UNSW CANBERRA

ACCS Discussion Paper #1

AUSTRALIA REARMED!

Future Needs for Cyber-Enabled Warfare

Greg Austin

January 2016

UNSW AUSTRALIA

Australian Centre for Cyber Security
UNSW Canberra

AUSTRALIA REARMED! Future Needs for Cyber-Enabled Warfare

Greg Austin, Ph D

ACCS Discussion Paper No. 1
January 2016

ABSTRACT

Australia's response to the emerging centrality of cyber space in the conduct of future war has been slow and fragmented. The Australian play-book is not blank but it looks very different from those of pace-setter countries: key chapters in their play books do not yet appear in ours. The dilatory tempo of Australian policy is true in different ways for various actors: the government, the armed forces, the private sector, and the strategic studies community. This paper describes a number of international benchmarks which might provide guideposts for a rapid catch-up in Australian capabilities for military security in the information age (for cyber-enabled war). The paper will be relevant to other middle powers, many of which are even more disadvantaged than Australia in national military policy for cyber space.

On the one hand, the paper looks at the future international policy environment. It calls out major trends in the policy settings of two countries of strategic interest to Australia: China and the United States. Both regard military dominance in cyber space as one of the primary determinants of success in war. The Australian government has not been prepared to canvas in public the centrality of cyber-enabled warfare nor craft policies and doctrines accordingly. The discussion of how Australian policy compares with that of China and the United States for cyber-enabled war lays the foundation the paper's review of international trends in war avoidance (preventive diplomacy) and Australia's need to shape those developments.

On the other hand, the paper previews trends in the technologies and characteristics of cyber-enabled war (attack technologies and defensive systems) and complex cyber-enabled war scenarios. The United States and China have taken decisions in 2015 that reveal their determination to race ahead to the next stage of the development of cyber arsenals. They seek to create conditions in cyber space that in war time could undermine the effectiveness of the weapons systems, deployed units and military-related civil infrastructure of an enemy as quickly as possible. The two major powers are placing considerable attention on disabling enemy cyber systems in the early stages of hostilities, or even on a pre-emptive basis. Trends in the technologies of cyber attack and defence are moving in a direction that will present almost insurmountable challenges to the security of many small and middle powers.

Australia will need to develop complex responsive systems of decision-making for medium intensity war that address multi-vector, multi-front and multi-theatre attacks in cyber space, including against civilian infrastructure and civilians involved in the war effort. Australia's defence forces need to maintain distinct capabilities for cyber warfare at the strategic level. The capabilities need to be unified in both policy and doctrinal terms in a way that lays a clear pathway for mobilization of the country in very short time to fight a medium intensity, cyber-enabled hot war. This will require new technologies of decision-making that do not yet exist, even in most other G20 countries.

The paper recommends that Australia builds a much more visible community of interest around the concept of cyber-enabled warfare with a recognised authoritative hub (a cyber warfare studies centre) that can unite political, military, diplomatic, business, scientific and technical interests and expertise. For reasons outlined in the paper, an ideal location for such a centre might be the Australian Defence Force Academy which might build off the foundations provided by the Australian Centre for Cyber Security at the University of New South Wales Canberra.

Author Note

Professor Greg Austin is an international security specialist recently appointed at the Australian Centre for Cyber Security (ACCS) in the University of New South Wales Canberra. He concurrently serves as a Professorial Fellow at the EastWest Institute, an NGO with key offices in New York, Brussels and Moscow. He is the author of *Cyber Policy in China* (Polity: Cambridge 2014), the first comprehensive study of China's response to the information age addressing political, economic, military and diplomatic aspects. As a Vice President of EastWest in 2009, Austin was co-founder with the late John Mroz, then CEO of EastWest, of the Worldwide Cybersecurity Initiative, now in its seventh year and re-badged under new leadership to focus on cyberspace cooperation. Austin is the author of a number of articles and papers on international security impacts of the information age, as well as several books or longer studies on the security policies of China, Taiwan, Japan, and Russia. His thematic interests include preventive diplomacy, energy security, countering violent extremism and ethics. He served in Australian defence intelligence for more than a decade. He has held appointments as a Ministerial Adviser, Secretary of a Senate Committee, and Canberra-based correspondent for the *Sydney Morning Herald*. During 15 years working in Europe, including seven years with EastWest, Austin held senior roles in the International Crisis Group, the Foreign Policy Centre London, and the Peace Studies Centre (Bradford). He has also worked as a consultant for the UK Cabinet Office, the UK Ministry of Defence, the European Commission and the Australian Department of Foreign Affairs. He has held academic posts in the Australian National University and a Senior Visiting Fellowship in the Department of War Studies at King's College London. He has a Ph D and Master's Degree in International Law.

ACCS Discussion Paper Series

The ACCS Discussion Paper Series is a vehicle to subject the research of scholars affiliated with the Centre to further review and debate prior to the finalisation of research findings in more formal scholarly outlets, such as journals or books. The goals of ACCS are outlined on the last page back cover of this publication.

More information on ACCS is available at our website:
https://www.unsw.adfa.edu.au/australian-centre-for-cyber-security/.

Contents

Introduction

For a quarter of a century, successive Australian governments have been unable to come to terms with the full import of the digital revolution transforming the world.[1] This has been particularly visible in the defence sector even though our major ally, the United States, began a clear transition in the mid-1990s. In 2014, the Defence Science and Technology Organisation (DSTO)[2] identified the main areas of vulnerability for Australia in cyber space as "increasing digitisation, complexity, outsourcing, interconnectedness, and a lagging cyber security posture".[3] It listed ten areas of vulnerability in the country's cyber posture, all serious, the last of which was that "future threats are not addressed".[4] The DSTO report focused most heavily on technical aspects. Since DSTO is a defence agency, we might interpret its assessment to refer to Australian defence posture in cyber space across the board.

As Australia prepares to release its next White Paper on defence policy, expert eyes are waiting to see whether it can not only address these past deficiencies but also match the declaration by Malcolm Turnbull, the country's new Prime Minister appointed in September 2015, that his government is one fit for the 21st century.[5] Turnbull has set out a vision, in broad terms only so far, that he wants the country to move more quickly to become a country of digital innovation. As an indication of intentions, he moved the responsibility for digital transformation policy to his own department of Prime Minister and Cabinet,[6] set up a Cabinet Committee (chaired by him) on Digital Transformation, and he has announced the establishment of a Growth Centre for fostering innovation in cyber security.[7] What will the new Defence White Paper say about the country's cyber war planning and capabilities?

The need for 21st century innovation in cyber aspects of the defence portfolio is urgent, as a number of submissions to the White Paper (originally planned for 2015) argued, not least those from specialists with direct experience in Australia's intelligence and security services, or its armed forces.[8] The submissions represent the latest in a series of efforts over the last decade to prompt more timely response by the Australian government or its agencies

---

[1] See Greg Austin, "Australia's Digital Skills for Peace and War", *Australian Journal of Telecommunications and the Digital Economy*, Vol 2. No. 4, December 2014.

[2] The organization has since been renamed the Defence Science and Technology Group.

[3] Australia. Defence Science and Technology Organization. "Future Cyber Security Landscape: A Perspective on the Future", Canberra, 2014, http://www.dsto.defence.gov.au/sites/default/files/publications/documents/Future-Cyber-Security-Landscape.pdf.

[4] The ten areas listed at p.22 are: "continued shortage of skilled cyber security personnel; resource constrained security investment, security solutions becoming very complex and difficult to implement fully; security lags technology so security tools become less effective; limited supply chain risk management including supplier/component diversity; business processes do not adequately factor-in security issues; inconsistent maturity of cyber security across and within the sectors, false belief that compliance equates to security; inconsistent flows of cyber security information within and between sectors, current threats absorbing all resources such that future threats are not addressed".

[5] Australia. Prime Minister. "Changes to the Ministry", 20 September 2015, https://www.pm.gov.au/media/2015-09-20/changes-ministry.

[6] James Riley, "Turnbull Moves Digital to PM&C", InnovationAus.com, 20 September 2015, http://www.innovationaus.com/2015/09/Turnbull-moves-digital-to-PM-C.

[7] Australia. Dept of Prime Minister and Cabinet. "PM&C contributes four key components to the Ideas Boom", 6 December 2015, https://www.dpmc.gov.au/pmc/media/2015/pmc-contributes-four-key-components-ideas-boom.

[8] At the time of publishing, these submissions could be viewed at http://www.defence.gov.au/Whitepaper/PublicSubmissions.asp.

to respond to the cyber challenges emerging in military and national defence policy. To date, few Australian policy documents on national security needs in cyber space have commented meaningfully on likely future trends (the 10-20 year time frame) yet it the future trends that must shape our responses. The occasional statements that do exist concentrate on descriptions of the "here and now".

There has been no effort in public by the government to benchmark Australian national security needs in cyber space in the same way as we benchmark naval, air and ground capability against strategic needs (strengths and weaknesses of potential enemies and their intentions) and against Australia's budget constraints. This paper attempts to use a benchmarking approach across a combined set of political, economic, military and technical issues to understand better the DSTO assessment that the country's cyber posture is lagging.

While recognising the limitations of benchmarking, the paper sees the value of such an exercise as helping to:

- assess performance objectively
- create sustained pressure for improvement
- expose areas where improvement is needed
- identify superior processes
- focus on the links between processes and results
- find innovative ways of responding to a problem.[9]

The Australian Strategic Policy Institute has achieved some prominence for its concept of a "cyber security maturity model".[10] This approach useful as far as it goes, but it includes only one sub-measure directly related to military affairs and preparation for war. Moreover, there are important differences between benchmarking against trends in the international security environment and benchmarking against a cyber maturity model, even though the latter is informed by assumptions (usually not revealed) about the external environment. In sum, the differences are listed in Table 1 and are based on the author's knowledge of three cyber maturity models.[11]

TABLE 1: DIFFERENCES BETWEEN BENCHMARKING FROM INTERNATIONAL PRACTICE VERSUS MATURITY MODEL

Benchmarking from International Practice	Benchmarking from Maturity Models
externalities (references others)	endogenous (self referential)
realities (actualities)	abstracted ideals
dynamic (adaptability)	static
challenging	complacent
oriented toward threats	oriented toward organisational status

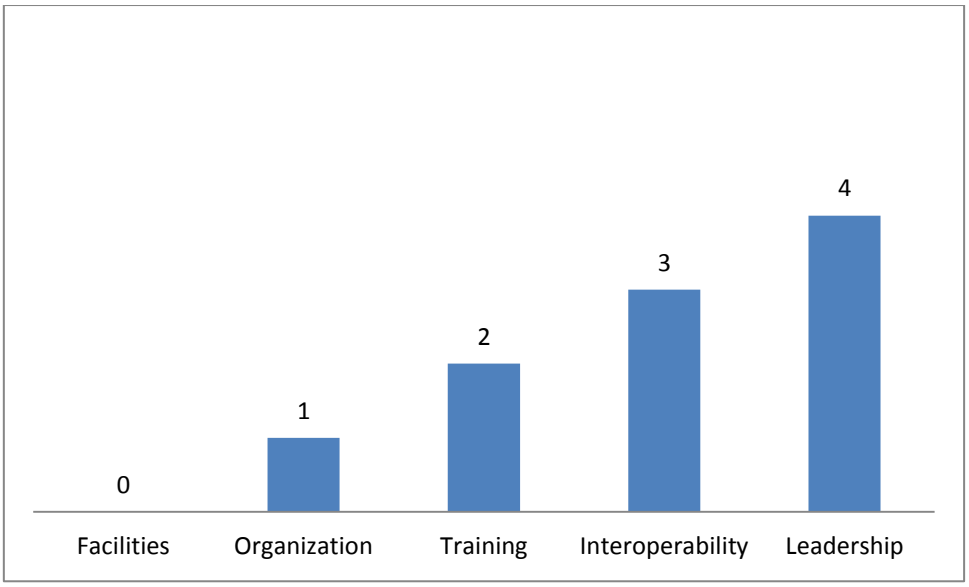
[9] Sigurdur Helgason, "International Benchmarking: Experiences from OECD Countries", Paper Presented at a Conference Organised by the Danish Ministry of Finance on International Benchmarking, Copenhagen, 20-21 February 1997, p. 2, www.oecd.org/governance/budgeting/1902957.pdf.

[10] Tobias Feakin, Jessica Woodall and Liam Nevill, "Cyber Maturity in the Asia-Pacific Region 2015", Canberra: Australian Strategic Policy Institute, 2015, https://www.aspi.org.au/publications/cyber-maturity-in-the-asia-pacific-region-2015

[11] These are Feakin, Woodall and Nevill, "Cyber Maturity"; Neil Robinson, Agnieszka Walczak, Sophie-Charlotte Brune, Alain Esterle, Pablo Rodriguez, "Stocktaking study of military cyber defence capabilities in the European Union (milCyberCAP)", Rand Europe, 2013, http://www.rand.org/content/dam/rand/pubs/research_reports/RR200/RR286/RAND_RR286.pdf; and David Ormrod and Benjamin Turnbull, "Toward a Cyber Military Maturity Model", abstract for a presentation at an international conference on Redefining R&D Priorities for Australian Cyber Security, 16 November 2015, University of New South Wales, Canberra, https://www.unsw.adfa.edu.au/sites/accs/files/uploads/Military%20Cyber%20Maturity%20Model%20v1.pdf.

As one example of the limitations of the maturity model approach, the European Defence Agency (EDA) Cyber Maturity Model has been based on a set of desired organizational end-states not external threats. Leaders from 20 participating member states were asked to grade their countries against these hypothetical end-states, not against the capabilities of real-world potential adversaries (such as Russia). Of some note, as illustrated in Figure 1, they graded themselves with "optimal" performance for leadership and lesser grades in every other field of policy, including "non-existent" for facilities development in support of cyber military operations. The question arises as to how good their leadership has been if they judged themselves to be so ill-prepared according to other key metrics. Of some note, the study found that leaders involved in the surveys appeared to be better at cyber exercises than more complex, longer-term efforts (such as developing doctrine and negotiating change). The weakness of over-reliance on cyber exercises without institutionalization of doctrines is that lessons learned usually disappear when the exercise participants move out of their assignments.

