia may be subject to export controls which, if invoked, immediately reduce the market potential for some Australian designed, developed and manufactured goods. There are follow-on impacts into the research and manufacturing sectors which, in turn, can adversely impact on stated objectives of self-reliance.

The computers, including the hardware, firmware and software that sit at the heart of the COP are now, almost invariably, commercial products that are widely available anywhere in the world. Creating and maintaining advantage, based on differentiation of equipment is increasingly difficult to achieve. Increasingly, the edge is established in how equipment is used. This is about know-how and at the core of which are human interactions and behaviours that reflect culture, doctrine and training from which stem values including trust, discipline, loyalty, imagination and innovation. How these values are applied by decision makers working on a problem that is presented to them by the COP is increasingly the source of advantage at all levels of decision.

How such knowledge is shared between nations, some with quite different cultures and practices for assessing and valuing information, is a problem of immediate and enduring concern.

How such knowledge is shared between nations, some with quite different cultures and practices for assessing and valuing information, is a problem of immediate and enduring concern. In this respect the COP is the beginning point for decision makers. It is certainly not the end point.

Conclusion

The main point of this chapter was to illustrate the range and diversity of information that is available today about Australia's maritime domains. To the extent that this information is able to be collected, collated and displayed in ways that can be comprehended by many users, a COP can be said to exist. How the information is used is an entirely different matter and is largely beyond the capacity of the technical system to influence.

As noted at the start of this chapter, there is a series of investment balances to be struck between different systems, components of systems and organisations. The Australian Government has come a long way in the past decade in its appreciation of its maritime domains and their governance. In no small measure this is a result of more comprehensive and detailed understanding of the environment itself as well as the human activities that occur in, over, under and through it.

DRAWING THE STRANDS TOGETHER

Few Australians have a clear and informed view of the vastness of Australia's maritime domain, the diversity of the environments and the activities that occur within that domain.

Maritime Domain Awareness is a beguilingly simple concept which embraces enormous complexity. This paper has sought to unpack this complexity and in doing so to explain the sorts of challenges faced by decision makers at all levels of activity. These challenges are magnified, or brought into even more stark relief in Australia because of its small population on the one hand and vast maritime areas for which it has some form of responsibility or interest on the other.

Until quite recently maritime threats to Australia and its interests were largely taken to mean foreign military forces with orders, intent and capacity to disrupt shipping to and from Australia, as occurred in both World Wars of the 20th Century. The 21st century has added complexity. Globalisation of economies and supply chains, resource depletion, climate change, the emergence of influential non-state actors and the impact of ubiquitous information and communications technologies (ICT) are transforming relationships in and between nations.

Good governance of the world's oceans is essential for the health of the planet as a whole, for the conduct of relations between nations and more generally to facilitate trade and commerce. Many Australians depend directly on the oceans for their livelihoods and many more have less apparent, but still important, dependencies. Many coastal towns and communities exist because of the tourists and holidaymakers who come to spend time at the beach.

Over the past two decades, Australia has invested substantially in systems to improve the situational awareness about Australia's maritime domains in a number of departments and agencies. Beyond the computing, display and associated technologies that enable the COP itself, there have been fundamental organisational and institutional reforms that have both enabled and compelled agencies to work more closely together, to coordinate activities and to share their information, their knowledge and their experience. The two stand-out examples are the creation of the Joint Operations Command (JOC) which is headquartered near Bungendore just outside of Canberra and the creation of the Australian Customs and Border Protection Service (ACBPS) following the release of the nation's first national security statement to the Parliament by Prime Minister Rudd in December 2008.

The continued evolution of Australia's border protection arrangements is welcomed, indicating that government is seeking to devise more effective ways of taking advantage of the internet and associated technologies whilst also becoming more efficient. In this regard the integration of the ACBPS into the Department of Immigration and Border Protection and the creation of an Australian Border Force seem to be logical steps.

Six of the more important questions that arise when discussing situational awareness are:

- How much situational awareness is enough?
- What is the optimal balance of investment between systems that can assist decision makers to obtain situational awareness and other systems that can respond when needed?
- Are there certain capabilities that contribute to situational awareness that must remain in sovereign control and if so, what are they?
- How is situational awareness achieved across jurisdictional, organisational and other boundaries?
- What is the impact of technological development and how do capability developers decide about the mix of platforms and sensor types in which to invest?
- What should be investment balance between platforms and sensors that collect information and the back-end systems that process, exploit and disseminate the results to decision-makers?

None of these questions is capable of being answered in isolation from any of the others. The potentials offered by new technologies are not being as well exploited as they might be because of the inherent caution that organisations apply when challenged, or forced, to embrace change.

In the 1980s, the ICT revolution began to transform all human activities, including those concerned with maritime domain awareness. No longer is it sensible or sufficient to invest in platforms and sensors. Data processing, storage, retrieval and dissemination systems need to be capable of handling the data provided by sensors in order that best use can be made of the information that has been collected. This suggests that three further principles are now coming into play.

- Ensure that data, irrespective of source, is not left unprocessed and analysed for want of appropriate investment in backend systems.
- Where possible automate data flows, analysis and dissemination – save time, reduce errors and release staff for higher order tasks where judgement is essential.
- Minimise, to the extent possible, the amount of data in the system that is classified.

These additional considerations call for the development of a systems approach to maritime domain awareness that comprehends that each and every element of the system is, or may be, connected to every other element. The power of the system, including its resilience and redundancy is in the network. Sensors and platforms become nodes that both contribute to and take information from the network. This relatively simple concept is extraordinarily complex to implement. Legislative restrictions, organisational impediments and a plethora of competing and conflicting technical standards combine to make cooperation and coordination very hard.

In the past decade substantial progress has been made in creating a system that provides maritime domain awareness to Australian decision makers. Perhaps the most important outstanding task is for a narrative to be developed that explains the importance of the safety and security of Australia's maritime domains to the nation's broader national security interests and economic well-being. These matters have not been well-articulated to the broader public in a comprehensive and comprehendible way. Sectional interests, for obvious reasons, discuss marine parks, commercial shipping policy, and the need for new submarines and surface ships. Needed is a story that draws the strands together to show how they are linked and to provide context for investment decisions that must be made in the coming decade, some of which will have consequences well into the second half of the 21st century.

Against a rapidly changing region dominated by the rise of China, India and, closer to home, Indonesia, Australia's approaches to understanding its maritime domains will be influenced by strategic factors and diplomatic judgements as well as operational imperatives. Australia's alliance relationship with the United States and its relationships with regional neighbours may be expected to have a profound impact on the strength of the information sharing and interoperability regimes that on which so much of Australia's maritime domain awareness depends.

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