FIGURE 1: EU DEFENCE LEADERS SELF-ASSESSMENT OF NATIONAL CYBER MILITARY MATURITY[12]



Legend: 0=non-existent, 1=initial, 2=defined,3-balanced, 4-advanced, 5-optimised

The first main section of this paper lays out selected aspects of what two countries of strategic interest to Australia–China and the United States–have done or may be planning to do in the 10-20 year time frame. Second, the paper previews trends and characteristics of cyber-enabled war, systems for attack and defence, asymmetric warfare, distributed warfare, and scenario planning. In summary, the benchmarks reviewed in the paper are derived from the sources listed in Table 2.

[12] There were 20 participating member states in the survey.

TABLE 2: LIST OF BENCHMARKS DISCUSSED

Future National Defence Postures

China: cyber power intent, cyber S&T intent, distributed cyber war, militia

United States: prompt information dominance, cyber weapons for all, R&D innovation, military education

War avoidance and peace building

Future 'Cyber-enabled war' trends

Future technologies of complex cyber attack and defence (multi-vector, sustained, cyber + kinetic)

Technologies of decision-making

Scenario planning

A comprehensive study of Australia's national security needs in cyber space relying on such benchmarks would require more research, expertise and time than have been available to this author. Therefore the value of this paper is more in its pointing to the need for, and potential scope of a comprehensive, public domain study. No government, much less an Australian government faced with declining technological competitiveness, stagnating R&D investment and stagnating ICT investment, can afford to undertake policy analysis of military cyber needs largely behind the veil and without clear benchmarks.

The discussion in the paper is introduced by a necessary review of the boundaries of the topic of "national security in cyber space" or "cyber-enabled war", premised on the view that Australian policy documents are not as consistent or rigorous in differentiating keys aspects of this as they might be. The NATO Cyber Cooperative Defence Centre of Excellence notes: "There are no common definitions for Cyber terms - they are understood to mean different things by different nations/organisations, despite prevalence in mainstream media and in national and international organisational statements."[13] In Australian policy documents, the term "cyber security" is too often used as a catch all to avoid specific public elaboration of concepts like cyber war and cyber effect operations.

National Security Needs in Cyber Space: Information Dominance

The term "cyber war" is shorthand for a phenomenon that is not easily captured in a single term, much less one that may have shared meaning for people involved in national security policy around the world. The inadequacy of the word "cyber" as a prefix is illustrated quite well by the title of the book, *Cyber War Will Not Take Place*.[14] The book depends in its main argument on a narrow interpretation of the term "cyber war" as one limited to operations in cyber space. As such, the argument is defensible but the number of countries actively preparing for what most of us call "cyber war" is growing. They obviously believe that something like cyber war or war in cyber space may take place. The only way to get around this lack of terminological precision in the word "cyber" is for each publication that uses it to say how it understands the term.

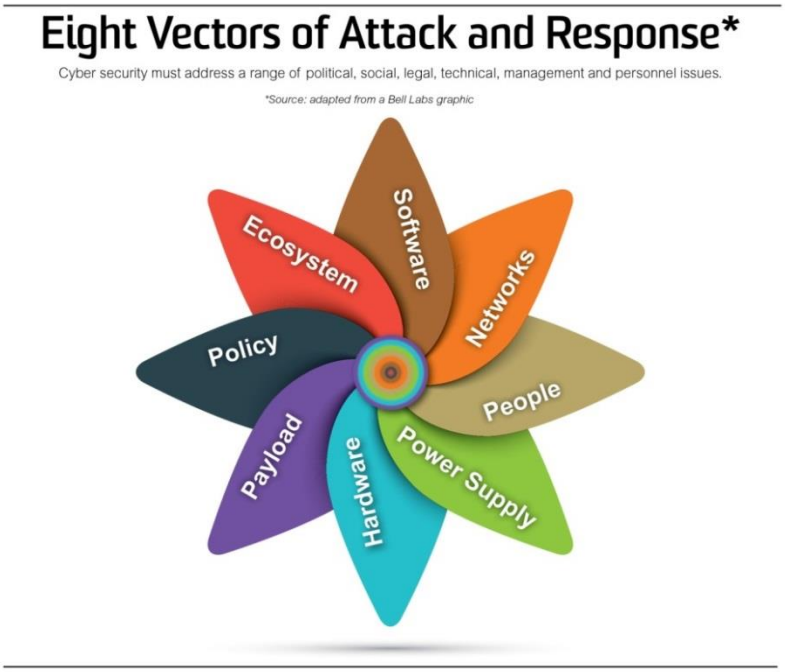
[13] See CCDCOE website: https://ccdcoe.org/cyber-definitions.html.

[14] Thomas Rid, *Cyber War Will Not Take Place*, Hurst: London 2013.

There has to be a clear distinction made between "cyber security" on the one hand and, on the other, discussions of military and defence needs in cyber space. The latter encompasses the former but is very different from it and it involves a much larger canvas of policy.

That said, it is worth reflecting on the concept of cyber security. It has at least eight "ingredients" or foundation elements, some of which some are narrowly technical (but which all involve human input and institutions) and others which are simultaneously technical but are deeply dependent on non-technical inputs. One view of these ingredients is captured in the graphic below which describes these eight ingredients as vectors of attack and response against civil or military targets. Figure 2 shows one conception of a comprehensive view of security in cyber space.

FIGURE 2: A CYBER SECURITY MODEL[15]



Each of the terms describing a vector can be interpreted in different ways, but "ecosystem" is worthy of calling out for explanation as it applies in a national security environment. It must be understood to include the entire "infosphere", including attack and defence systems of potential or actual enemies and allies. This approach is very useful for calling out cyber impacts on warfare and war planning beyond those involving traditional notions of "cyber security" (involving computer software and hardware).

But this was an approach developed by engineers to address problems of protection of information and information systems at the enterprise level in peace time. It is an essential departure point for broadening our understanding of what shapes security in cyber space in the military sphere but it does not do justice to wider institutional, political, legal and social aspects of war fighting in the cyber domain or of kinetic war-fighting dependent on the cyber domain. All military strategy and planning depend on the institutional, political, legal and social environment as much as they do on engineering, systems management or capability-based approaches.

[15] Graphic adapted from a Bell labs graphic and designed by Kurt Barnett, UNSW Canberra.

For this reason, we might understand the term "cyber war" (adapting Clausewitz) to refer to the continuation of politics through cyber means with warlike intent. Cyber means must involve "machine-based computation" with or without support from kinetic military capabilities (missiles, bombs, guns). But "cyber war" independent of the non-cyber domain, is as Rid argues, probably unimaginable. This paper therefore see the interests of national defence planning as better served by using a concept like "cyber-enabled war", since war of any kind is an act involving the political, economic and civilian resources of states, as well as their military technological resources. We must also note that most developed countries depend on computers and IT-based communications systems for the targeting and operation of all modern missiles, bombs and guns.

The use of the term "cyber-enabled war" in this paper should not be seen as conforming to the meaning either of the term "information operations" or the term "cyber space operations", as used by the U.S. Joint Chiefs in their doctrinal publications,[16] since these U.S. terms are intended only to convey the scope of military operations that do not by themselves constitute the totality of state actions in any war, including in "cyber-enabled war". The U.S. government avoids concepts like "cyber war" but in so doing, as is clear in later this paper, they assign an overwhelming centrality in their military strategy to cyber space.

A unifying element between the concept of "cyber-enabled war" and "information operations", is the concept of "information dominance" as the principal organising objective of national security policy (preparation for war) in the information era. Both the United States and China have used this concept but not always with the consistency one might expect.

In sum, the author does not see cyber space as a separate domain[17] of military, social, economic or political life. It cuts across all domains. Cyberspace governs all economic, social, scientific, business and medical activity dependent on any sort of computerized record keeping or more complex analysis. In military affairs, cyber space encompasses the entire fabric of strategic command and control, weapons systems, battle space management and intelligence dissemination, on which national military security depends. Cyber space unifies all domains of warfare, especially its political control and its political impacts.

Moreover, the U.S. Joint Chiefs have identified three layers of policy and operational activity in cyberspace: physical, logical and the "persona", but go further by integrating these into consideration of the environments (informational, operational and political), and considerations like the relationship between information operations and cyber space operations, and the involvement of the private sector.[18]

As of 1 January 2016, Australia had not embraced the idea of "information dominance", preferring a less enthusiastic embrace of the revolution in military affairs by

---

[16] U.S. Joint Chiefs of Staff (JCS), *Cyberspace Operations*, 2013, JP 3-12R, www.dtic.mil/doctrine/new_pubs/jp3_12R.pdf; and U.S. Joint Chiefs of Staff, *Information Operations*, 2012, JP 3-13, www.dtic.mil/doctrine/new_pubs/jp3_13.pdf.

[17] The choice by the United States government and its armed forces to refer to cyber space as a fifth domain is understandable from an organizational point of view. It was easier politically for the government to stand up its new Cyber Command as a separate command if it was presented as an add-on to the existing single services not taking over key parts of them. But it is important to note that language around "fifth domain" is politically loaded and organisationally driven, rather than a statement of reality. The U.S. decision to set up a national Cyber Command announced in mid-2009, was followed by formal establishment of cyber commands in the single services (air force in August 2009, marine corps in October 2009, navy in January 2010, army in October 2010). The USAF had been in lead with its efforts to set up a new cyber command beginning in 2006 but this was subsumed into the idea of setting up a unified command. The single service cyber commands now owe their loyalty as much to the joint Cyber Command and other unified commands as to the single services.

[18] See JCS, *Cyberspace Operations*, 2013, pp. 2-8.

having a doctrine on "information activities". Australia has also been reluctant to acknowledge the U.S. doctrine of "prompt global strike", a cyber-enabled military strategy[19] which is discussed later below and which Russia and China see as particularly ominous. The reluctance of Australia's defence planners has been shaped by the broader national environment. The concept of "information society" as framed around the world does not seem to have as much life in Australia as in most developed countries. This has had a retarding effect on the country's digital preparedness for national security purposes.[20] While the imminent Defence White Paper is likely to provide for elaboration of doctrines of cyber-enabled war in some fashion, the elaboration of a new doctrine can only be the start of a process of change that can take decades to implement and will remain hostage to the broader levels of social response (or lack of it) to the high potential of the information revolution. The essence of this revolution is how information is gathered, aggregated, redistributed and used─ not on how many or what type of computers or IT professionals an organization has.

International Trends in Planning for Cyber-enabled War

Australia's national security needs are shaped above all by what other powerful countries or non-state actors are doing now, are planning to do, or on the balance of probability (or even as a contingency) may do in the future. This section of the paper looks primarily at two cases: China and the United States. Since national security is a balance between political, economic, military and social considerations, any estimate of how the two great powers impact Australian security needs in cyber space must address the full spectrum of national security: economic as well as military. The economic and social bases of national security include a country's national industry base, its scientific and technical potential, and the skills of its people. The political setting is also an essential determinant of war policy, so this section concludes with a review of the dominant trend in war policy globally: that of war avoidance in a situation of cyber arms racing.

Comparing Cyber Military Policy in China and Australia

China is a country of immense national security interest to Australia, not least because of its economic weight and its value to us as an economic partner. Chinese leaders accept the view of the cyber age as being revolutionary in its impact. In February 2014, President Xi told his country and the world that the government would do everything in its power to

[19] The concept of "prompt global strike" evolved over several years between 2003 and 2006, from one related to use of kinetic weapons on a trans-continental basis (hours and minutes) to one that also involved global cyber strike (milliseconds). Key reference documents include U.S. Space Command, "Strategic Master Plan FY06 and Beyond", 2003, www.wslfweb.org/docs/final%2006%20smp--signed!v1.pdf; "The National Defense Strategy of the United States of America", 2005, www.wslfweb.org/docs/final%2006%20smp--signed!v1.pdf (referring only to "prompt global action" in a range of scenarios); and U.S. Department of Defense Report, "Quadrennial Defense Review Report", 2006, www.archive.defense.gov/pubs/pdfs/QDR20060203.pdf. The last document notes (p.29): "Non-kinetic capabilities will be able to achieve some effects that currently require kinetic weapons. The Department will fight with and against computer networks as it would other weapon systems." The idea of "Prompt global strike" is not so much a "doctrine" or strategy as it is a statement of capability and intent, but it has clear implications for strategic stability and deterrence. Russia and China see it as a strategy that has destabilised their security.

[20] See Austin, "Australia's Digital Skills for Peace and War".

become a cyber power.[21] As analysed in my book, *Cyber Policy in China*, this announcement came after almost 15 years after China first committed itself to the goal of what it called informatisation: the maximum exploitation of advanced information and communications technologies to all walks of life, including military power and internal security.[22] The Xi announcement was intended by him to convey the view that China was lagging badly in cyber capability across a broad range of civil and military missions and interests.

Cyber Power Intent: In September 2014, Xi told the country it needed a new cyber military strategy. In December 2014, the government introduced new regulations for cyber security intended to help promote the rapid growth of China's domestic cyber security industry. In May 2015, the country issued a new Military Strategy in which the government declared for the first time in such a document the idea that "Outer space and cyber space have become new commanding heights in strategic competition among all parties".[23]

Since declaring his intent in February 2014 to do everything necessary for China to become a cyber power, President Xi Jinping and his government have been hyperactive on all relevant fronts: political, legal, economic, organisational and diplomatic. Leadership attention to this set of issues became even more focused in May 2014 when the United States indicted five Chinese military personnel for cyber espionage involving commercial secrets of U.S.-based corporations.[24]

Today, China is among the G20 countries with a very high level of government commitment to transform itself to exploit the information revolution. Australia can learn from that level of commitment. In 2015, the World Economic Forum ranked China at 25th in the world in terms of the importance of ICTs in government vision of the future, Australia was at 40th, behind countries like Azerbaijan, The Gambia, Indonesia, Macedonia and New Zealand (ranked 7th). Japan, the Republic of Korea, and Malaysia were ranked ahead of China and Australia in terms of government commitment to "network readiness" and preparation for the information age.

Cyber S&T: The scale of the China's ambition to become a world leader in the S&T base of cyber power is documented in a 2011 plan by the country's Academy of Sciences, called *Information Science and Technology in China: A Roadmap to 2050*. The vision is staggeringly ambitious and complex. It sees China approaching the frontiers of science, economics and social organization in the sphere of information technology by mid-century.

One impetus for the 2011 report was a strategy document, *Technological Revolution and China's Future: Innovation 2050*, from the Academy of Sciences which served not just as an overarching mobilizing document, but also marked the launch of a series of seventeen subsequent sector-based roadmap reports also looking ahead to 2050. The 2009 foundation report on innovation, which had involved some 300 Academy researchers and experts for more than a year, recommended that China prepare itself for a new revolution in S&T in the coming ten to twenty years in green energy, artificial intelligence, sustainable development, information networking systems, environmental preservation, space and ocean systems, and, most interestingly, national security and public security systems.

---

[21] Xinhua, "Xi Jinping Leads Internet Security Group", 27 February 2015, http://news.xinhuanet.com/english/china/2014-02/27/c_133148273.htm.

[22] Greg Austin, *Cyber Policy in China*, Cambridge UK: Polity Press, 2014.

[23] China, Information Office of the State Council, "China's Military Strategy", May 2015, http://news.xinhuanet.com/english/china/2015-05/26/c_134271001.htm.

[24] For an extended discussion of this topic, see Greg Austin, "China's Cyber Espionage: The National Security Dimension and U.S. Diplomacy" Discussion paper, 2015, available at http://thediplomat.com/wp-content/uploads/2015/05/thediplomat_2015-05-21_22-14-05.pdf.

This all means that China as an economic and military actor in cyber space is determined to look and feel very different in 20 years time. For the benchmarking exercise in this current paper, we need therefore to ask how in the next 20 years will China change its S&T profile in cyber space and how we can benefit from that or otherwise secure our national security interests in respect of China? This benchmarking leads not just to an academic comparison of estimated static national capability at given intervals, but also provides an insight into a dynamic policy process inside China in which Australia may seek to intervene to shape China's choices to meet its strategic interests. This has diverse aspects, not least in respect of shaping normative behaviour about cyber war but also in respect of mutually advantageous development of both internationalised and exclusively sovereign R&D capability in both countries.

By way of comparison, Australia's former Chief Scientist, Professor Ian Chubb, observed in September 2014 that Australia is the only country in the OECD without a national plan for science, technology or innovation.[25] At this time, Chubb offered an assessment of where Australia sat in ICT research. He said that there were four fields for which the Australian field-weighted citation rate is higher than the EU15 average—earth sciences, physical sciences, mathematical sciences and the biomedical and clinical health sciences sub-group. Australia's performance in six fields was below the EU15 average, but above the world average—agricultural and veterinary sciences, technology, chemical sciences, engineering, environmental sciences and biological sciences. He reported that one field was below the world average. It was information and computing sciences. In October 2015, in commenting on a new report he commissioned on how to fix weaknesses in Australia's innovation system, he lamented that Australians are complacent about their prosperity.[26]

Until the appointment of Malcolm Turnbull as Prime Minister in September 2015, the last Australian Prime Minister before him to make a speech of any significance or depth on the information revolution had been Paul Keating in 1997, and he made that one year after he left office.

In the Annual report of the Australian Defence Department in 2014, the Secretary of the Department Dennis Richardson called out the proposition that "underinvestment in facilities and ICT is starting to catch up with us and will, unless addressed, have a negative impact on ADF capability".[27] In the subsequent Annual Report, the department graded its ICT performance as less than successful. "Key reform project delivery" by the CIO Group was rated amber, on a four point scale from good to bad (green, blue, amber, red). It rated delivery by the CIO Group of ICT elements of endorsed projects and system enhancements at amber (while four of five of the Group's KPIs, including information security, were rated blue).[28]

On an all of government basis, Australia (like China) has not been performing as well as it might in the ICT sector. Australian government investment in ICT flat-lined between 2008-09 and 2013-14, actually decreasing for both software and hardware, while increasing

[25] Australia. Office of the Chief Scientist. "Professor Chubb Releases 'Science, Technology, Engineering and Mathematics: Australia's Future', Press Release, 2 September 2014. Available at: http://www.chiefscientist.gov.au/2014/09/professor-chubb-releases-science-technology-engineering-and-mathematics-australias-future/.

[26] http://www.abc.net.au/pm/content/2015/s4342492.htm.

[27] Australia. Dept of Defence, "Defence Annual Report 2013-14, Canberra 2014, http://www.defence.gov.au/annualreports/13-14/.

[28] Australia. Dept of Defence, "Defence Annual Report 2014-15, Canberra 2015, http://www.defence.gov.au/annualreports/14-15/.

for people managing the ICT assets.[29] In 2014, the government's audit office assessed that "Agency processes and practices have not been sufficiently responsive to the ever-present and ever- changing [cyber security] risks that government systems are exposed to".[30] Other indicators of Australia's lagging performance in the ICT sector are spelled out at greater length elsewhere.[31]

On current indications, within 20 years, China's civil economic and military capabilities in cyber space will likely be very far ahead of Australia's, whereas today both countries might be judged to be lagging and to have held themselves back in all sorts of ways. A "great leap forward" by China in cyber war S&T relative to Australia is inevitable given China's current wealth and scientific and industrial capability. Australian cannot do much about that. But where China stands out relative to Australia in what both governments can control is in the likely impact over the longer term of Beijing's much higher commitment in the past fifteen years to transformation through cyber S&T compared with the Australian government's lack of commitment in key areas of policy over the same period.

China's Concept of Distributed Warfare: In spite of undoubted successes in cyber espionage by the People's Liberation Army (PLA), China has moved quite slowly to adjust to the opportunities and challenges presented by cyber warfare.[32] As mentioned above, it has made a series of new commitments and taken innovative measures to make the transition more quickly. Among these measures has been a move to joint or unified commands on the model of the U.S. armed forces. This has been based on the strong conviction of Chinese specialists, learning from their American counterparts, that maximum exploitation of and defence against cyber assets can only be assured through inter-service operations and advanced command control systems, which in turn are integrated with space-based surveillance, intelligence and targeting capability (C4ISTAR).[33] It will take China a decade or two to bed down this transition.

Against the background of this perceived need to centralise command and control, and given China's past practices of clinging to outmoded patterns of national level command and control, including compartmented intelligence collection, it is all the more remarkable that it has in 2015 also committed to a countervailing doctrine that accepts the unique characteristic of cyber war called "distributed warfare". This is discussed later in the paper as a general phenomenon of high importance to any advanced country, but its application in the Chinese case is worth calling out. This is the principle that the operational combat environment of cyber-enabled war provides new opportunities for lower level formations widely dispersed to achieve strategic impacts in quite distant theatres. It also captures the consideration that the cyber environment places a premium on decapitation of superior level command authorities and even of basic communications systems in such a way that lower level combat units may need to fight without the benefit of continuous communications and intelligence.

---

[29] Australia. Dept of Finance, 2015, "Australian Government ICT Trends Report 2013-14", http://www.finance.gov.au/sites/default/files/Australian%20Government%20ICT%20Trends%20Report%202013-14_0.pdf.

[30] Australia. Australian National Audit Office, "Cyber Attacks: Securing Agencies' ICT Systems", 2014, http://www.anao.gov.au/Publications/Audit-Reports/2013-2014/Cyber-Attacks-Securing-Agencies-ICT-Systems/Audit-summary.

[31] See for example, Austin, "Australia's Digital Skills for Peace and War".

[32] This is discussed at length in Austin, *Cyber Policy in China*, Chapter 5.

[33] C4ISTAR is a U.S. military acronym standing for "command, control, communications, computers, intelligence, surveillance, target acquisition, reconnaissance".

For China, recognition of this concept at the same time as it is moving towards centralisation is all the more remarkable. It has been captured in a turn of phrase in the 2015 military strategy: "you fight your way, I fight my way" in Section 3, "Guidelines of Active Defence": "the armed forces will adhere to the principles of flexibility, mobility and self-dependence so that 'you fight your way and I fight my way'. Integrated combat forces will be employed to prevail in system-vs-system operations featuring information dominance, precision strikes and joint operations."[34] The two sentences presented together make plain the need for self-dependence even in operations intended to achieve information dominance.

In practical terms, it will take some five to ten years for China to develop its forces to any meaningful capability in this direction, but when it does achieve such a capability it will be at a scale that dwarfs that of smaller, less wealthy countries, such as Australia.

One practical implication of the shift in Chinese doctrine might be that any country operating with or against Chinese forces may well face isolated warships or ground force units acting confidently but with superseded orders and/or degraded intelligence assets because they have been cut off from superior echelons. This circumstance would not be desirable in fast-moving combat regardless of whether one is fighting with or against China.

Militia: China has two levels of reserve forces: what might be called normal reserve forces (reasonably well trained personnel and units that can be mobilised for combat anywhere in the service of the country; and far less trained militia units which are normally assigned to civil defence tasks in their own locality. China has been developing cyber military capabilities in some militia units. While this might be construed as related to civil defence tasks in the home province, such as protection of cyber aspects of critical infrastructure, the character of cyber war is far different from kinetic warfare which has always been shaped by geographic proximity to one degree or another. Since this civil defence function of militia has been revived and professionalised by Chinese leaders in the past decade and since the Chinese government has developed a massive internal surveillance and communications take-down capability based on cyber assets, China is exceptionally well placed to develop the most powerful and best-organized cyber militias in the world. It does not now have such a strong capability but it has taken steps along this path.

One added reason for China to develop cyber militia for integration into strategic and operational military tasks in wartime or in preparation for war is that it can draw on a massive pool of personnel in the civil work force who have high skills in their normal employment, in contrast to the PLA and reserve forces which will probably not have large numbers with the necessary skills on a scale that can compete with the U.S. forces for several decades. In the 10 to 20 year time frame, China's capability in cyber war will need to be assessed against the certain availability of a skilled workforce that no Western country could easily marshal in support of state policy short of an all-out declaration of war and time for mobilisation.

Countries like Australia with a small highly trained cyber work force in uniform can usefully learn from the Chinese conditions that could, in a ten to fifteen year time frame, create a unique and powerful cyber militia capability.

Comparing Cyber Military Policy in the United States and Australia

Prompt Information Dominance: Australia's principal ally, the United States, has a military strategy premised on information dominance as the foundation for what it calls "prompt global strike". This is a strategic objective in war, not just a tactical or theatre-level ambition. In conformity with this strategy, the United States is investing heavily in military

[34] See http://www.chinadaily.com.cn/china/2015-05/26/content_20820628_3.htm.

uses of cyberspace and undertaking a rapid transformation of its forces. In 2015, the Pentagon issued a new Cyber Strategy[35] and the Commander of Cyber Command, Mike Rogers, issued a new planning document, titled "Beyond the Build".[36]

In U.S. planning, "cyber effect operations" in wartime seek to impair the confidentiality, integrity or availability of not just the machines but the data contained therein. This can include penetrating enemy intelligence systems and altering the information about one's own forces or even information about the disposition of the opposing country's forces. A Presidential Directive says that the United States will seek to apply "cyber effect operations" (COE) in all spheres of national activity affecting war, diplomacy and law enforcement.[37] It says that offensive COE (OCOE) "can offer unique and unconventional capabilities to advance U.S. national objectives around the world with little or no warning to the adversary or target and with potential effects ranging from subtle to severely damaging". A Pentagon Law of War Manual issued in June 2015, and prepared with input from Australian military lawyers, says it is lawful for a country in wartime to undertake pre-emplacement of "logic bombs" in an enemy country's networks and information systems.[38]

But there is a deeper dimension to the U.S. concept of cyber war beyond "information operations" or "cyber effect operations". It relates to the role of information and how a country's military power and strategic impact in war can be magnified by cyber means. In November 2012, the U.S. Joint Chiefs of Staff issued a new joint training manual on "Information operations".[39] It identified the information environment as the aggregate of "individuals, organisations, and systems that collect, process, disseminate or act on information". This is a strategic level orientation in which the United States aims above all else to disrupt the enemy's decision-making as a prelude to and adjunct for kinetic operations: the integrated employment during military operations of information capabilities "in concert with other lines of operation, to influence, disrupt, corrupt, or usurp the decision making of adversaries and potential adversaries while protecting our own." Cyber space operations, covered in part by a separate military doctrine (Joint Publication) under that rubric, provide a sub-component to information warfare strategy.[40]

There are significant innovations in the 2015 policy statements from the Pentagon, including recognition in "Beyond the Build" that cyber defences in DoD are weaker than the threats it faces and that military units must be able to operate with degraded systems and a

---

[35] United States. Department of Defense. "DoD Cyber Strategy", Washington DC, 2015, http://www.defense.gov/Portals/1/features/2015/0415_cyber-strategy/Final_2015_DoD_CYBER_STRATEGY_for_web.pdf.

[36] U.S. Cyber Command, "Beyond the Build: Delivering Outcomes through Cyberspace", U.S. Department of Defence, Washington DC, June 2015, http://www.defense.gov/Portals/1/features/2015/0415_cyber-strategy/docs/US-Cyber-Command-Commanders-Vision.pdf.

[37] United States. The White House. "Presidential Policy Directive 20: U.S. Cyber Operations Policy", 2012, available at: http://fas.org/irp/offdocs/ppd/ppd-20.pdf.

[38] United States. Department of Defense. *Department of Defense Law of War Manual*, Washington DC, 2015, p.995, http://www.defense.gov/Portals/1/Documents/pubs/Law-of-War-Manual-June-2015.pdf. The chapter on cyber operations specifically allows for pre-placement in wartime of cyber weapons (often called time-release "logic bombs"): "Cyber operations can be a form of advance force operations, which precede the main effort in an objective area in order to prepare the objective for the main assault. For example, cyber operations may include reconnaissance (e.g., mapping a network), seizure of supporting positions (e.g., securing access to key network systems or nodes), and pre-emplacement of capabilities or weapons (e.g., implanting cyber access tools or malicious code)." While this statement in the manual refers to the U.S. view of its own actions in wartime, it would also be regarded by most states as the applicable international law in peacetime.

[39] JCS. "Information Operations".

[40] JCS. "Cyberspace Operations".

lack of cyber situational awareness (including command and control, intelligence and targeting data).

The most important lesson from the 2015 "DoD Cyber Strategy" is that to be effective in cyber-enabled war a country needs to plan for it, structure its forces accordingly, train them for it and develop the foundations for public engagement in it. The strategy document makes plain that there are so many foundations of cyber war that need to be out in the open, ranging from critical infrastructure protection to industry-based R&D and developing a civilian cyber work force. The document makes plain that any country intent on fighting a cyber capable adversary will be more effective the more it can talk publicly about the detail.

By comparison, there has been no such recognition in Australian policy documents of the novel, arguably central role, of cyber-enabled warfare. Of some note, as of 12 January 2015, the term "cyber effect" does not appear to be found anywhere on the Australian Department of Defence website, except in a submission for the Defence White paper by this author. It is more than likely that the concept is well known in development work in the ADF and that the ADF has already conducted cyber effect operations of some kind.[41] On the UK Ministry of Defence website there is not a similar aversion to the term, though one finds quickly a plea on 24 September 2015 by the current Secretary for Defence in the UK, Michael Fallon, to "put cyber front and centre of our thinking".[42]

Cyber Weapons for All: In spite of billions of dollars spent, new forces and command entities raised, and military education and recruitment revamped, the United States has in 2015 recognized how far it has yet to travel. On 3 June, the Commander of U.S. Cyber Command, Admiral Mike Rogers, observed as follows: "Our task is to make this domain understood by other warfighters and integrated into broader military and governmental operations while providing decisionmakers and operational commanders with a wider range of options while resources are constrained and threats are growing".[43] In this short report, titled "Beyond the Build: Delivering Outcomes through Cyberspace", Adm. Rogers emphasized the need to be able to offer commanders and policy makers "cyber tools in all phases of operations" and an increase in momentum in building both "capacity and capability". One report of a large project on U.S. decision-making for information operations found that the DoD does not yet understand how to measure the decision-making agility of a cyberspace operations organization".[44] These concepts rarely receive a public airing in Australia.

R&D Innovation: One key element of U.S. national policy is its recognition of the need to "Leverage the nation's ingenuity through an exceptional cyber workforce and rapid technological innovation".[45] It was expressed in just that language in the 2011 strategy which was the predecessor to the 2015 strategy.

In 2011, this was held up as one of the Department's five principal strategies for cyberspace. The language was not picked up in the same way in the 2015 strategy which has a much sharper focus on operational aspects of the cyber war problem. Yet the centrality of

---

[41] This can be deduced from the public references to deployment of Defence civilian cyber specialists to combat areas in Afghanistan.

[42] Michael Fallon MP, Speech to Cyber Symposium 2015, Paris, 24 September 2015, https://www.gov.uk/government/speeches/cyber-symposium-2015.

[43] Cyber Command, "Beyond the Build".

[44] Steven W. Stone, "Factors Influencing Agility in Allocating Decision-Making Rights for Cyberspace Operations", 20th ICCRTS Paper 096, June 2015, p. 1, http://static1.squarespace.com/static/53bad224e4b013a11d687e40/t/54da5be5e4b0e9d26e577151/1423596517506/096.pdf. Cited with the author's permission.

[45] United States. Department of Defense. "Department of Defense Strategy for Operating in Cyberspace", Washington DC, 2011, p. 11, available at: http://www.defense.gov/news/d20110714cyber.pdf.

the civil sector underpinning of the country's cyber war capability is visible through the 2015 document. The references from the 2011 strategy provide a more concentrated expression of the set of issues involved, and these are highly relevant to the Australian case. It makes the obvious commitment to catalysing new education opportunities in a situation of high and unmet demand: "catalyse U.S. scientific, academic, and economic resources to build a pool of talented civilian and military personnel to operate in cyberspace". But it says that its plans in this area of skill development will be paradigm changing and will include the private sector:

- streamline hiring practices for its cyber workforce
- exchange programs to allow for "no penalty" cross-flow of cyber professionals between the public and private sectors to retain and grow innovative cyber talent
- adoption and scaling of cross-generational mentoring programs
- the development of Reserve and National Guard cyber capabilities
- infusing an entrepreneurial approach in cyber workforce development
- preserving and developing DoD's intellectual capital
- replicate in the DoD the dynamism of the private sector
- harness the power of emerging computing concepts (especially speed and incremental development rather than a single deployment of large, complex systems)
- opportunities for small and medium-sized businesses and entrepreneurs to move concepts rapidly from innovative idea, to pilot program, to scaled adoption across the DoD enterprise
- emphasise agility, embrace new operating concepts, and foster collaboration across the scientific community.

Thus, for the United States, the national goal to ensure military competitiveness in cyber space depends on a "paradigm changing" approach to innovation, national education and work force development and how these are then reflected in paradigm changing approaches to military workforce development and deployment. There is almost no evidence in the public domain that Australia has such a comprehensive view of how to make this paradigm shift.

Military education: On a narrower military front, we can look at the education of junior officers and the role of their officer training academies in cyber policy development. The U.S. Military Academy at West Point is arguably the most advanced in all aspects. Here are some highlights:

- in 2001, it became the first undergraduate institution the National Security Agency certified as a "Center of Excellence" in Information Assurance Education
- in 2014, it ranked 9th among more than 5,000 tertiary education providers in the United States in terms of quality of education in cyber security
- a Cadet Cyber Enrichment Program offering internships in industry
- a Cyber Leaders Development Program providing up to 800 hours non-academic training for each cadet
- a community outreach program where cadets teach local students cyber security
- an Army Cyber Institute (cyber warfare research and teaching, set up in 2014; planned for 75 staff by 2017, funded in excess of $20 million) which involves cadets in its work
- Co-publisher of the journal *Cyber Defense Review* (launched February 2015)
- Cyber Research Centre (in the Electrical Engineering and Computer Science Faculty)
- Host of the first Joint Service Academy Cyber Security Summit in May 2015.

The United States Air Force Academy (USAFA) has extensive cadet-based programs in cyber security, outer space operations and broader challenges of technological and management innovation. Its Center of Innovation combines a range of disciplines pertinent to the broader information revolution in civil affairs or the revolution in military affairs.[46] The U.S. Naval Academy has an undergraduate major in Cyber Operations.

In comparison, Australian officer cadet pathways involving cyber military issues are seriously underdeveloped, though the Australian Defence Force Academy may have created a world first when it inaugurated a compulsory undergraduate course in cyber security in 2015.

War Avoidance and Peace Building

Australia's national security needs in cyber space are driven above all else by the goal of war avoidance in which diplomacy and politics are the main tools. Therefore the trend in global politics toward or away from confrontation in cyber space or on cyberspace issues should be a major driver of the country's national security planning. The global trend on this front is mixed, with both increasing tensions and stepped-up efforts to reduce tensions. The seriousness of this consideration should not be under-estimated.

The importance can be illustrated at one extreme end of the spectrum by developments involving the nuclear forces of Russia and the United States.[47] The question of strategic nuclear stability, and changes in it, impacts on Australia in two ways. First, strategic nuclear stability conditions and shapes overall strategic stability, an objective described in Australia's National Security Strategy as "promoting a secure international environment conducive to advancing Australia's interests". Second, it involves U.S. C4ISTAR cyber assets in Australia that are involved in nuclear weapons preparedness. The command and control of nuclear weapons, especially their targeting but also early warning, depend in part on a securable cyber space.

In June 2013, Russia and the United States agreed to set up a cyber-risk reduction center (a hot line) staffed by technical specialists inside the existing bilateral nuclear risk reduction center. Its purpose is to allow the two countries to exchange information on cyber incidents that might impinge on nuclear military readiness. This was an important development in the bilateral cyber military relationship.[48]

Yet in December 2014, Russia's revised military doctrine declared that the U.S. cyber-enabled strategy of "Prompt Global Strike" is one of Russia's four main military dangers, having been a little more circumspect in its 2010 doctrine with the statement that the only military nuclear threat it face was "disruption of the functioning of its [Russia's] strategic nuclear forces, its systems of missile warning and control in outer space or of nuclear munitions storage facilities".[49] In October 2014, Russia had already acted on its increased concern, including through the deployment into its strategic missile forces of cyber

[46] See the center's website http://www.usafa.edu/df/dfe/dfer/centers/coi/.

[47] For an extended analysis, see Greg Austin and Pavel Sharikov, "Preemption is Victory: Aggravated Nuclear Instability of the Information Age", Working Paper, January 2015.

[48] For an extended discussion of the evolution of that relationship, see Franz Stefan Gady and Greg Austin, "Russia, the United States, and Cyber Diplomacy: Opening the Doors", EastWest Institute, New York/Brussels/Moscow, September 2010, http://www.eastwest.ngo/sites/default/files/ideas-files/USRussiaCyber_WEB.pdf.

[49] "The Military Doctrine of the Russian Federation", 5 February 2010, translation, Carnegie Endowment, http://carnegieendowment.org/files/2010russia_military_doctrine.pdf. This statement is also in its 2014 doctrine. See "Military Doctrine of the Russian Federation" (*Voennaya doktrina Russkoi Federatsii*), issued December 2014, http://news.kremlin.ru/media/events/files/41d527556bec8deb3530.pdf.

defence units for the first time.[50] This link between cyber risk reduction and nuclear threats goes a long way to explaining rhetoric like a "cyber Pearl Harbor" used by former CIA Director Leon Panetta in October 2012.

The case of United States/China relations on military uses of cyber space is also very important in terms of overall strategic stability. According to the few authoritative sources available, China's military leaders are deeply disturbed by U.S. policy and see it as new evidence of muscle-flexing and dominating behaviour.[51] This concern is aggravated by perceptions of inadequacy in cyber warfare capabilities relative to the United States, and a sense in China of profound weakness in the face of the information and electronic warfare power of the Americans' global alliances. The core diplomatic challenge is how to manage the asymmetry in cyber military power (which will persist for some time) without falling into a new Cold War.[52]

At the other end of the spectrum of cyber space interaction among states are a string of cooperative measures by states over more than decade in multilateral and bilateral settings. These include agreements in the G20, APEC, the ASEAN Regional Forum and various iterations of a Group of Governmental Experts (GGE) under the auspices of the United Nations looking at international security aspects of information and communications technology.[53] By 2015, the overwhelming message of these initiatives was that global and national economic stability, as well as plain good governance, depend on constraining state-on-state cyber attacks in peacetime.[54] An equally important objective of these efforts has been to contain cyber probing and attacks in order to prevent unintended conflict escalation. The management of these issues was seen as a protracted but feasible process in an environment where all major powers not only see war amongst them as highly unlikely but also hold up this view as a major plank of policy.

The most surprising moves in 2015 were bilateral. On 8 May, China and Russia concluded a formal agreement with Russia not to interfere unlawfully in each other's information resources and networks.[55] Second, China and the United States agreed to negotiate a "code of conduct" of some kind in cyberspace.[56] (In January, China and Russia

---

[50] RIA Novosti, "Russia Strategic Missile Forces Create Cybersecurity Units: Defense Ministry", 16 October 2014, http://sputniknews.com/military/20141016/194157367/Russian-Strategic-Missile-Forces-Create-Cybersecurity-Units.html.

[51] See Greg Austin, "Managing Asymmetries in Chinese and American Cyber Power", *Georgetown Journal of International Affairs*, "International Engagement on Cyber IV", October 2014, 141-151; and Austin, *Cyber Policy in China*.

[52] For an extended analysis of background to U.S./China relations on cyber space issues and policy recommendations, see Greg Austin, "China's Approach to International Legal Norms for Cyber Space", (in publication with the NATO Cyber Defence Centre of Excellence); and Greg Austin and Franz Gady, "Cyber Detente between the United States and China", EastWest Institute, New York/Brussels/Moscow, November 2012, http://www.eastwest.ngo/idea/cyber-detente-between-united-states-and-china.

[53] An extensive overview of these can be found in Greg Austin, Bruce McConnell, Eric Cappon, Nadya Kostyuk, "A Measure of Restraint in Cyberspace: Reducing Risk to Civil Nuclear Assets", EastWest Institute, 2014, pp. 13-14, http://www.eastwest.ngo/sites/default/files/A%20Measure%20of%20Restraint%20in%20Cyberspace.pdf.

[54] Progress in 2015 has been summarized in Greg Austin, Bruce McConnell and Jan Neutze, "Promoting International Cyber Norms: A New Advocacy Forum", EastWest Institute, New York, December 2015, http://www2.ewi.info/idea/slowing-cyber-arms-race.

[55] For a text of the approved agreement, see Russia. Federal Government. Order on the Signing on an Agreement between the Russian Federation and the People's Republic of China on Cooperation in the Field of Securing International Information Security, (in Russian), Moscow, 30 April 2015, http://pravo.gov.ru/laws/acts/34/555656451088.html.

[56] U.S. Secretary of State announced on 23 June 2015 the following: "We believe very strongly that the United States and China should be working together to develop and implement a shared understanding of appropriate

had participated in tabling a slightly revised draft of the proposed code of conduct for cyberspace initially submitted to the United Nations in 2011.)[57]

By signing the new bilateral agreement in May, China and Russia together appear to have pre-empted the advisory effect of the GGE report, and its recent predecessors, to give legal effect to some of the principles proposed. The bilateral agreement goes very close to constituting a formal military alliance in cyber space, since it lays out a mutual obligation of assistance in the event of a wide range of cyber attacks.

The Russia/China agreement is a fulfilment of a decade of involvement by the two countries in cooperative measures on cyber space governance, including through the Shanghai Cooperation Organization talks beginning in 2006. The new agreement formalizes at a bilateral level an intensifying multilateral effort building off the proposal in the UN system for a code of conduct in cyberspace. The agreement is as much about that effort as it is about strengthening each other in the face of US cyber pre-eminence. Article one describes malicious use of cyber space "as a fundamental threat to international security". Article 4 only commits the two countries not to undertake actions like "unlawful use or unsanctioned interference in the information resources of the other side, particularly through computer attack".

This is not a commitment to refrain from all use of military cyber assets against each other. Article 4 only says that each country has the equal right of self-defence in cyber space against "unlawful use or unsanctioned interference in the information resources of the other side, particularly through computer attack". Neither Russia nor China regards cyber espionage or preparations for war in cyberspace as "unlawful" or "unsanctioned". Of some note, Article 6.2 commits both parties to protect state secrets of the other, and references a prior bilateral treaty with that precise effect dating from 24 May 2000.

In early September 2015, in advance of a state visit by President Xi Jinping to the United States, China sent the Politburo member with responsibility for its non-military spy agencies, Meng Jianzhu,[58] to Washington for several days of official discussions to try to dampen controversies within the United States about the norms of cyber espionage.[59] This was at that time the high point in direct official contact on the subject resulting from a robust diplomatic campaign by the United States which reached a new peak in March 2013 when

---

state behavior in cyber space, and I'm pleased to say that China agreed that we must work together to complete a code of conduct regarding cyber activities." See United States, Department of State, The Strategic & Economic Dialogue / Consultation on People-to-People Exchange Closing Statements, Washington, DC, June 24, 2015, http://www.state.gov/secretary/remarks/2015/06/244208.htm. While Kerry implies that this was a U.S. proposal, it appears to have been a Chinese proposal, flagged in the opening remarks several days earlier by China, rather than a United States proposal, and it had been China's policy since 2011 at least.

[57] See United Nations, Letter dated 9 January 2015 from the Permanent Representatives of China, Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan and Uzbekistan to the United Nations addressed to the Secretary-General, A/69/723, 13 January 2015, https://ccdcoe.org/sites/default/files/documents/UN-150113-CodeOfConduct.pdf.

[58] Of special note, Meng controls the civilian spy agencies (Ministry of State Security for external intelligence and Ministry of Public Security for domestic intelligence). He does not control the main signals intelligence agency of China which sits in the People's Liberation Army, under the control of the Central Military Commission of the Chinese Communist Party (CCP). Meng is the Secretary of the Central Political and Legal Commission of the CCP, one of the most powerful political bodies in the country because of its role is the protection of all aspects of the "political and legal" system in the country.

[59] White House, "Readout of Senior Administration Officials' Meeting with Secretary of the Central Political and Legal Affairs Commission of the Communist Party of China Meng Jianzhu", 12 September 2015, https://www.whitehouse.gov/the-press-office/2015/09/12/readout-senior-administration-officials-meeting-secretary-central.

National Security Adviser Thomas Donilon made public demands on China to abide by rules of the road prohibiting cyber espionage for commercial purposes.[60]

The Meng visit was highly productive, with the two countries agreeing not to conduct commercial espionage against each other for the benefit of their own companies and to set up a Cabinet-level working group for problem solving on cyber security issues from a law enforcement angle.[61]

Just weeks earlier, the United Nations published the report of the fourth Group of Governmental Experts (GGE) on certain aspects of information and telecommunications affecting international security.[62] With Chinese representation in the GGE, this report marked a new peak in intergovernmental consensus on some related issues, including most importantly the endorsement of a range of possible "voluntary, non-binding norms, rules or principles" for restraint in international cyber practices.

The 2015 GGE report reached agreement on three important and potential "voluntary non-binding norms" for state behavior in cyber space:

- states should not attack each other's critical infrastructure for the purpose of damaging it
- states should not target each other's cyber emergency response systems
- states should assist in the investigation of cyberattacks and cybercrime launched from their territories when requested to do so by other states.[63]

As promising as these moves in the direction of restraint and war avoidance have been, they only begin to scratch the surface of what is needed. There is no commitment among the major military powers of the world to any idea of military sufficiency in cyber space or the idea of the security dilemma (the concept that by strengthening one's own military power, this weakens a state's security because it prompts military rivals to increase their capabilities).

Australia has been deeply involved in many of these initiatives over the past decade, including through chairing one iteration of the UN GGE over several sessions. At the same time, the absence of highly developed positions in Australia on many of the military aspects of cyber space means that the Australian diplomacy on cyber war avoidance and restraint in cyber space operates on a somewhat narrow and under-resourced channel.

Cyber War: Trends and Technologies

In 2009, Martin Libicki, one of the most respected scholars of cyber warfare, concluded in a report he wrote for the United States Air Force that "strategic cyberwar is unlikely to be decisive" and that "operational cyberwar has an important niche role but only that".[64] In 2012, Thomas Rid and Peter McBurney from King's College London make an important distinction between target-specific cyber weapons that may be high value in terms

[60] Greg Austin, "Cybersecurity: The Toughest Diplomatic Challenge Is China's Weakness", The Global Journal, April 2, 2013, http://theglobaljournal.net/article/view/1049/.
[61] For further analysis of the agreements, see Greg Austin, "Why the China-US Cyber Agreement May Prove Destructive", The Diplomat, 7 October 2015, http://thediplomat.com/2015/10/why-the-china-us-cyber-agreement-may-prove-destructive/.
[62] United Nations, "Report of the Group of Governmental Experts on Developments in the Field of Information and Telecommunications in the Context of International Security" (UN GGE 2015), A/70/174, 22 July 2015, http://www.un.org/ga/search/view_doc.asp?symbol=A/70/174.
[63] UN, GGE 2015.
[64] Martin C. Libicki, *Cyberdeterrence and Cyberwar*, Santa Monica CA: Rand Corporation, 2015.

of effect and those of more general application (not target-specific) that are of lower value in terms of effect.[65] They say there is a clear penalty involved in developing the high-value weapons which "increase the resources, intelligence and time required for development and deployment" and are "likely to decrease the number of targets" and the "political utility of cyber-weapons".

These assessments are sound, but they must be interpreted against the definitions of "cyber war" or "cyber weapon" that the authors use. In the Libicki case, his definition of cyber war was a narrow one (does not involve "real" war, that is a physical one),[66] and Rid and McBurney define a cyber weapons as "computer code that is used, or designed to be used, with the aim of threatening or causing physical, functional, or mental harm to structures, systems, or living beings."[67]

There are at least three important dimensions of the policy problem presented by cyber-enabled war that such assessments do not take into account:

- will the cost/benefit relationship in technical development and use of cyber weapons change in the 10-20 year time frame?
- will the political character of a cyber weapons change as countries accumulate entire cyber arsenals, rather than single cyber weapons?
- does the political character of a cyber weapon change as countries move away from conventional military strategies to information age strategies where information dominance is judged to be the decisive capability?

My answer to all three questions would be yes. Over time, the conclusions by Libicki, Rid and McBurney are likely to be less relevant. For the purposes of this paper, we must note the highly dynamic character of the policy field represented by cyber-enabled war as countries accumulate capability, as technological options expand, and as key governments of interest continue to move decisively toward information dominance as an over-arching military strategy.

One of the best descriptions of the trends may be a 2011 book, *America the Vulnerable*, by the former Inspector General of the U.S. National Security Agency, Joel Brenner, who takes a distinctly non-technical approach and accords political and economic underpinnings of war and strategy a higher place than most specialists on cyber war.[68] While not agreeing with a number of his conclusions, I would like to illustrate the preceding point by calling out his understanding of how China has reacted to U.S. and Allied capability for information operations over the time since the first Gulf War in 1991 with a deepening and quickening attention to cyber warfare.[69] This is laid out in different parts of the book,[70] and is essential for understanding that the technologies and strategies of cyber-enabled warfare are not static─anything but! One essential take away from the Brennan book is that cyber war as a real-life phenomenon (budgets, soldiers, politicians, industry and war-fighting) is only in its infancy and that it may be about to mature very quickly.

A second essential conclusion from the Brennan book is a very stark one that has grave national security implications for Australia's war planning and is one that successive

---

[65] Thomas Rid and Peter McBurney, "Cyber Weapons", *RUSI Journal*, February/March 2012, vol. 157, no. 1 pp. 6–13, 6, https://www.rusi.org/downloads/assets/201202_Rid_and_McBurney.pdf.

[66] In his chapter six, Libicki looks at the relationship between the two forms of war.

[67] Rid and McBurney, p. 7.

[68] Joel Brenner, *America the Vulnerable: Inside the New Threat matrix of Digital Espionage, Crime and Warfare*, New York: Penguin Press, 2011.

[69] Brenner, *America the Vulnerable*, 117-9, 121-2, 125-7, 130-1, 131-36, 137-47, 153-4.

[70] His mention in one place of China's understanding of Australia's role in U.S. global capability is worthy of note (p. 120).

Australian governments have found hard to acknowledge directly. Brenner concludes that his country "cannot defend our [its] electronic networks that control our energy supply, keep aircraft from colliding in midair, clear financial transactions, or make it possible for the President to communicate with his cabinet secretaries".[71] For any country, as cyber war capabilities of potential adversaries expand, those highly vulnerable aspects of cyber civil infrastructure that underpin military preparedness, including mobilization of forces through civil airspace, also become more likely targets.

Brenner aptly titles his first chapter, "Electronically Undressed". If the United States cannot defend its critical infrastructure in cyber space at present, and it cannot, and if the world is on the edge of a rapid expansion of cyber warfare capabilities by countries of interest to Australia, this would appear to have implications which Australian governments should publicly acknowledge and to which they should more consistently provide appropriate responses.

Brenner outlines a suite of policy measures, most of which are highly reasonable. While few address issues of war fighting capability or strategy, all of them represent potential contributions to national security preparedness in cyber space. For example, he calls out the need to move toward highly secure computing ("verifiable software and firmware") by promoting public support for research in this area. The implications of this transition are spelled out at length in a 2014 paper from the EastWest Institute, which argued that governments have tolerated for too long the exposure of their security to the vulnerabilities (of the sort outlined by Brenner).[72] This EastWest paper called on them to "send clear [market] signals to enable security-driven IT innovation, starting top-down with the highest security requirements in the highest value targets". As importantly, it urged governments to "cooperate internationally to realize this new paradigm quickly and to stem the evolution of high-end cyber attackers before they can inflict more damage".

The Brenner book is but one of many sources indicating the scale of the challenge in national security arising from the rapidly intensifying transformations of the information age. A policy framework that is slow, incremental and largely oblivious to the emerging trends of cyber war (the sort of framework Australia has had) will fail badly. For this reason, the September 2015 document, "Beyond the Build", issued by the Commander of U.S. Cyber Command, Adm. Rogers, and referred to above, must stand as a summary indicator of where all countries seeking to maximize national security and cyber war planning must head in the 10-20 year time frame.

We might note and contrast three assessments which highlight the forward planning aspect, one backward-looking Australian assessment and the other two looking to the future from U.S. sources:

- *ACSC 2015 Threat Report:* "Australia has not yet been subjected to any activities that could be considered a cyber attack"[73]; "Robust cyber defences will continue to allow a high degree of confidence in network and information security."

---

[71] Brenner, *America the Vulnerable*, p.245.

[72] Sandro Gaycken and Greg Austin, "Resetting the System: Why Highly Secure Computing Should Be the Priority of Cybersecurity Policies", EastWest Institute, New York/Brussels/Moscow, January 2014, p.5, http://www.eastwest.ngo/sites/default/files/Resetting%20the%20System.pdf.

[73] Australian Cyber Security Centre (ACSC), "Threat Assessment 2015", pp.8, 24. Cyber attack is defined by ACSC as follows: "Includes deliberate acts through cyber space to manipulate, destruct, deny, degrade or destroy computers or networks, or the information resident in them, with the effect, in cyber space or the physical world, of seriously compromising national security, stability or prosperity". See https://www.acsc.gov.au/publications/ACSC_Threat_Report_2015.pdf.

- *U.S. Worldwide Threat assessment 2015*: "2014 saw, for the first time, destructive cyber attacks carried out on US soil by nation state entities" "we must be prepared for a catastrophic large scale strike – a so-called cyber Armageddon" … "unpredictable instability is the new normal"[74]
- Georgia Tech: *Emerging Cyber Threats Report 2015*: "Low-intensity online nation-state conflicts become the rule, not the exception"[75]

The differences between the first of these assessments and the other two could not be more stark. The ACSC seems to be saying that since Australia has not been attacked, the country can be confident that it is secure in cyber space. The other two assessments from U.S. sources paint a very different picture: Australia has probably been attacked and does not know it and it is no more secure, probably less so, than the United States from imminent and longer term future threats.

Special Features of Cyber War

Leaving aside the great powers preparations for cyber war for a moment, there are other important politico-strategic aspects of war in cyber space that have relevance regardless of the country involved and which are also likely to evolve in the next 10-20 years in ways that Australia should take into account.

First, there is the new potential offered by cyber space for asymmetric warfare by weak military powers (and non-state actors) against states that are clearly superior in conventional (kinetic) military terms. While this concept has been present for a long time, it is not a static phenomenon but changes with advances in technology. According to a study, compiled by the U.S. Director of National Intelligence in 2000, of likely threats to 2015, asymmetric warfare was then the first of only three likely military threats faced by the United States.[76] The other two were strategic threats from weapons of mass destruction and regional conflict threats. The DNI report defined asymmetric conflicts as those in which "state and nonstate adversaries avoid direct engagements with the US military but devise strategies, tactics, and weapons—some improved by 'sidewise' technology—to minimize US strengths and exploit perceived weaknesses". By 2015, the DNI confirmed in its annual worldwide threat assessment just this prognostication, though in slightly different words. Listing "cyber" first in its list of threats, DNI concluded: "the likelihood of a catastrophic attack from any particular actor is remote at this time". He said that the more likely threat, rather than one that debilitates the entire US infrastructure, would be "an ongoing series of low-to-moderate level cyber attacks from a variety of sources over time, which will impose cumulative costs on US economic competitiveness and national security."[77]

---

[74] Director of National Intelligence**,** Remarks as delivered by The Honorable James R. Clapper, Director of National Intelligence, Opening Statement to the Worldwide Threat Assessment Hearing, Senate Armed Services Committee, Thursday, Feb. 26, 2015, http://www.dni.gov/index.php/newsroom/testimonies/209-congressional-testimonies-2015/1175-dni-clapper-opening-statement-on-the-worldwide-threat-assessment-before-the-senate-armed-services-committee**.**

[75] Georgia Tech information Security Centre and the Georgia Tech Research Institute, "Emerging Cyber Threats Report 2015", 2014, p. 13, https://www.gtisc.gatech.edu/pdf/Threats_Report_2015.pdf.

[76] Director of National Intelligence, "Global Trends 2015: A Dialogue about the Future with Non-Government Experts", NIC2000-2, December 2000, http://www.dni.gov/files/documents/Global%20Trends_2015%20Report.pdf.

[77] Director of National Intelligence, "Statement for the Record, Worldwide Cyber Threats, House Permanent Select Committee on Intelligence", James R. Clapper, Director of National Intelligence, September 10, 2015, http://www.dni.gov/files/documents/HPSCI%2010%20Sept%20Cyber%20Hearing%20SFR.pdf.

Second, there is the opportunity for "distributed" warfare, a capability (and arguably a practice) that will become more pervasive over time. In simple terms, distributed warfare is the translation of the national-level use of coercive power to disconnected individual units, mirroring the same decentralisation of political power that has been visible in the role of social media in breaking down the power of authoritarian regimes forces in countries like Egypt or the Hong Kong Special Administrative Region. There are several ways of understanding this phenomenon in respect of military applications. One is to look at the role of patriotic hackers, whose potential in warfare may be likened to partisan forces capable of disrupting an enemy but which are either affiliated loosely with their home government or not connected at all, often acting against its interests or express wishes. Patriotic hacking is an important and evolving phenomenon in Australia's immediate strategic environment, most notably in China, South Korea and Japan.

Another dimension of distributed warfare is the contribution and role of cyber militias, people who have a civilian day job but who can be directed by the national government at short notice to participate in national security activities, including cyber war if need be. As noted above, China has an active program of developing cyber militia units, but also relies on its unique political system to co-opt companies and firms. The United States does not have such an explicit reliance on cyber militias, in part because it has an established network of high-tech companies who can be quickly and easily paid to feed into U.S. national security activities if need be. According to the government, it has at least 10,000 cleared companies it can consult for advice on highly classified technical aspects of the country's intelligence needs.[78]

The above forms of distributed warfare are challenging enough to national security operations, demonstrated not least by the Snowden affair in which one of these paid employees was able to use his individual "network power" to blow open some of the most sensitive aspects of U.S. cyber warfare capability and preparations. The Snowden revelations on Operation Prism, which implicated nine leading U.S. corporations in direct and large scale involvement in U.S. national security missions in cyber space, produced an even more damaging outcome in that these companies reacted by distancing themselves from any political subordination to or co-optation by the national government as participants in distributed cyber warfare capability. Microsoft for example has made plain its position that it treats all clients equally, including the United States and China.[79] This reverse positioning of U.S. corporations away from integration into the distributed warfare assets of the government was evident when U.S.-based company Symantec participated in the analysis of and revelations about Stuxnet, leading to the disruption of that live U.S. intelligence operation and subsequent exposure of it.[80] One implication of this is that Australia must continually evaluate any presumption it makes about the security affiliations and dispositions (patriotic or neutral) of all U.S.-based corporations, not to mention Australian-based corporations.

But the biggest challenge presented by distributed warfare is the fundamental change in the relations between a central command authority and its deployed units. In an era of information dominance and concrete enemy plans for decapitation of command and control,

[78] Director of National Intelligence, "Industry Snapshot: Summary of Partner Responses to the FY 2015-2019 IC S&T Investment Landscape," Washington DC, 2015, http://www.dni.gov/files/documents/atf/In-STeP%20-%20Industry%20Snapshot.pdf.

[79] This has been made plain repeatedly by Microsoft representatives speaking at international conferences attended by the author.

[80] Kim Zetter, "How Digital Detectives Deciphered Stuxnet, the Most Menacing Malware in History", Wired Magazine, 7 November 2011, http://www.wired.com/2011/07/how-digital-detectives-deciphered-stuxnet/.

whether through cyber and kinetic means, all military units must now have ways of re-connecting with each other if key links in the central chain are broken. As mentioned above, China has responded to this much more explicitly than most countries in its most recent military strategy (May 2015). It foreshadows a lessening of central command authority to foster the conditions of victory in cyber war under the rubric of "self-dependence" for individual military units ("you fight your way and I fight my way").

One of the political consequences of distributed warfare and its asymmetric potential is that it may also break down the traditional value of military alliances, especially the provision of extended deterrence. Australia benefits from the technical support of its intelligence allies, especially the Five Eyes,[81] in preparing for cyber war and conducting information operations. Australian forces also enjoy considerable integration into advanced command and control arrangements with US. forces for operations. There is however considerable evidence to suggest that the reliance by middle powers on the United State for extended deterrence may not have as much impact in cyber space as for kinetic operations. The United States has agreed with NATO partners that an attack in cyber space can constitute an armed attack for the purpose of invoking mutual response under Article 5 of the treaty. The question however is whether cyber incursions of a warlike character or preparatory to war would in practice attract that U.S. support. It is more than likely that middle powers allied to the United States would have to plan for a higher degree of self-reliance in cyber space than in maintaining kinetic military capability because the recognition of thresholds of incursion or assault in cyber space is far less developed and far more ambiguous than in kinetic scenarios. There is little room for doubt about intent when several bomber aircraft of one country penetrate the airspace of another that this constitutes a threat of armed attack. The same clarity is not yet in place for cyber incursions.

Future Technologies of Attack and Defence

Trends in technologies for cyber attack and defence have been described in many places: from government agencies, scholars, vendors, netizens and hackers. Those of significance for benchmarking national security needs range across all eight vectors of the "cyber flower" described above, but they also include those that cut across and combine the individual vectors. These might be called "systems of systems" technologies. The scale of the challenge in forecasting technologies of attack and defence systems should not be dumbed down by anyone person's understanding of security in cyber space. The first thing that strikes a policy analyst coming to the question from a neutral, non-specialist position is the immense diversity of estimations about future technologies of attack and defence systems. There is also the consideration that novel (disruptive) cyber technologies will emerge and be deployable at short notice, in time periods as short as a matter of days.

From the point of view of benchmarking Australia's national security needs, this paper has chosen to highlight just a few that are not particularly prominent in public discussion or among specialists, as evidenced by published research or by public statements in Australia.

If one looks narrowly at the typical security specialist's horizon, the characterization of threat development around complex cyber attacks is a useful place to start. In 2015, a U.S. based analyst, Carl Herberger, the Vice President of Security Solutions at Radware, reported that in 2013 the average cyber attack he had observed involved seven attack vectors (though some had reached over 25 attack vectors), different phases (each with several waves), with

[81] The "Five Eyes" is an intelligence alliance between the United States, the United Kingdom, Canada, New Zealand and Australia arising from their collaboration in the Second World War.

successive phases relying on methods that worked in the previous phase but adding new attack vectors.[82] This was rather well captured in a FireEye presentation in 2013 which listed four characteristics of the emerging threat landscape: coordinated persistent threat actors, dynamic polymorphic malware, multi-vector attacks and multi-phase attacks.[83]

These characterisations are very important benchmarks. But they don't take us as far as we need to look. On the one hand, they address only a narrow slice of the eight vectors of attack, and don't say a lot about defensive systems.

As one leading international example of future defensive systems, we might look at the topic of critical infrastructure protection and the acknowledged world leader in cyberspace defence of it, the Idaho National Laboratory (INL). The focus of this work is not military battlefield systems, but it provides many benchmarks for development of battlefield systems and for defence policy makers and ADF leaders who must be able to depend on certain critical infrastructure. After all, there is no victory in war without survivable critical infrastructure. That is one meaning of the word 'critical'.

We can take the case of electric power supply which is just one of eight factors of cyber security, is itself controlled by digital assets, and is possibly the most ignored vector of attack and response. This was the subject of testimony of an Associate Director of INL, M Brent Stacey, on 21 October 2015, which is extracted verbatim below:

- The presumption that a control system is "air-gapped" is not an effective cyber security strategy. This has been demonstrated by over 600 assessments.
- Intrusion detection technology is not well developed for control system networks; the average length of time for detection of a malware intrusion is four months and typically identified by a third party.
- As the complexity and "interconnectedness " of control systems increase, the probability increases for unintended system failures of high consequence - independent of malicious intent.
- The dynamic threat is evolving faster than the cycle of measure and countermeasure, and far faster than the evolution of policy.
- The demand for trained cyber defenders with control systems knowledge vastly exceeds the supply.[84]

INL has identified a three tier defensive approach, again rendered verbatim:

1. Hygiene: "the foundation of our nation's efforts , composed of the day - to-day measure and countermeasure battle"; "important routine tasks such as standards compliance, patching, and password management"; "primarily the role of industry, with both vendors and asset owners participating".
2. Advanced persistent threat: "the more sophisticated criminal and nation state persistent campaigns"; requiring "a strategic partnership with industry and government"; "these roles are still evolving"; "ICS-CERT provides critical surge response capacity and issues alerts of current vulnerabilities to the government and asset owners"

[82] See more at: http://inspiratron.org/blog/2015/05/29/the-art-of-cyber-war/#sthash.LxJiSSIc.dpuf.
[83] See http://www.exclusive-networks.be/wp-content/uploads/2013/11/FireEye-breakout-session.pdf.
[84] United States. House of Representatives. Science Subcommittee on Energy And Science Subcommittee On Research And Technology, Written Testimony of Mr. Brent Stacey, Associate Laboratory Director for National & Homeland Security, Idaho National Laboratory, 21 October 2015, p.3, http://docs.house.gov/meetings/SY/SY20/20151021/104072/HHRG-114-SY20-Wstate-StaceyB-20151021.pdf.

3. High impact low frequency events: "catastrophic and potentially cascading events that will likely require substantial time to assess, respond to, and recover from. This level is primarily the responsibility of the government."

Research at INL focuses on the two highest priority tiers (#2 and #3 in the list above), aiming for a "two- to four-year research-to-deployment cycle" and to "achieve transformational innovations that improve the security of our power infrastructure by reducing complexity , implementing cyber-informed design, and integrating selected digital enhancements". The laboratory "is pursuing a grand challenge to develop novel and deployable solutions to take a set of high value infrastructure assets off the table as targets". This program assumes pervasive insecurity: It promotes "a paradigm shift in the methods used to historically develop control systems. This paradigm is predicated on the fact the traditional trust relationships in peer communications are no longer a satisfactory assumption. Instead, a resilient control system design expects a malicious actor or actions to be part of normal operation and is designed to mitigate such actions".[85]

Australia has no comprehensive effort that remotely matches the approach adopted by INL, and in fact much of the government's effort is spent on the lowest priority tier (#1 in the list above) identified by INL: the cyber security hygiene of operators and enterprises.

A 2012 UK analysis provides some additional insight into the processes threatening cyber resilience of another aspect of critical infrastructure, the financial services sector.[86] The study was based on consultation with industry. Interviewees identified as one of the top 3 technology risks the "development or emergence of new technology and poor change management in relation to new technologies".[87] A 2013 academic study on a similar subject warned against the danger of estimating risks in isolation from each other: "Estimation of CPS[88] risks by naively aggregating risks due to reliability and security failures does not capture the externalities". [89] It called out "biased security choices" that "reduce the effectiveness of security defenses". Looking to future threats, it warned that CPS "are subjected to complex risks, of which very little is known despite the realization of their significance".

Technologies of Decision-making

High performance computing, a technology that is well established though rapidly evolving, is being seen increasingly as an essential tool of cyber defence management at the national level military level, as well as a new weapon in the hands of adversaries. A 2014 paper from Sandia Laboratory lays out a future "technology of decision-making" based on

[85] See website of Idaho National laboratory, https://inlportal.inl.gov/portal/server.pt/community/distinctive_signature__icis/315/grand_challenge.
[86] United Kingdom. Financial Conduct Authority, HM Treasury and the Bank of England, "Technology and Cyber Resilience Benchmarking Report 2012", London 2013, http://www.bankofengland.co.uk/financialstability/fsc/Documents/technologyandcyberresiliencebenchmarkingreport2012.pdf'
[87] The other two were network and critical system outages, and access management and control of administration privileges.
[88] Cloud Platform Services.
[89] Saurabh Amin, Galina A. Schwartz, Alefiya Hussain, "In Quest of Benchmarking Security Risks to Cyber-Physical Systems", *IEEE Network*, January/February 2013, 19-24, 24, http://www.eecs.berkeley.edu/~schwartz/IEEEMag2013.pdf.

high performance computing[90] that might usefully be understood by analogy as an attempt to create for cyberspace, as a global civil domain, an up-scaled version of the global strategic C4ISTAR system for U.S. command of its strategic nuclear weapons, including indicators and warning.

The study took as a core operating principle the proposition that the cyber security terrain for national decision-making is a "continuous lifecycle with human, organizational, legal, and technical interdependencies". It identified seven high priority "wide-area problems" in the field of cyber security that have high relevance to a middle power like Australia in understanding its technologies of decision-making for cyber-enabled war. These priority problems, listed verbatim, are:

1. disjointed response to wide-area and multi-target attack
2. widely dispersed and fragmented detection and notification capabilities
3. ill-defined government, commercial, and academic roles and responsibilities
4. divided and rigid wide-area cyber protection posture
5. unresolved wide-area common and shared risks
6. fragile interdependent wide-area critical access and operations
7. unresolved attribution of attack and compromise.

The authors concluded by recommending areas for further research in high performance computing to support national security decision making for cyber space.[91]

It is unsurprising that U.S. government laboratories have the remit and the resources to take on such challenges, and that scientists in middle powers do not have the same opportunities. As far as Australia is concerned, in the absence of public disclosure about similar activities at the strategic level of warfare, we can probably conclude that the remit and resources for such analysis, and subsequent procurement action, are very different. Australia does have well developed assets for research in and application of high performance computing, but in the absence of public records, one might conclude that these have not been rigorously applied to the special demands of decision-making for cyber-enabled war at the strategic level.

If we translate the ecosystem of threat and defence implied by the mere handful of trends in technology and response to those trends mentioned above, we can only conclude that small to middle powers like Australia are staring down the barrel of almost insurmountable challenges unless they are able to develop complex responsive systems of decision-making for medium intensity war that address simultaneous multi-vector, multi-front and multi-theatre attacks in cyber space, including against civilian infrastructure and civilians involved in the war effort, by a determined enemy. And all of that before we even think about emerging technologies like quantum computing, anti-satellite weapons, mass deployment of drones as distributed airborne C4ISTAR platforms, a return to traditional HF-based communications for cyber activities, and laser-based communications.[92]

---

[90] Curtis M. Keliiaa and Jason R. Hamlet, "National Cyber Defense High Performance Computing and Analysis: Concepts, Planning and Roadmap", SANDIA Report**,** SAND2010-4766, September 2010, pp.7-8, http://prod.sandia.gov/techlib/access-control.cgi/2010/104766.pdf.

[91] These areas for research were: trusted connection and automated processes; informatics, statistics and anomalous behavior; mathematics analysis and intrusion detection; complexity science and emergent behavior; modeling and simulation; analysis and correlation algorithms; sociology and psychology.

[92] Robert Koch and Mario Golling, "Blackout and Now? Network Centric Warfare in an Anti-Access Area Denial Theatre", in M. Maybaum, A.-.M. Osula, and L. Lindström (eds), *2015 7th International Conference on Cyber Conflict: Architectures in Cyber Cyberspace*, Tallinn: NATO CCDCOE, 2015, 169-184, 178-180, https://ccdcoe.org/cycon/2015/proceedings/12_koch_golling.pdf.

Scenario Planning for Cyber-enabled War

There are many components to planning, funding and training a defence force for the future. One of the most important is the intelligence foundation: what are other countries doing and planning to do? What might they do in certain circumstances based on what we know? How might future technologies affect their military strategies? These are the sorts of issues canvassed above. An additional tool is that of scenario development, which is especially useful where uncertainty about the intelligence available will be high, as is certainly the case in cyber-enabled warfare. The value of scenario planning is widely appreciated in the ADF, though not often exercises in respect of cyber-enabled warfare.

Since the cyber-enabled warfare plans of Australia's potential adversaries and even of its allies are likely to remain opaque for the ADF, the merits of scenario planning as summarized by two research scholars for a NATO-related cyber conflict conference, are worthy of close scrutiny.[93] There are classic elements, such as the elucidation of likely geopolitical scenarios, but they also see merit in cyber-space scenarios for their ability to tease out alternative responses to future technologies and in creating a stimulus to change among policy makers and managers. They also call out, as Adm. Rogers has done, the value of providing a common 'language' and doctrinal approach to possible future trends. Above all, the authors highly recommend the use of scenarios as a concrete tool for reducing strategic surprise ("Reduction of the impact of uncertainty through the notion of 'robustness'").

Most major powers have been involved in scenario planning for civil cyber emergencies. Fewer have published any details of scenarios for cyber-enabled war, but there is no shortage of scenarios for such. As one example, in late 2014, the United States government conducted an exercise, Cyber Flag, with a wide number of scenario elements[94] that have not been associated with any similar public domain announcement about preparation for cyber war. These included:

- joint force response to a regional crisis involving significant cyber military activity
- full spectrum military operations (with "cyber plus kinetic" effect combat goals)
- alliance cyber operations with air, land and naval forces
- operating while being subjected to cyberattacks affecting national command and control.

This type of exercise scenario is useful, but like most it has specific training and development purposes that need to be limited to the development stage of the forces involved and do not necessarily reflect the totality of the type of situation (contingency) for which military planners at the executive level of government must prepare.

For the purposes of benchmarking international best practice in scenario development or contingency planning for cyber-enabled warfare, it would be important to undertake a detailed study since none seems to exist in the unclassified domain. But for the purposes of this paper, it may be sufficient to note that defence planning at the national level, in terms of future war, would be the "kingdom of the blind" if a country did not have an agreed vision of the likely contours of a cyber-enabled war. For the United States, one of the most cited for the United States is the case of a military confrontation with China over Taiwan.[95] This is

[93] "The use of Scenarios in Long Term Defence Planning", April 2007, https://plausiblefutures.wordpress.com/2007/04/10/the-use-of-scenarios-in-long-term-defence-planning/.
[94] Bill Gertz, "Cyber War Games Held", *Washington Times*, 12 November 2014, http://www.washingtontimes.com/news/2014/nov/12/inside-the-ring-cyber-war-games-held/?page=all.
[95] David C. Gompert and Martin Libicki, "Cyber Warfare and Sino-American Crisis Instability", *Survival*, 56 (4), 7-22, https://www.iiss.org/en/publications/survival/sections/2014-4667/survival--global-politics-and-strategy-august-september-2014-838b/56-4-02-gompert-and-libicki-04fc.

highly credible and involves wide-ranging cyber attacks against U.S. civil infrastructure to prevent mobilisation of U.S. forces or delay their deployment to the Western Pacific.

An alternative way of constructing a scenario would be take the most notable incidents of state-sponsored and criminal cyber actions that might be most relevant to a particular type of medium intensity conflict and see how they might be combined to develop a scenario of relevance to particular countries. For a country like Australia, the list of possible attack vectors for cyber-enabled kinetic war would be long, but we can illustrate the scope by alluding to the following potential combination:

> Estonia 2007 (a shut down of the financial and banking system) + China's kinetic anti-satellite test 2007 + Stuxnet 2010 (cyber sabotage) + release by the group Anonymous of military personnel data + cutting of undersea cable (numerous incidents) + closing down of civil satellite links (Egypt) + closing down electric grids (U.S. operation in Yugoslavia 1999) + insertion of false data into military systems + attacks on Saudi Aramco + planting malware in civil aviation systems + opening flood gates on dams + closing down military communications.[96]

Consideration of such scenarios leads us to three possible broad conclusions about Australian government policy. First, medium intensity cyber-enabled war outlined in such a scenario is a sufficiently remote possibility that we need not plan for it. Second, we have not studied it sufficiently to know or to have developed a national consensus on the subject of the type of cyber-enabled war we are likely to face. Or third, we cannot regard Australia's cyber military policy as mature until the government:

- has had an open and candid conversation in public with key stakeholders about the sort of threat scenarios our armed forces and communities may face in a medium intensity cyber-enabled war
- has developed defence policies and armed forces, supported by the civil sector, that could perform credibly in those scenarios given reasonable warning time
- has articulated a diplomatic strategy to reduce the risks of such a war if it looks like emerging
- has articulated a civil defence strategy for the inevitable high impact disruption of our civil economy and communities in such a war
- has set in place policies for development of our industry base and work force that can support all of the above to the extent that our national economy permits and limitations of alliance support dictate.

This author thinks that either the second or third possible conclusions are more logical than the first. I lean to the third, but am prepared to credit the second.

Conclusion and Recommendations

There are many departure points for benchmarking Australia's national security needs for cyber-enabled war. On the one hand, there are developing capabilities in countries like China and the United States, Australia therefore needs to respond with its own sovereign

[96] This sort of scenario was canvassed by Mark Seinor at an international conference on "Redefining R&D priorities for Australian Cyber Security" on 16 November 2015. See https://www.unsw.adfa.edu.au/australian-centre-for-cyber-security/cyber-r-d for a list of presentations, including that by Seinor.

capabilities. On the other hand, there is the important consideration that cyber security is bigger than each of us, either at the national level of the international level.

Just where a country like Australia needs to position itself in this highly dynamic and complex environment (the information ecosystem) is something that only the collective wisdom of the country's best minds can answer, working in partnership. We need first of all an open and public debate on our military, security and civil needs in cyber space and how well our emerging capabilities match those needs. We would have to admit, as so many specialists have argued, that we are badly lagging.

While a large slice of the national security cyber domain must remain secret, the Australian public and its key actors in policy (private sector companies, state governments, foreign suppliers, military allies, citizens, civil society groups, lawyers, judges, security agencies, university researchers and educators) need to see a clear vision, in a number of places, and in public, of where we are headed and how we reconcile competing demands of national security in the information age with each other or with other public policy demands, such as open trade, international investment, privacy, industry regulation or industry support. Based on this paper, the Australian government, the Department of Defence and the ADF might consider articulating a comprehensive set of policies around the following benchmark indicators:

- A national innovation strategy that keeps the country at the forefront of international best practice in cyber technologies that can be applied in war
- A military strategy for cyber-enabled warfare that takes account of the proven and estimated character of such an armed conflict, including public intelligence assessments of likely cyber war threats and a top-end (but credible) scenario
- A strategy for sovereign cyber war capability and cyber survivability in a time of direct military confrontation with a major power
- A capital procurement program centred on advanced cyber-enabled war capabilities, including space-based assets and new technologies of decision-making
- A renovation of military institutions, training and education
- Necessary investments in niche technologies and research capabilities
- A strategy for managing civilian-military divides and critical infrastructure protection in times of military conflict
- A strategy for mobilizing cyber-capable reservists or civilians in times of military crisis
- A sharp distinction between the national needs for cyber security as largely a civil domain set of issues and the needs for cyber-enabled war fighting capability.

Above all else, Australia needs to build a community of interest around the concept of cyber-enabled warfare with a recognised authoritative hub that can unite political, military, diplomatic, business, scientific and technical interests and expertise. The ideal location for this would be the Australian Defence Force Academy (ADFA) for several reasons. It would be Canberra-based and therefore close to government and military headquarters, as well as accessible to peak industry bodies, key defence contractors and the country's main strategic studies centres. A cyber warfare centre located at ADFA could draw on the existing collocated academic resources of the Australian Centre for Cyber Security inside UNSW Canberra and its cohort of more than 50 related researchers throughout UNSW. The two centres might be co-badged in some way. The best argument for ADFA as the location could be the need to foster a quantum leap inside the armed forces in attitudes toward and knowledge of cyber-enabled warfare as it continues to transform

traditional ways of war-fighting and diplomacy. What better way than to do this than through the main officer cadet training facility in the country.

Such an enterprise would closely resemble the model of a similar centre at the U.S. Military Academy at West Point NY described earlier in the paper. That may be somewhat inappropriate for Australia given the relative imbalance between the wealth of the two countries and size of their armed forces. Arguably, a model more tailored to Australian defence interests and circumstances might combine the cyber war set of issues other high technology needs, such as outer space, and focus more generally on technology and innovation in the defence arena, with cyber-enabled warfare as one of its highest research and training priorities.

One thing is crystal clear. Australia will not make the necessary transitions for cyber-enabled warfare quickly enough unless it makes a number of new policy commitments and substantial institutional transformations very soon.

References

Amin, Saurabh; Schwartz, Galina A. and Hussain, Alefiya "In Quest of Benchmarking Security Risks to Cyber-Physical Systems", *IEEE Network*, January/February 2013, 19-24, 24, http://www.eecs.berkeley.edu/~schwartz/IEEEMag2013.pdf

Austin, Greg, *Cyber Policy in China*, Cambridge UK: Polity Press, 2014

____ "International Legal Norms in Cyber Space: Evolution of China's National Security Motivations", forthcoming January 2016, with the NATO Cyber Defence Centre of Excellence as part of an edited volume on Cyber Norms

____ "China's Security in the Information Age" in Lowell Dittmer and Yu Maochun (eds), *Routledge Handbook of Chinese Security*, Routledge, 2015, 355-370

____ "Australian Defence Policy in the Information Age", Submission for the 2015 Australian Defence White Paper, 22 September 2014, 5,000 words, http://www.defence.gov.au/Whitepaper/docs/028-Austin.pdf

____ "Australia's Digital Skills for Peace and War", *Australian Journal of Telecommunications and the Digital Economy*, vol 2. No. 4, December 2014

____ "China's Cyber Espionage: The National Security Dimension and U.S. Diplomacy" Discussion paper, 2015, available at http://thediplomat.com/wp-content/uploads/2015/05/thediplomat_2015-05-21_22-14-05.pdf

____ "Managing Asymmetries in Chinese and American Cyber Power", *Georgetown Journal of International Affairs*, "International Engagement on Cyber IV", October 2014, 141-151

Austin, Greg (co-authored), Bruce McConnell and Jan Neutze, "Promoting International Cyber Norms: A New Advocacy Forum", EastWest Institute, New York, December 2015, http://www2.ewi.info/idea/slowing-cyber-arms-race

____ and Franz Stefan Gady, "Cyber Detente between the United States and China", EastWest Institute, New York/Brussels/Moscow, co-authored with Franz Stefan Gady, November 2012

____ and Franz Stefan Gady, "Russia, the United States, and Cyber Diplomacy: Opening the Doors", EastWest Institute, New York/Brussels/Moscow, co-authored with Franz Stefan Gady, September 2010

____ and Pavel Sharikov, "Preemption is Victory: Aggravated Nuclear Instability of the Information Age", co-authored with Pavel Sharikov (Moscow), Working Paper (unpublished), 2015

____ and Sandro Gaycken, "Resetting the System: Why Highly Secure Computing Should Be the Priority of Cybersecurity Policies", EastWest Institute, New York/Brussels/Moscow, January 2014, http://www.eastwest.ngo/sites/default/files/Resetting%20the%20System.pdf

____ and Bruce McConnell, Eric Cappon, Nadya Kostyuk, "A Measure of Restraint in Cyberspace: Reducing Risk to Civil Nuclear Assets", EastWest Institute, 2014

Austin, Greg (news commentary) "Cybersecurity: The Toughest Diplomatic Challenge Is China's Weakness", The Global Journal, April 2, 2013, http://theglobaljournal.net/article/view/1049/

____ "Why the China-US Cyber Agreement May Prove Destructive", The Diplomat, 7 October 2015, http://thediplomat.com/2015/10/why-the-china-us-cyber-agreement-may-prove-destructive/

Australia. ABS, "The Information Society and the Information Economy in Australia, in *Year Book Australia, 1999*, http://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/1301.0Feature%20Ar

ticle551999?opendocument&tabname=Summary&prodno=1301.0&issue=1999&num=&view=
Australia. Australian Cyber Security Centre, "Threat Assessment 2015", Canberra, 2015, https://www.acsc.gov.au/publications/ACSC_Threat_Report_2015.pdf
Australia. Department of Prime Minister and Cabinet. "Strong and Secure: A Strategy for Australia's National Security", 23 January 2013, http://apo.org.au/research/strong-and-secure-strategy-australias-national-security
Australia. Office of the Chief Scientist. "Professor Chubb Releases 'Science, Technology, Engineering and Mathematics: Australia's Future', Press Release, 2 September 2014, http://www.chiefscientist.gov.au/2014/09/professor-chubb-releases-science-technology-engineering-and-mathematics-australias-future/
Australia. Office of the Chief Scientist. *Science, Technology, Engineering and Mathematics: Australia's Future*, Office of the Chief Scientist 2014, Australian Government, Canberra. Available at: http://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf
Brenner, Joel *America the Vulnerable: Inside the New Threat matrix of Digital Espionage, Crime and Warfare*, New York: Penguin Press, 2011.
China. Information Office of the State Council. "China's Military Strategy", May 2015, http://news.xinhuanet.com/english/china/2015-05/26/c_134271001.htm
Feakin, Tobias and Jessica Woodall and Liam Nevill, "Cyber maturity in the Asia-Pacific Region 2015", Canberra: Australian Strategic Policy Institute, 2015, https://www.aspi.org.au/publications/cyber-maturity-in-the-asia-pacific-region-2015
Georgia Tech information Security Centre and the Georgia Tech Research Institute, "Emerging Cyber Threats Report 2015", 2014, https://www.gtisc.gatech.edu/pdf/Threats_Report_2015.pdf
Gompert, David C. and Martin Libicki, "Cyber Warfare and Sino-American Crisis Instability", *Survival*, 56 (4), 7-22, https://www.iiss.org/en/publications/survival/sections/2014-4667/survival--global-politics-and-strategy-august-september-2014-838b/56-4-02-gompert-and-libicki-04fc
Helgason, Sigurdur "International Benchmarking: Experiences from OECD Countries", Paper Presented at a Conference Organised by the Danish Ministry of Finance on International Benchmarking, Copenhagen, 20-21 February 1997, p. 2, www.oecd.org/governance/budgeting/1902957.pdf
Japan. 2013. "Cybersecurity Strategy: Towards a World-leading, Resilient and Vigorous Cyberspace", Tokyo: Information Security Policy Council, http://www.enisa.europa.eu/activities/Resilience-and-CIIP/national-cyber-security-strategies-ncsss/JAP_NCSS2.pdf
Keliiaa, Curtis M. and Jason R. Hamlet, "National Cyber Defense High Performance Computing and Analysis: Concepts, Planning and Roadmap", SANDIA Report**,** SAND2010-4766, September 2010
Koch, Robert and Mario Golling, "Blackout and Now? Network Centric Warfare in an Anti-Access Area Denial Theatre", in M. Maybaum, A.-.M. Osula, and L. Lindström (eds), *2015 7th International Conference on Cyber Conflict: Architectures in Cyber Cyberspace*, Tallinn: NATO CCDCOE, 2015
Libicki, Martin C. *Cyberdeterrence and Cyberwar*, Santa Monica CA: Rand Corporation, 2015
Ormrod, David and Benjamin Turnbull, "Toward a Cyber Military Maturity Model", abstract for a presentation at an international conference on Redefining R&D Priorities for Australian Cyber Security, 16 November 2015, University of New South Wales,

Canberra, https://www.unsw.adfa.edu.au/sites/accs/files/uploads/Military%20Cyber%20Maturity%20Model%20v1.pdf

Plausible Futures Newsletter, "The use of Scenarios in Long Term Defence Planning", April 2007, https://plausiblefutures.wordpress.com/2007/04/10/the-use-of-scenarios-in-long-term-defence-planning/

Reuters. "China's Xi urges army to create strategy for information warfare", 30 August 2014. Available at: http://www.reuters.com/article/2014/08/30/us-china-xi-defence-idUSKBN0GU0H020140830

RIA Novosti, "Russia Strategic Missile Forces Create Cybersecurity Units: Defense Ministry", 16 October 2014, http://sputniknews.com/military/20141016/194157367/Russian-Strategic-Missile-Forces-Create-Cybersecurity-Units.html

Rid, Thomas and Peter McBurney, "Cyber Weapons", *RUSI Journal*, February/March 2012, vol. 157, no. 1 pp. 6–13, https://www.rusi.org/downloads/assets/201202_Rid_and_McBurney.pdf

Robinson, Neil and Agnieszka Walczak, Sophie-Charlotte Brune, Alain Esterle, Pablo Rodriguez, "Stocktaking study of military cyber defence capabilities in the European Union (milCyberCAP)", Rand Europe, 2013, http://www.rand.org/content/dam/rand/pubs/research_reports/RR200/RR286/RAND_RR286.pdf

Russia. "Military Doctrine of the Russian Federation" (*Voennaya doktrina Russkoi Federatsii*), December 2014, http://news.kremlin.ru/media/events/files/41d527556bec8deb3530.pdf

Russia. "The Military Doctrine of the Russian Federation", 5 February 2010, translation, Carnegie Endowment, http://carnegieendowment.org/files/2010russia_military_doctrine.pdf

Russia. Federal Government. Order on the Signing on an Agreement between the Russian Federation and the People's Republic of China on Cooperation in the Field of Securing International Information Security, (in Russian), Moscow, 30 April 2015, http://pravo.gov.ru/laws/acts/34/555656451088.html

Stone, Steven W. "Factors Influencing Agility in Allocating Decision-Making Rights for Cyberspace Operations", 20th ICCRTS Paper 096, June 2015, http://static1.squarespace.com/static/53bad224e4b013a11d687e40/t/54da5be5e4b0e9d26e577151/1423596517506/096.pdf

United Nations. "Report of the Group of Governmental Experts on Developments in the Field of Information and Telecommunications in the Context of International Security" (UN GGE 2015), A/70/174, 22 July 2015, http://www.un.org/ga/search/view_doc.asp?symbol=A/70/174

United Nations. Letter dated 9 January 2015 from the Permanent Representatives of China, Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan and Uzbekistan to the United Nations addressed to the Secretary-General, A/69/723, 13 January 2015, https://ccdcoe.org/sites/default/files/documents/UN-150113-CodeOfConduct.pdf

United States. Cyber Command, "Beyond the Build: Delivering Outcomes through Cyberspace", U.S. Department of Defence, Washington DC, June 2015

United States. Department of Defense, "*Quadrennial Defense Review Report", 2006,* www.archive.defense.gov/pubs/pdfs/QDR20060203.pdf

_____ "Department of Defense Strategy for Operating in Cyberspace", Washington DC, 2011, p. 11, http://www.defense.gov/news/d20110714cyber.pdf

_____ "DoD Cyber Strategy", Washington DC, 2015, http://www.defense.gov/Portals/1/features/2015/0415_cyber-strategy/Final_2015_DoD_CYBER_STRATEGY_for_web.pdf
_____ *Department of Defense Law of War Manual*, Washington DC, 2015, p.995, http://www.defense.gov/Portals/1/Documents/pubs/Law-of-War-Manual-June-2015.pdf
United States. Director of National Intelligence, "Global Trends 2015: A Dialogue about the Future with Non-Government Experts", NIC2000-2, December 2000, http://www.dni.gov/files/documents/Global%20Trends_2015%20Report.pdf
_____ "Industry Snapshot: Summary of Partner Responses to the FY 2015-2019 IC S&T Investment Landscape," Washington DC, 2015, http://www.dni.gov/files/documents/atf/In-STeP%20-%20Industry%20Snapshot.pdf
_____ "Statement for the Record, Worldwide Cyber Threats, House Permanent Select Committee on Intelligence", James R. Clapper, Director of National Intelligence, 10 September 2015, http://www.dni.gov/files/documents/HPSCI%2010%20Sept%20Cyber%20Hearing%20SFR.pdf
_____ Remarks as delivered by The Honorable James R. Clapper, Director of National Intelligence, Opening Statement to the Worldwide Threat Assessment Hearing, Senate Armed Services Committee, Thursday, 26 February 2015, http://www.dni.gov/index.php/newsroom/testimonies/209-congressional-testimonies-2015/1175-dni-clapper-opening-statement-on-the-worldwide-threat-assessment-before-the-senate-armed-services-committee
United States. House of Representatives. Science Subcommittee on Energy And Science Subcommittee On Research And Technology, Written Testimony of Mr. Brent Stacey, Associate Laboratory Director for National & Homeland Security, Idaho National Laboratory, 21 October 2015, p.3, http://docs.house.gov/meetings/SY/SY20/20151021/104072/HHRG-114-SY20-Wstate-StaceyB-20151021.pdf
United States. Joint Chiefs of Staff (JCS), *Cyberspace Operations*, 2013, JP 3-12R, www.dtic.mil/doctrine/new_pubs/jp3_12R.pdf
_____ *Information Operations*, 2012, JP 3-13, www.dtic.mil/doctrine/new_pubs/jp3_13.pdf
United States. Space Command, "Strategic Master Plan FY06 and Beyond", 2003, www.wslfweb.org/docs/final%2006%20smp--signed!v1.pdf
United States. The National Defense Strategy of the United States of America, 2005, www.wslfweb.org/docs/final%2006%20smp--signed!v1.pdf
United States. The White House. "Presidential Policy Directive 20: U.S. Cyber Operations Policy", 2012, available at: http://fas.org/irp/offdocs/ppd/ppd-20.pdf
_____ "Readout of Senior Administration Officials' Meeting with Secretary of the Central Political and Legal Affairs Commission of the Communist Party of China Meng Jianzhu", 12 September 2015, https://www.whitehouse.gov/the-press-office/2015/09/12/readout-senior-administration-officials-meeting-secretary-central
Waters, Gary; Ball, Desmond; Dudgeon, Ian. 2008. *Australia and Cyber-Warfare*, Canberra Papers in Strategy and Defence, Australian National University ePress. Available at: http://press.anu.edu.au/wp-content/uploads/2011/08/whole_book5.pdf
Watson, Chris. 2007. "Joint Information Operations: The Way Ahead", *Australian Army Journal*, Vol. 4 (1), 77-98. Available at: http://www.army.gov.au/Our-future/Publications/Australian-Army-Journal/Past-

editions/~/media/Files/Our%20future/LWSC%20Publications/AAJ/2007Autumn/07-JointInformationOperati.pdf

World Economic Forum (WEF), *Global Information Technology Report 2003-2004*, New York: Oxford University Press, for the World Economic Forum and others, 2004, http://www-wds.worldbank.org/servlet/WDSContentServer/IW3P/IB/2005/11/17/000090341_20051117162002/Rendered/PDF/343090GITR2003.pdf

____ *Global Information Technology Report 2010-2011*, New York: Oxford University Press, for the World Economic Forum and others, 2011, http://www3.weforum.org/docs/WEF_GITR_Report_2011.pdf

____ *Global Information Technology Report 2013*, New York: Oxford University Press, for the World Economic Forum and others, http://www.weforum.org/reports/global-information-technology-report-2013

____ *Global Information Technology Report 2014*, New York: Oxford University Press, for the World Economic Forum and others. Available at: http://www.weforum.org/reports/global-information-technology-report-2014

ABOUT ACCS

The Australian Centre for Cyber Security (ACCS) is a unique, interdisciplinary research and teaching centre. It has its headquarters at UNSW Canberra, bringing together more than 50 researchers across UNSW. It serves as a national hub for policy related research and education across the full spectrum of cyber security (hardware, software, payload, networks, policy, human factors, organizational factors and the information ecosystem).

RESEARCH PRIORITIES

The centre enhances UNSW's existing and emerging research strengths in four broad areas:

- Australian Cyber Strategy, Law and Policy
- Technologies of Cyber Security, Information Assurance and Situational Awareness
- People in Command
- World Politics, Security and International Law in Cyber Space.

ACCS combines expertise from a range of relevant communities; political, cyber industry, defence, academic, individual and organisational users, and the media. The centre depends on close working relationships with both domestic and international industry and government, including UNSW's unique half-century relationship with Defence.

EDUCATION WITH ACCS

ACCS at UNSW Canberra is host to three innovative Masters of Cyber Security streams and other professional education programs. We offer advanced inter-disciplinary study at Master's degree level in some of the most exciting aspects of security in cyber space: adversary tradecraft, reverse engineering of malware, red teaming, cyber war, cyber crime, cyber terrorism, to name just a small selection of our offerings. Our teaching staff includes scholars with global reputations in their field. Further information can be found on the websites indicated below with hyperlinks:

- technical stream: Cyber Security
- management stream: Cyber Security Operations
- strategy and diplomacy stream: Cyber Security, Strategy and Diplomacy

Download a brochure on these courses here.

Details on high quality professional education courses delivered in intensive mode can be found in this brochure. ACCS professional courses are delivered by full-time and adjunct staff. The adjunct staff have high relevant direct experience in Australia's intelligence and security agencies. Our state of the art facilities include red and blue team labs and utilise an isolated network with Cyber Range, Ixia traffic generator and other enterprise grade tools.